3.0 ALTERNATIVES ANALYSIS

The following Alternatives Analysis addresses both the MEPA Certificate of the Secretary of Environmental Affairs on the ENF (April 22, 2002) and the USACE Scope of Work for this DEIS (June 21, 2002), and has been developed in response to extensive public scoping comments. A "tiered" approach has been used to address a wide range of comments and address differences between the Federal and Massachusetts state legal requirements. This analysis begins with a general overview of both conventional and renewable energy generating technologies, evaluates the New England region for alternative wind power sites, and tiers down to a progressively more detailed analysis of potentially feasible alternatives for comparison purposes.

As requested in the MEPA scope, the Alternatives Analysis begins with a "generic" comparative discussion of the impacts expected from comparably sized traditional fossil fuel fired power plants (natural gas, oil and coal) located in either an upland or a coastal location (see Section 3.2.1). The criteria used for this discussion were specified in the MEPA scope. The analysis continues with a general evaluation of Renewable Technologies as called for in the USACE scope (see Section 3.2.2) to gain a better understanding of whether any may be considered reasonable methods of accomplishing the project objective.

The alternative wind park siting analysis (Section 3.4) begins with the screening of a number of New England-wide upland and offshore sites which were proposed through the public scoping process including input from cooperating State and Federal agencies. These sites are evaluated in Section 3.4.2 using preliminary screening criteria developed by the USACE in consultation with cooperating agencies.

In October of 2003, through a qualitative, flexible approach to site screening, it was determined by the District Engineer of USACE-NAE that four locations warrant more detailed analysis as potentially feasible alternatives for comparison purposes. This detailed analysis (section 3.4.3) evaluates each site for a number of resources derived from the Corps of Engineers public interest factors (33 CFR Part 320.4a).

Section 3.4.4 then presents a comparison of three alternatives originally addressed by the Applicant within Nantucket Sound (including the Applicant's proposed site at Horseshoe Shoal) evaluating 12 project design siting criteria for each site.

As specified in the MEPA certificate, Section 3.5 presents a detailed alternatives analysis for the submarine and upland cable routes for the transmission system that will transmit the power generated offshore, (from the Applicant's proposed site at HSS) onshore to the established New England power grid. The information contained in this section has been summarized from Cape Wind Associates, LLC's (and Commonwealth Electric Company d/b/a NSTAR Electric's) petition to the Commonwealth of Massachusetts Energy Facilities Siting Board (EFSB) and Department of Telecommunications and Energy (Docket number EFSB 02-2/D.T.E. 02-53).

3.1 Geographic Scope and Primary Project Criteria

The geographic scope of the Project is limited to the New England Region (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) in order to provide renewable power through the Independent System Operator – New England (ISO-NE) transmission system to end users throughout New England, including Cape Cod and the islands of Martha's Vineyard and Nantucket.

The commercial electricity market (including electric bulk power generation and transmission) is managed by Independent System Operators as part of the framework developed by the Federal Energy Regulatory Commission (FERC) to support the deregulation of the United States electric industry. ISO-New England Inc. was established in 1997 and presently manages and operates the region's power grid and transmission reservation system, as well as administering the wholesale electricity marketplace. ISO-NE manages a power grid made up of more than 350 generating units connected by more than 8,000 miles of transmission lines, which serves 14 million people in an area covering 66,672 square miles over six states (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont). An analysis of the need for the proposed renewable energy project which examines the reliability, economic and environmental benefits for Massachusetts and the New England region is presented in Appendix 5.16-B.

In order to fulfill the project purpose and need, primary project criteria for establishing reasonable alternatives for evaluation include:

- New England location capable of interconnecting to ISO-NE system. It is understood that new generation facilities may require minor upgrades to the existing transmission system in order to access the grid; and
- Renewable technology with demonstrated commercial feasibility, capable of producing electricity on a utility scale (200-1,500 MW[4]) that could be operational in the reasonable foreseeable future (2-3 years). Small, distributed power generation facilities are not considered reasonable alternatives, as they would not accomplish the project objective.

3.2 Assessment of Energy Generating Technologies

3.2.1 Impact Assessment of Fossil Fuel Fired Power Plants

According to the MEPA ENF Certificate (April 22, 2002), the EIR "should include an evaluation of alternative feasible technologies for generating 420 MW of electricity, as well as an assessment of alternative locations for the proposed technology. The point of the EIR alternatives analysis will be to vary the project parameters of reasonable feasible alternatives to disclose relative impacts so that the general public and state agencies can be informed of relative impacts." The discussion below therefore contains a "generic" analysis as requested by MEPA for a gas-fired mainland power plant with a capacity of 454 MW[5], to determine such parameters as air emissions, water use, fisheries, avian, visual, and other environmental impacts. The generic discussion, as requested by MEPA, also includes a gas-fired plant sited in a coastal location. For comparative purposes, the EIR also briefly discusses the impacts of comparably sized oil-fired and coal-fired power plants located in both mainland and coastal locations. The siting of fossil fuel fired power plants is not strictly dependent upon the location of the fuel resource. This allows more flexibility in the siting of fossil fuel power plants enabling them to take advantage of existing transmission lines and load pockets. The following is an impact assessment of fossil fuel fired power plants that are equivalent in comparison to approximately 454 MW, the maximum size of the Applicant's Proposed Project.

Due to the intermittent nature of wind power the proposed Project is estimated to generate, on average, approximately 170 MW of electricity. However, because the Project is expected to operate at or near capacity nearly 20% of the year, all assessments (including System Impact Studies being conducted by NSTAR for ISO-NE, as well as studies requested by the EFSB) have been based on the proposed maximum generating capacity of 454 MW.

3.2.1.1 Mainland Plants

3.2.1.1.1 Natural Gas Fired Power Plants

Air Emissions

The USEPA has established National Ambient Air Quality Standards (NAAQS) for the primary pollutants (so-called "criteria pollutants") emitted by a variety of sources, including fossil fuel fired electric generating facilities. The objective of these standards is to protect public health and the environment. Although air quality in the New England states generally conforms with these standards, challenges still exist. New England lies within the Ozone Transport Region (OTR), which was established with recognition of the challenges that the Mid-Atlantic and Northeast states face due to the transport of air contaminants from states located to the west and south. Portions of New England are further classified as serious or even severe nonattainment areas for one or more criteria pollutants, primarily due to emissions of nitrogen oxides (NOx) and volatile organic compounds (VOCs). These classifications, created by the Clean Air Act Amendments of 1990, impose stringent emissions limitations on stationary sources, such as new electric generating facilities. Emissions of fine particulate matter and other

[4] As discussed in Section 2.0, (Purpose and Need), based on a review of historical ISO-NE data on proposed / planned interconnection and long term firm point-to-point transmission service requests to ISO-NE, the energy generating capacity of new utility-scale and regionally significant energy facility projects that have been permitted or are presently being studied for interconnection with the regional power grid have generating capacities that range between 200 and 1,500 MW.

[5] Since the issuance of the MEPA ENF Certificate, the maximum output achievable for the Proposed Project has been revised upward to 454 MW due to technological advances. Therefore, the analysis requested by MEPA has been adjusted to reflect the new maximum output of the wind park.

pollutants generated from fuel combustion contribute to regional haze and poor visibility within formerly pristine wilderness areas. The Federal and State governments have shown an increased concern for these visibility issues.

As a result of these existing air quality conditions, new large sources of emissions are required to implement emission control systems that represent Lowest Achievable Emission Rate (LAER) and Best Available Control Technology (BACT). Although the determination of LAER and BACT are highly technical exercises with project-specific considerations, the level of emissions control required can be estimated by considering similar recently permitted projects.

In order to estimate the level of emissions that may result from a natural gas fired electric generating facility capable of producing approximately 454 MW, the Applicant has considered limitations imposed on two recently permitted facilities within Massachusetts: the 580 MW (2 x 290 MW) Blackstone and Bellingham Combined Cycle Combustion Turbine (CCCT) plants constructed by American National Power. These facilities will operate with the most stringent level of emissions controls imposed for recently permitted electric generating facilities capable of producing several hundred megawatts of power. The level of annual emissions approved for these facilities, along with that predicted for a new 454 MW facility, are shown in Table 3-1.

The estimates shown in Table 3-1 demonstrate that a state-of-the-art natural gas fired energy facility would result in emissions of hundreds of tons of pollutants per year. These emissions would be additive in a region already confronted with major air quality challenges. The formation of these pollutants and their environmental impacts has been well established as discussed below.

Emissions of NOx result from the combustion of nitrogen contained in fuel and the air supplied for combustion. Nitrogen oxides contribute to the formation of ground level ozone and acid rain. Emissions of VOC and carbon monoxide (CO) are the result of incomplete fuel combustion, which occurs to some degree even in state-of-the-art combined cycle combustion turbines (CCCT) systems being installed today. Although efficient combustion techniques employed in today's combustion turbines combined with the use of relatively clean burning natural gas reduce VOC and CO emissions below any other fossil fuel fired combustion technology, large quantities of these pollutants would still be emitted. Sulfur dioxide (SO2) emissions from natural gas fired facilities are the lowest of all fossil fuel fired combustion facilities due to the low sulfur content of natural gas. Emissions of SO2 contribute to acid rain, sulfate deposition and can react with other compounds in the atmosphere to form fine particulate. Particulate matter also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash). Although natural gas has the lowest ash content of any fossil fuel, and the use of extremely efficient gas turbine combustion technology affords the best possible controls for particulates formation, an approximately 454 MW plant would have the potential to emit greater than 100 tons per year of particulate. Further, natural gas fired combustion turbines emit very fine particulate matter less than 2.5 microns in diameter (PM2.5). PM2.5 health concerns have driven the EPA to promulgate a new ambient air quality standard for this pollutant[6]. The danger associated with PM2.5 is the particle's ability to avoid the human body's air filtering mechanisms and deposit deep within the lungs. Elevated particulate levels have been attributed to a variety of health effects such as respiratory ailments, especially in the young and the elderly(USEPA, 2004a).

In addition to the emissions of criteria pollutants, a gas-fired facility would also emit non-criteria pollutants and carbon dioxide. Non-criteria pollutants include Hazardous Air Pollutants (HAPs), which the EPA considers of special concern and for which the EPA has developed national emission standards for specific source categories such as combustion turbines. Some of the hazardous air pollutants emitted by a natural gas fired combustion turbine include formaldehyde, xylene, toluene, and benzene.

Carbon dioxide has been attributed to an increase in average global temperatures. The emission of greenhouse gasses and climate change is a concern to many in the scientific community. Natural gas fired energy facilities represent the best method to reduce the total emissions of carbon dioxide from fuel burning power plants as compared to other combustion technologies because of the combustion efficiency of the combined cycle system and the low carbon content of natural gas per MW of energy produced.

[6] (Federal Register / Vol. 62, No. 138 / Friday, July 18, 1997).

Noise is also a concern when operating any industrial facility, particularly an energy generating facility. Normal facility operation involves the operation of air handling and cooling equipment, which would increase background noise levels, particularly during nighttime quiet hours.

Water Use

Fossil-fuel-based electricity production requires a reliable, abundant, and predictable source of water. According to the U.S. Department of Energy's National Energy Technology Laboratory (DOE NETL) the process of thermoelectric generation from fossil fuels is water intensive – requiring an average of approximately 25 gallons of water to produce a kWh of electricity. Water use by existing fossil fueled power plants accounts for 48% of total water use (saline and freshwater) in the U.S. (estimated at 195 Billion gallons / day) and 39% of total freshwater withdrawals.[7]

Natural gas fired energy facilities utilize water in many operations including steam generation, emission control systems, and cooling. Facilities may draw water from city water supplies, surface water bodies, or groundwater sources. The use of local potable water supplies removes valuable drinkable water from these systems. The use of groundwater may draw down aquifers, which can also adversely impact potable water supplies. Withdrawals from a surface water body could also decrease water levels, potentially adversely impacting aquatic habitats and depleting valuable water resources.

Fisheries

Acid rain, which results from emissions of nitrogen oxides and sulfur oxides formed in combustion, is known to negatively affect fish populations. Increased water acidity has been attributed to declines in fish populations in many locations in the Northeast. The EPA has attributed reduced fish populations, the elimination of fish from some water bodies, and decreasing biodiversity to acid rain. These effects are attributed not only to the increased acidity but also to increases in aluminum, which is leached from the surrounding soil by the acid rain and carried to the river, stream or lake (USEPA, 2004b). Although not all plants and animals are affected equally by acid rain, increased acidity and aluminum have been attributed to decreased fish weights and increased egg and fry mortality in many species.

Large withdrawals from a surface water body that alter water levels, can also adversely affect fish. Water withdrawals impact fish directly through entrainment into a facility's cooling water supply system or impingement on the water intake structures. Both of these factors have been documented to result in significant fish kills. If the facility discharges wastewater to the surface water body, the water quality can be adversely impacted, with subsequent negative impacts on fish populations.

Stormwater runoff from developed facilities can also result in negative impacts to the aquatic environment. Runoff from parking lots and buildings, even when managed via a stormwater system, can contain nutrients such as sulfates and nitrates, fertilizers, and the normal nutrients found in soils. These materials contribute to the eutrophication of surface water bodies. Increased plant growth caused by these materials can cause an increase in algae blooms and high levels of turbidity (suspended material), resulting in fish kills, and loss of sensitive benthic (bottom-dwelling) animals in the ecosystem.

Avian

A natural gas combustion turbine facility can have several impacts on avian populations. Attendant structures such as stacks and transmission lines present the potential for collisions. Construction of a facility and its associated interconnects may also impact bird populations by removing habitat and nesting areas. In addition to facility impacts, the impacts of drilling, extraction and transportation of natural gas should also be considered. These operations impact birds in much the same ways as the facility itself but on a greater scale.

Visual

The most obvious visual features of a gas fired energy facility are the combustion gas exhaust stacks. Although the stacks for a natural gas fired combustion turbine are usually shorter than those found in other types of combustion installations, the visibility of the stack and exhaust gas plume are significant. If a facility uses evaporative technology, cooling tower vapor plumes may extend for long distances from the top of the cooling

[7] USGS, Estimated Use of Water in the United States in 2000, USGS Circular 1268, May 2004

towers. These plumes can result in reduced visibility and impacts on local transportation thoroughfares, depending on the location of the facility. Although a facility that uses "dry-cooling" technology (i.e., air to water heat exchangers) does not discharge a vapor plume, the dry cooling towers are approximately three times larger than equivalent evaporative technology cooling systems.

In addition to daytime visual impacts, the facility would also have nighttime visual impacts. Normal facility lighting and the need to light the exhaust stacks for aviation safety concerns can increase the facility's visual impacts.

Other

A mainland natural gas fired facility would bring the potential for environmental impacts from vehicular traffic in both the construction and operation phases. Construction transportation impacts would result from delivery of materials and equipment and the removal of excavated soils and waste construction material from the site. Transportation impacts at an operating natural gas fired facility would be lower than those associated with liquid or solid fossil fuel fired facilities which have added fuel transportation requirements. However, the delivery of ammonia, which may be used in emission control systems and other chemicals, results in increased traffic and increased potential for spills and releases of hazardous materials to the environment. Employees commuting to and from the facility would also increase traffic in local areas.

Construction of the facility, electrical transmission lines, natural gas supply line, sewer and water connections and other associated interconnects would result in large areas of land alteration. These activities have the potential to negatively impact wetlands, waterways and terrestrial environments. The ammonia used in the emission control system would also need to be stored on site in large quantities that present the risk for releases and exposure to any nearby residences.

The siting of natural gas fired power plants is not strictly dependent upon the location of the fuel resource. This allows more flexibility in the siting of fossil fuel power plants near existing transmission lines and load pockets.

As previously discussed in Section 2.0 and Appendix 2.0-A, New England's dependence on natural gas coupled with the declining natural gas reserves in North America, and the infrastructure investments needed in the New England pipeline delivery system have raised concerns that demand for natural gas will exceed its supply, leading to shortages and higher energy prices.

Summary of Findings

An energy facility using natural gas fired, CCCT systems has the potential to result in the lowest overall environmental impacts for a mainland fossil fuel fired power plant. Air emissions from such a facility are the lowest of any fossil fuel fired generating technology. However, several hundred tons per year of air contaminants would potentially be emitted and the impacts of these emissions could be extensive. Facility emissions will impact the surrounding environment and will affect the air quality of the surrounding area during the entire operational life of the facility.

The facility and interconnect construction impacts to both wetlands and terrestrial environments can have lasting effects. Large water consumption and discharge associated with an approximately 454 MW facility can negatively impact aquifers, surface water bodies and aquatic species. Construction of such a facility would also result in the alteration and loss of land for open space or other beneficial uses. The use of chemicals poses increased risks to local populations and the environment.

3.2.1.1.2 Oil-Fired Power Plants

Air Emissions

An oil-fired electric generating facility constructed in New England would be required to meet the BACT and LAER for air emissions in the same manner as a natural gas fired facility. However, even with these controls, oil firing would increase emissions in comparison to a natural gas fired facility. The increase in emissions is largely the result of greater fuel impurities that are present in liquid fossil fuels. These impurities increase emissions of SO2, VOC, PM, non-criteria pollutants and HAPs. The increased fuel nitrogen content and combustion temperatures

associated with oil firing will increase NOX emissions. Emissions of CO will also increase, as will other products of incomplete combustion.

Water Use
An oil-fired facility presents the potential for many of the same water use impacts as a natural gas fired combustion turbine facility as discussed above. In addition, many oil-fired combustion turbine systems rely on water injection for the control of NOx emissions, resulting in increased water consumption. The water is injected into the turbine along with the oil to decrease the temperature of combustion and decrease the NOx emissions. This technique is beginning to be phased out due to improvements in dry, low NOx burners capable of firing oil.

Fisheries
An oil-fired generating facility would have fisheries impacts similar to those of a natural gas fired facility. However, an oil-fired facility would have an increased impact on surface water bodies due to greater acid gas emissions. These emissions, consisting of SOx and NOx as discussed previously, would increase acid deposition both locally and far downwind from the facility. The emissions of acid rain, which have been shown to have impacts on fish populations as discussed previously, would be greater for an oil-fired facility.

Avian
An oil-fired energy facility would present potential for the same avian impacts as discussed previously for a natural gas fired facility.

Visual
An oil-fired facility would have visual impacts similar to those of a natural gas fired facility. The oil-fired facility may have a greater stack plume height due to higher combustion temperatures and the use of water for NOx control. An oil-fired facility will also have large fuel tanks, often with the capacity to store one million gallons of fuel or more. Such a tank would be approximately 70 feet in diameter and 50 feet tall.

Other
The construction, chemical and employee related transportation, and on-site chemical storage issues described for a natural gas fired facility would be similar for an oil-fired facility. However, a mainland oil-fired facility would need to receive its fuel by overland transport. This would increase the facility's traffic and transportation concerns dramatically. Several million gallons of fuel per year would need to be delivered to the facility by road or rail. The delivery of fuel will increase traffic on local roads and the emissions from transport will add to the already greater emissions caused by oil combustion. If particulate emissions control equipment such as electrostatic precipitators are required, the facility would also generate ash that would require off-site disposal.

The siting of oil-fired power plants is not strictly dependent upon the location of the fuel resource. This allows more flexibility in the siting of fossil fuel power plants near existing transmission lines and load pockets.

The facility would have much the same impact to wetlands and land use as a gas fired facility. However, the risks associated with fuel oil transportation and the potential for environmental impacts from oil releases would also be present.

The U.S. currently depends heavily on foreign oil supplies. This reliance coupled with regional instability in primary oil producing regions presents potential concerns with the long-term reliability and economic stability of an oil-fired energy facility.

3.2.1.1.3 Coal-Fired Power Plants

Air Emissions
A coal-fired facility would be either a circulating fluidized bed (CFB) boiler with a complex emission control system or integrated gasification combined cycle (IGCC) combustion turbine system in order to meet the requirements of BACT and LAER. Either of these types of facilities would emit significantly more criteria pollutants, non-criteria pollutants and HAPs than a natural gas or oil-fired facility. Emissions of mercury, a persistent bioaccumulative toxin, have also been associated with coal combustion and are the focus of new regulations for existing coal-fired

power plants. The storage of coal and the likely use of evaporative cooling technology increase the potential for particulate emissions.

Water Use

Coal-fired facilities require significantly more water consumption than natural gas or oil-fired facilities. A coal-fired boiler has a greater heat load than a natural gas fired turbine resulting in increased water consumption. Dry cooling technology can often become too large for this type of unit requiring the use of wet cooling towers that further increase evaporative losses and water consumption. Coal burning facilities consume water within scrubber systems used for the control of sulfur dioxide and acid gas emissions.

Stormwater runoff from coal storage areas can have impacts on wetlands and the local environment. The stormwater runoff can contain toxic chemicals found in coal, which can be washed to surrounding surface water bodies through the stormwater collection systems.

Fisheries

In addition to the impacts described for natural gas or oil-fired facilities, coal-fired facilities increase the potential for acid gas emissions as compared to either an oil or natural gas fired facility. The impacts of stormwater runoff are increased as discussed above along with the impacts of mercury emissions.

Avian

A coal-fired facility would present the potential for the same types of impacts to avian populations as discussed previously for other types of fossil fuel fired facilities.

Visual

The impacts of a coal-fired electric generating facility would be similar but greater than either a natural gas or oil-fired facility. The stack height of a coal-fired facility is usually greater than an equivalently sized gas or oil-fired combustion turbine because the emissions from a coal-fired facility must be discharged higher in the atmosphere to achieve proper dispersion and ensure that NAAQS are not exceeded. The use of wet cooling towers, as discussed above, would also add to the visual impacts of the facility due to the vapor plume that would rise from the tops of the towers. Vapor plumes from cooling towers have also been known to create a safety hazard in cold weather when ice is formed on roads due to water vapor deposition. A coal-fired facility also has a coal storage area that may not be enclosed and will often cover as much, or more, area as the facility's buildings. The addition of a coal train offloading area and the coal delivery system also increase the total facility footprint and the visual impacts.

Other

The transportation of chemicals and employees, along with on-site chemical storage, would be much the same as a natural gas or oil-fired facility. The transportation of coal to a mainland facility capable of providing approximately 454 MW requires the use of a large navigable river or rail. New England has few navigable rivers large enough to accommodate coal barges, and sites with available land suitable to develop a large power plant, are limited along those . Therefore, rail transport would be the most likely fuel delivery option for a mainland facility. A rail line connection would add to the facility's land use and ecological impacts. Mining of coal can also present significant environmental impacts. The use of particulate emissions control equipment such as electrostatic precipitators would result in generation of ash that would require off-site disposal.

The siting of coal-fired power plants is not strictly dependent upon the location of the fuel resource. This allows more flexibility in the siting of fossil fuel power plants near existing transmission lines and load pockets.

Summary of Findings

A coal-fired facility would result in increased air emissions, water consumption, land use, visibility and overall environmental impacts when compared to a natural gas or oil-fired facility.

3.2.1.2 Coastal Plants

3.2.1.2.1 Coastal Natural Gas Fired Power Plants

Air Emissions
Air emission impacts for a coastal plant will be similar to that described for a mainland plant.

Water Use
Water use impacts for a coastal plant will be similar to that described for a mainland plant.

Fisheries
The impact to fisheries will be the same as a mainland plant except that the facility could impact shellfish as well as finfish if the facility used sea water as the cooling water source or discharged cooling water or wastewater to the ocean. The warmed water released back into the sea may result in a thermal plume which has been shown to have negative impacts on local fisheries.

Avian
Avian impacts would be the same as a mainland facility.

Visual
Visual impacts would be the same as a mainland facility.

Other
The construction of a large facility on a coastal plain can affect the surrounding environment in several ways. The effect of construction runoff into tidal environments can have significant negative impacts on the delicate tidal ecosystems. These ecosystems are often the breeding grounds for economically important fish and shellfish species. In addition, the facility would need to ensure that proper prevention measures are taken to mitigate potential for erosion or discharge of contaminants from stormwater. A facility powered by Liquefied Natural Gas (LNG) would need deep water access for LNG tanker deliveries which is likely to involve significant dredging with its associated marine impacts.

Summary of Findings
The impacts associated with the use of ocean water as cooling water along with construction of a facility in a coastal plain are the greatest difference between a coastal and mainland facility. Fish populations and other aquatic species can be affected by the withdrawal and discharge of cooling water. In addition, the construction of a facility on the coast has the potential to adversely impact the tidal environment.

3.2.1.2.2 Coastal Oil-fired Power Plants

Air Emissions
Air emission impacts for an oil-fired facility located along the coast will be very similar to a mainland facility. Fuel delivery will likely be the primary difference between a coastal and mainland facility. The emissions from ship traffic used to deliver the large quantities of oil have the potential to increase emissions compared to overland transport.

Water Use
Water use would be very similar to a mainland facility.

Fisheries
The impacts on fisheries would be similar to a coastal natural gas fired facility.

The construction of a ship offloading area may increase the facility's impacts on the tidal and coastal environments. The offloading area would present the potential for spills during offloading. The spills would be easily discharged to the water where they could have significant effects on the tidal and ocean life. In addition to the increased possibility of spills at the offloading area, the increase in ship traffic to supply the facility would also serve to increase the risk of maritime oil spills.

Avian
Avian impacts would be much the same as a mainland facility, however in the event of an oil spill from a delivery barge there could be significant impacts to birds and bird habitat.

Visual
A coastal oil-fired facility would have a similar visual impact as a mainland facility. The visual impact would be greater due to the increase in ship traffic. This impact would not only create a visible impact close to the plant but would also affect the areas the ships would navigate through in order to reach the facility. In addition to this the construction of the ship docking and unloading structures would increase the visual impacts of the facility.

Other
Other impacts would be the same as a mainland plant. Overland transportation impacts may be reduced if ship transport is possible; however, the increased ship traffic would have detrimental effects as discussed above. Marine accidents during fuel delivery, resulting in spills of large quantities of oil, have the potential to significantly impact the coastal environment as well as avian populations[8].

Summary
The impacts associated with the use of ocean water as cooling water as discussed above are the greatest impact difference between a coastal and mainland facility. The effects on fish populations and the presence of temperature sensitive species can be affected by the use of surface water bodies as cooling water. The additional impact from large ship and barge traffic would only slightly increase the emissions as compared to the total facility emissions. However, the increased impacts caused by an offloading area and increased ship traffic could severely affect the coastal environment.

3.2.1.2.3 Coastal Coal-fired Power Plants

Air Emissions
Air emission impacts will be the same as a mainland coal-fired facility.

Water Use
Water use would be the same as a mainland coal-fired facility

Fisheries
The impact to fisheries would be similar to a coastal oil-fired facility.

Avian
Impacts to avian populations would be the same as for a mainland coal-fired facility.

Visual
Visual impacts would be similar to a mainland coal-fired facility. The visual impact would be greater due to the addition of ship traffic. This impact would not only create a visible impact close to the plant but would also affect the areas the ships would navigate through in order to reach the facility.

Other
These impacts would be very similar to the mainland coal-fired facility with reduction in overland transport; however, the increase in ship traffic would have the same detrimental effects as discussed above.

Summary of Findings
A coal-fired coastal power plant would result in the increase of emissions and impacts over a gas or oil-fired facility. The impacts are very similar to a mainland coal-fired facility with the possibility of increased damage to sensitive tidal environments.

[8] http://www.buzzardsbay.org/oilspill-4-28-03.htm

3.2.2 Renewable Technologies

Renewable energy technologies produce electrical power that is generally more expensive than electrical power generated by conventional fossil fuel combustion. However, they also possess certain favorable environmental attributes, including:

- Low or no air emissions or wastewater discharges when compared to traditional fossil fuel electrical power generation (excepting certain biomass technologies);
- Avoidance of environmental impacts related to drilling, mining or other extraction methods associated with fossil fuel production; and
- Utilization of sustainable resources or waste streams that would otherwise require disposal.

Renewable energy technologies are also often associated with favorable policy drivers and economic benefits, making development of these technologies viable. Current policy drivers include Massachusetts Department of Energy Resources (DOER) Renewable Energy Portfolio Standards (RPS), Connecticut Department of Public Utility Control (CT DPUC) RPS and Maine Public Utilities Commission (PUC) Eligible Resource Portfolio Requirement, which require a minimum percentage of electrical energy sales within their respective states to come from New Renewable Generation Attributes. Economic benefits include both state and federal tax incentives.

Alternative renewable energy technologies discussed in the following section were identified using guidance from the Council on Environmental Quality (CEQ) regarding National Environmental Policy Act (NEPA) regulations. This guidance states that the selection of alternatives should be "bounded by some notion of feasibility" to avoid NEPA from becoming "an exercise in frivolous boilerplate."[9]

The following sections provide information relative to those renewable energy technologies that have been identified as meeting a reasonable standard of feasibility.

3.2.2.1 Photovoltaic (Pv)/Solar

Photovoltaic/Solar technologies used to generate electrical power include:

- Concentrator technology, which uses an arrangement of photovoltaic cells that includes a lens to concentrate sunlight onto small-area cells.
- Flat-plate technology, which uses an arrangement of photovoltaic cells mounted on a rigid flat surface with the cells exposed freely to incoming sunlight.

3.2.2.1.1 Reliability

Photovoltaic systems produce power intermittently because they work only when the sun is shining. More electricity is produced on a clear, sunny day with more intense sunlight and when the sunlight is at a more direct angle (i.e., when the sun is perpendicular to the photovoltaic modules). Cloudy days can significantly reduce output, and no power is produced at night. Furthermore, photovoltaic systems work best during the summer months, when the sun is higher in the sky (and therefore at a more direct angle to the modules) and the days are longer.

Photovoltaic systems are not well suited for use in the New England region as a reliable source of large scale electrical generation due to lower direct insolation (intensity of incoming solar radiation) than levels found in other areas of the country, such as Florida and the Southwest. Lower insolation levels tend to be characteristic of the region due to the sun's position in the sky, especially in the winter months.

Insolation values in the Northeast result in average duty cycles of approximately 1,500 hours per year in Massachusetts, versus average duty cycles of approximately 2,200 hours per year in high insolation areas. Less than ideal insolation values, coupled with the fact that sunlight is an intermittent resource (i.e., nights, periods of cloud cover, etc.) decrease the reliability of photovoltaics.

[9] Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519, 551 (1978).

3.2.2.1.2 Current Technology Status

Based on systems currently in operation, flat plate systems range in size from 50 kW – 200 kW and concentrator sizes range between 2 kW-200 kW; well below the Applicant's proposed project size of approximately 454 MW. At these lower power generation levels, photovoltaic applications are most feasible and economical for off-grid and consumer applications. Currently there are 299 operational photovoltaic projects representing approximately 1053 kW of capacity installed in Massachusetts, with another 105 projects representing an additional 410 kW registered for funding through the Massachusetts Technology Collaborative (MTC), but not yet operational. Additional MTC co-funded projects that are in early stages of design will add another 500 - 600 kW of capacity. Thus, the combined total of all currently operating and proposed photovoltaic installations in Massachusetts is estimated to be approximately 2 MW (MTC, 2004).

Photovoltaic arrays employ modular construction designs and are therefore relatively easy to construct/install. Once installed, photovoltaic modules have an average lifetime of 25 years, and are characterized by low operation and maintenance (O&M) costs during that period.

Despite their prevalence in consumer applications, photovoltaics have the highest cost of energy among renewable energy sources (greater than $0.20/kWh in 2002)[10]. The high cost of energy may be attributed to the costs of producing the materials in photovoltaic cells and modules, which is very energy intensive. In addition, photovoltaic technology is not very efficient. Currently, crystalline technologies, which are among the most efficient photovoltaic systems, are only approximately 13% efficient. Photovoltaic technology developments being pursued are expected to increase the efficiency of crystalline photovoltaic cells up to 18% by 2010.

Efforts are also being made to reduce the costs of photovoltaic modules. Unfortunately, the gains that may be made in cost reduction will likely be offset by accompanying decreases in module efficiency. For example, thin film technologies being developed will result in lower module costs but will also result in lower efficiencies. Table 3-2 summarizes the state of photovoltaics research.

As indicated above, the high capital costs associated with photovoltaics, coupled with low efficiencies, make this technology economically unfeasible on a large scale. While the cost of energy of other renewable energy sources averages approximately $0.15/kWh, photovoltaics remain significantly higher. Although advances in the development of new materials are expected to reduce the cost of energy generated by photovoltaic technology to $0.21-0.50/kWh, these developments have yet to be achieved or demonstrated in practice.

3.2.2.1.3 Ability to Serve Regional Needs

Regionally, most photovoltaic systems are being used in off-grid and consumer applications. Those systems that have been constructed in Massachusetts, in total, represent about 435 kW of electrical generation, well below that generated by the Proposed Project. The average insolation values that can be expected in this region, coupled with the intermittent nature of sunlight (i.e., night) results in limited potential for photovoltaic installations in the region. When installing off-grid and consumer applications, storage batteries are required to maximize system efficiency. Several small grid-connected photovoltaic systems are equipped with storage batteries that can store electrical power for distribution to the grid at later periods. However, these photovoltaic units have power outputs of only 2-11 kW; significantly smaller than 454 MW. A study conducted by Sandia National Laboratories indicated that while it was technically feasible to incorporate storage into a 2.4 kW grid-connected photovoltaic system, the economics remained a challenge.

The largest example of grid-connected photovoltaics was the 6.5 MW array at Carissa Plains California[11], however, this system has been dismantled due to degradation through UV browning of the PV modules and the resultant decreased electricity production which made it more cost effective for the owner to sell the modules than to sell the electricity produced[12] . Presently the world's largest single-site solar powered generating plant is the 3.9 MW Rancho Seco photovoltaic array located in California[13]. A photovoltaic system capable of generating

[10] NREL Energy Analysis Office. www.nrel.gov/analysis/doc/cost_curves_2002.ppt
[11] Stuard Baird, M.Eng., M.A., Energy Fact Sheet, Energy Educators of Ontario, 1993
[12] http://www.agores.org/publications/pv2010/vol3chapter1.pdf; www.azsolarcenter.com/technology/tech-4.html
[13] http://platts.com/Magazines/POWER/2004/february/maturing.html?S=printer

anywhere near 454 MW of electrical power would have extremely high capital costs, resulting in high electricity generation costs, making the project economically infeasible.

3.2.2.1.4 Affected Environment

The production of photovoltaic modules is very energy intensive and involves the use of potentially hazardous chemicals and the generation of hazardous waste. For example, current photovoltaic module manufacturing processes require high temperature operations such as doping (high temperature diffusion) to produce the semiconductor material required to generate electric current.

Photovoltaic modules are not very efficient in converting solar power into electrical power and average only about 13%. Based on an average electricity production rate estimated to be 100 watts per square meter (W/m^2) of panels[14], a 454 MW plant would require a 14.6-square-mile array of solar panels.

3.2.2.1.5 Environmental Impacts

Operation of photovoltaic systems results in no emissions or fuel requirements although significant energy and material resources, often considered hazardous to the environment or human health, are required to manufacture photovoltaic modules. . In addition, the operation of such systems does not result in generation of any noise or require any water use. Construction and operation of systems capable of generating several hundred megawatts of electrical power would, however, result in the alteration and consumption of large tracts of land. This level of land alteration has the potential for negative impacts to ecosystems and habitats.

Large land use poses potential impacts on flora and fauna, their habitats and wetlands, and limits land availability for other beneficial uses. Additionally, large arrays of photovoltaic modules are highly visible and pose aesthetic challenges.

As indicated above, photovoltaic modules may contain small amounts of hazardous materials such as cadmium and lead. Improper disposal of modules containing hazardous materials may result in environmental contamination. For example, some modules may be classified as hazardous waste according to the US EPA. Several Cadmium Telluride photovoltaic modules have failed the US EPA Toxicity Characteristic Leaching Procedure (TCLP) for potential leaching of cadmium in landfills, and some Silicon photovoltaic modules failed tests for leaching of lead. The presence of these, and other hazardous compounds, increases cost and complexity when dealing with photovoltaic modules that have reached the end of effective service.

3.2.2.1.6 Summary of Findings

Photovoltaic technology offers several environmental benefits and meets Massachusetts' DOER Renewable Energy Portfolio Standards. Although the environmental impacts of photovoltaic systems while operational are minimal (i.e., no emissions), an approximately 454 MW photovoltaic array requires the alteration and consumption of a large land area.

In addition, the economics of grid-connected photovoltaic systems are prohibitive when compared to current grid power prices, even when coupled with the various financial incentives offered through state and federal programs.

Lower insolation values in the region further limit the feasibility of this renewable technology in the Northeast U.S. Even in areas outside the Northeast where insolation values are high and photovoltaic technology is better suited, the technology has not been demonstrated for regional commercial power supply levels. While small-scale applications are a good match for photovoltaic technology, development of large central power plants is probably among the least promising approaches for use of photovoltaic technology.[15]

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[14] Information provided by Nisshin Electric Co., Ltd as published by APEC Virtual Center for Environmental Technology Exchange (http://www.apec-vc.or.jp)

[15] Briefing by Union of Concerned Scientists, adapted from material in the UCS book *Cool Energy: Renewable Solutions to Environmental Problems,* by Michael Brower (MIT Press, 1992), 220 pp.

3.2.2.2 Tidal

A tidal power plant is similar in technical concept to hydropower generation facilities in rivers. A barrage (dam) with a powerhouse and turbines is constructed across an estuary or embayment to form a basin (headpond) of sufficient size to allow production of electricity over a reasonable period each day. For the simplest design, the basin is allowed to fill during flood tides through the floodgates and powerhouse, with turbines spinning freely. Power is subsequently produced during the ebb tide. By altering the design of the powerhouse and turbines, power may also be produced during the flood tide, or during both ebb and flood tides.

3.2.2.2.1 Reliability

Several nations possess working tidally driven electric generating facilities. A 240 MW generating station at La Rance, France, a 20 MW experimental facility in Nova Scotia, and a 0.4 MW tidal power plant in Russia are currently operational. These systems, however, are located in regions with a tidal range greater than 10-15 feet (3-4.5 meters) that is necessary for them to be effective. In the US, only the northern coast of Maine and southern coast of Alaska have the appropriate tidal ranges. In general, this part of the country does not have the tidal ranges required to produce the hydrostatic head necessary to make tidal power feasible.

Power generation from tidal driven systems is highly variable. Since there are two high tides and two low tides each day, electrical generation from tidal power plants is characterized by periods of maximum generation every 12 hours, with no electricity generation for brief periods in between (i.e., at the six-hour mark between tides). On average, the total energy output from tidal power is equal to 25-35% of the theoretical maximum load generated over a period of one year due to the intermittent nature of tidal flow. The variability may be reduced by generating electrical power during both the flood and ebb tides. However, two-way generation does not produce any more total energy than one-way ebb generation because of the lower heads during each generation phase compared to one-way systems, the water wasted by opening the sluice gates part way through the generation cycles, and the lower efficiency in operating turbines in reverse.

In addition to the insufficient tidal range present in this area and the variability of tides resulting in variable electrical generation, operation of mechanical equipment in the saline environment (i.e., corrosion), along with the potential impacts of severe ocean storms on the equipment, creates concerns with long term reliability. Any structure located in a marine environment would need to be constructed to withstand ocean storms and use materials that can withstand exposure to the saline environment. However, when the mechanical components of such a structure are submerged, as in the case of some types of tidal generators, the impacts from the saltwater environment are compounded. Incorporation of these design principles results in high capital costs and increases costs of the electrical energy produced.

3.2.2.2.2 Current Technology Status

Tidal power technology is technically proven and dependable, although variable in its electrical generation output. As previously indicated, several nations possess working tidally driven electric generating facilities and others are conducting feasibility studies. Each of these generating facilities employs a variation of the traditional barrage system described below.

Ebb generation - Electrical power generation occurs during the ebb tide. For maximum power generation the turbines do not start to release the water until well after the tide has started to ebb, to maximize hydrostatic head.

Flood Generation - In this case the power is generated during the flood tide and the turbines pump water into the basin.

Ebb Generation Plus Pumping At High Tide - After high tide, the sluice gates are closed and the turbines are reversed in order to act as a pump, forcing more water into the basin. The pumping stops when the sea level has fallen to a point where it is no longer economical to pump the required head. The additional water pumped into the basin is released through the turbines at a much greater head than initially pumped, therefore a net gain in energy results. However, not only does pumping water into the basin require additional energy expenditures,

the turbines must be redesigned to allow for pumping and power generation. Often, turbine blades are curved for maximum efficiency in the direction of generating power, resulting in a significant reduction in efficiency when they are used in reverse as a pump. Variable blade turbines required to improve efficiency while pumping are more expensive and require greater maintenance.

Two-way Power Generation - In two-way generation systems electrical power is generated from both the ebb and flood tides. Ebb generation starts at a basin level that is less than that of single cycle generation (towards the end of the generating cycle, the sluice gates are opened to allow flow from the basin to the sea and hence drop the water level in the basin). This is necessary to achieve a sufficient difference in water height during the flood generation phase. At low tide, the sea and basin levels become equal and the gates are closed. Once the sea has risen to the optimum height, generation begins by operating the turbines in the opposite direction.

In addition to these traditional methods of tidal power generation, there are efforts to develop alternative systems that do not involve barrage structures, such as tidal current turbines and multi-chamber tidal generators that may be sited offshore. A 1 MW pilot project has been proposed by Verdant Power to develop a tidal site on the Merrimack River in Massachusetts using a helical tidal current turbine.

3.2.2.2.3 Ability to Serve Regional Needs

Tidal power does not have the ability to serve a significant portion of the electrical needs of the region, as there are no viable sites in southern New England due to the low tidal height change in the region. Currently, there is only one major tidal generating station in operation, which is the 240 MW station in France. The average tides experienced at that site are approximately 26 feet (8 meters), well above those seen along the Northeast coast.

Even if constructed, the number of sites and associated tidal regime in northern Maine may not be sufficient to generate approximately 454 MW. Tides are variable along the Maine coast, ranging from approximately 9 feet (2.7 meters) along the southern coast to approximately 18 feet (5.6 meters) at Eastport. Additionally, there is a high capital cost associated with the construction of tidal power facilities, as well as construction of appropriate transmission lines that would result in high costs of energy. At this time the existing transmission infrastructure is not sufficient to carry electrical power from northern Maine to the other parts of New England. Location of any electrical generation facility in this area would require the construction of new transmission lines and/or major upgrades to existing lines (see Appendix 3-D). High capital costs, combined with low annual load factors, would make the implementation of tidal power economically infeasible.

3.2.2.2.4 Affected Environment

Tidal power developments may encompass large embayments and affect wide geographic areas, including estuaries, rivers, bays and areas further seaward. Removing energy from the tide and reducing the volume of seawater exchanged across the barrage site may alter water circulation or tidal patterns for great distances around the structures.
Effects may be seen as far as 500 km from the barrage site[16], and may include flooding of portions of nearby coasts and raising long-term storm damage potential.

3.2.2.2.5 Environmental Impacts

Tidal power on a utility scale, where feasible, would alter the marine environment of a substantial hydrogeographic area around the development. Although tidal power is considered a renewable technology, there are environmental impacts associated with the technology. Environmental impacts of tidal power include alterations of the marine environment that may lead to reduced productivity. Within the headpond, tidal range will be reduced and mean water level will rise resulting in greater extremes in surface temperatures. Many aquatic species are sensitive to temperature and may be adversely affected. The reduction in tidal flow and amplitudes may change turbidity and sedimentation in the headpond areas and reduce the dilution and assimilation of effluent from stormwater and wastewater, again adversely impacting the marine environment.

[16] American Fisheries Society, Resource Policy Handbook, January 1997 - Rulifson, R.A., M.J. Dadswell, and G.K. Mahoney. 1986. *Fisheries* 11(4):36-39

According to the American Fisheries Society (AFS, 2001), changes in turbidity and sedimentation due to construction of tidal power barrages have the potential to alter biotic conditions in the headpond areas and alter the food chain. Fishery impacts would be greatest in those areas where fish are abundant and fish passage is repeated by the same population many times over the year. Introducing hydraulic turbines into that type of environment will create problems inherent to fish passage associated with hydroelectric power installations sited in rivers. Estuarine environments generally contain larger fish populations, larger fish species and marine mammals that may be impacted by altered migration routes, and changes in the availability of food organisms.

Wintering and migratory birds may also be impacted by the construction of tidal power facilities due to habitat disturbance and impacts to prey species.

In addition the large structures on the shoreline may pose aesthetic challenges and limit use of portions of the shoreline for recreational or other beneficial uses.

The construction of a traditional barrage requires a considerable amount of building materials, including concrete, sand, and steel. Mining of raw materials and the associated refining/production of finished materials, as well as transportation of finished materials to the site, requires considerable amounts of energy that present further environmental impacts.

3.2.2.2.6 Summary of Findings

Due to the insufficient tidal fluctuations in this region, tidal power is not a feasible renewable energy alternative. Economically, this alternative is not feasible due to the capital costs of a tidal plant and the necessary transmission system upgrades. Furthermore, development of tidal power in this region, which requires significant coastal construction and modification, could have significant environmental impacts on marine life.

3.2.2.3 Biomass

Biomass power is the use of biomass feedstocks in place of traditional fossil fuels (i.e., natural gas, oil or coal) to produce electricity. Biomass technologies include:

- Direct Combustion – Stoker or fluidized bed technology;
- Biomass Gasification – Process that converts wood and/or green waste into a synthetic gas component; and
- Close-coupled gasification – Multi-hearth gassifier with interconnected boiler section.

Direct Combustion power plants burn biomass fuel directly in boilers that supply steam for the same kind of steam-electric generators used in fossil fuel combustion applications. Biomass gasification converts biomass into a gas that can then fuel combustion turbines in either a simple cycle or combined cycle configuration. Close-coupled gasification is a synergistic combination of direct combustion, biomass / waste gasification, and emission control technologies.

3.2.2.3.1 Reliability

Electrical power generation from combustion of biomass has been demonstrated and offers a reliable source of renewable energy. Biomass power plants in the U.S. currently represent 7,000 MW of installed capacity, the second largest amount of renewable energy in the nation (hydropower accounts for the largest amount of renewable energy in the nation). Since biomass technologies employ combustion processes to produce electricity, they can generate electricity at any time, unlike many other renewable energy sources, which tend to be intermittent. Furthermore, unlike renewable-based systems that require costly advanced and/or developing technology (such as photovoltaics), biomass fired facilities generate electricity using commercially available equipment and well-established technology. Many innovations in power generation with other fossil fuels may also be adaptable to the use of biomass fuels.

Biomass, if properly grown and managed, is a renewable resource. Biomass fuels may be obtained from numerous sources, including by-products from the timber and paper industries, agricultural crops, raw material

from forests and demolition wood waste. Biomass resources in the Northeast region are plentiful and include wood and peat.

3.2.2.3.2 Current Technology Status

Biopower, including biomass gasification, is not a new technology. Commercial systems are available for direct-fired applications. U.S. biopower plants have a combined capacity of approximately 7, 000 MW, and use roughly 60 million tons of biomass fuels (primarily wood and agricultural wastes) each year. Biomass combustion facilities exist throughout the Northeast due to the availability of fuel.

Direct-fired biopower plants have matured and employ complex multi-component pollution control systems to reduce emissions from combustion. Due to the inherently low heat value of biomass, direct-fired plants are not very efficient. Biomass integrated gasification (BIG) plants are expected to be twice as efficient as conventional biomass plants and have significantly lower emissions. The recent focus in biopower has been on the commercialization of large-scale gasification systems integrated with combined cycle gas turbines (CCGT) for high efficiency. Presently, the majority of the demonstration projects under development are small-scale systems (25 kW – 5 MW) and fully commercialized BIG/CCGT systems are not yet available. Only 1 BIG/CCGT system in "commercial operation" exists, a 6 MW plant in Sweden.

3.2.2.3.3 Ability to Serve Regional Needs

Biopower capitalizes on the Northeast's abundant forests. In addition, biopower offers the potential for productive use of crop residues, wood-manufacturing wastes, and the clean portion of construction and demolition wastes. However, biopower generation costs are significantly higher than those of traditional fossil - fuel plants because biomass contains less energy per pound of fuel, is costly to transport over long distances, and requires more preparation and handling than fossil fuels.

Furthermore, the power output of individual existing bioplants in New England is less than 50 MW. Current demonstrations of BIG/CCGT systems produce only one to ten MW of electrical power, and commercialization of this technology is not expected for some time. Therefore, numerous biopower plants would be required to produce approximately 454 MW. At the scale of existing biomass facilities (20-50 MW) steam turbine/boiler systems are inefficient (plant efficiencies average approximately 20%), contributing to high electricity costs. Furthermore, each one of these plants would require a large amount of land for the facility, as well as fuel storage. The construction of facilities in those areas where the most abundant sources of biomass are located (i.e., northern New England) would also require construction of new transmission lines since these sites are not close to transmission interconnects and/or load pockets.

3.2.2.3.4 Affected Environment

Unlike most other renewable energy sources, biomass power results in significant air emissions and air quality impacts. Not only does combustion of biomass generate air emissions, but emissions are also generated as a result of the transportation of biomass to the biomass plants.

Biomass power also affects water quality on several levels. Biomass combustion technology consumes water for steam generation and cooling, as is the case with traditional fossil fuel facilities. Cooling water must be discharged to a receiving water body. The introduction of treated water may introduce water treatment chemicals into the water body or raise the temperature of the water, impacting the environment. Finally, stormwater runoff from both the combustion facility itself, as well as harvested land may impact surface water bodies.

Biomass power requires large tracts of land and has both on-site and off-site impacts. A grid-connected biomass electrical power generation facility can occupy several acres of land just for the power plant components alone. These facilities also require large on-site fuel storage facilities as well as structures for connecting to the transmission grid, which requires additional land.

Significant off-site land impacts include the collection of biomass fuels and disposal of combustion ash. Harvesting timber and growing agricultural products for fuel requires large volumes to be collected and transported. Biomass plants also produce solid waste by-products of combustion that are typically landfilled. Depending on the type of biomass fuel used (i.e., harvested trees vs. construction and demolition wood waste), the ash may be classified as hazardous waste. If the ash is classified as hazardous waste, it will likely be disposed of in a permitted landfill.

3.2.2.3.5 Environmental Impacts

Air Quality

All biomass combustion technologies generate air emissions, although gasification results in lower emissions than direct biomass combustion, since many contaminants are removed during the gasification and subsequent gas cleaning processes. Biomass feedstocks contain little sulfur compared to oil and coal, and varying amounts of nitrogen. Uncontrolled sulfur dioxide (SO_2) emissions from biomass combustion are negligible when compared to uncontrolled SO_2 emissions from coal and oil combustion. Uncontrolled nitrogen oxides (NO_x) emissions, however, can be comparable to those generated from coal and oil combustion and are one of the top air quality concerns associated with biomass combustion. NO_x emissions are dependent on the conversion process, the nitrogen content of the biomass and level of emissions control systems employed. Generally, wood contains less nitrogen than other crops or crop residues. Fluidized bed boilers generate less thermal NO_x than grate-fired boilers or gasifier-based boilers and gas turbines because of their lower and more uniform combustion temperatures.

In addition, carbon monoxide (CO) and particulate matter (PM) are emitted as a result of biomass combustion. Emission rates of CO from the combustion of biomass may be higher than those from coal plants. Both CO and PM emissions can be controlled through conventional technologies.

Based on emission rates obtained from the US EPA RACT/BACT/LAER database and the US EPA Compilation of Air Pollutant Emission Factors (AP-42) and comparison of heat input rates and electrical power outputs of biomass facilities in the region, a facility (or facilities) capable of producing approximately 454 MW would have the following annual potential criteria pollutant emissions:

Pollutant	Emission Rate (lb/MMBTU)	Potential Emissions (TPY)
NO_x	0.30	5,220
CO	0.35	5,966
PM	0.03	477
VOC	0.1	895
SO_2	0.025	746

Ecological

The collection of biomass fuels can have significant environmental impacts since biomass power requires large volumes of material to be collected and transported. The collection, processing and combustion of biomass fuels may result in adverse environmental impacts if the fuel source contains toxic contaminants. Agricultural waste handling can result in pollution of local water resources. Burning biomass may also deprive local ecosystems of nutrients that forest or agricultural waste may otherwise provide.

Biomass power may cause ecological impacts as a result of growing and harvesting large quantities of biomass for energy. Impacts include detrimental effects on wildlife habitat and biodiversity, reduced soil fertility, increased erosion and reduced water quality. Impacts will depend on the specific scenario developed. For example, displacing more natural land cover, such as forests and wetlands, with energy crops would very likely have negative impacts.[17] Although displacing annual crops with perennial biomass crops may reduce runoff, serving to decrease erosion and improve water quality,[18] runoff during crop establishment could be comparable to or greater than that from annual row crops. Burning biomass may also deprive local ecosystems of nutrients that forest or agricultural waste may otherwise provide.

[17] Cook et al., 1991; Miles and Miles, 1992; US Congress OTA, 1993; Tolbert and Downing, 1995; Tolbert and Schiller, 1996
[18] Perlack et al., 1992; US Congress OTA, 1993

3.2.2.3.6 Summary of Findings

Biopower technologies are proven electricity generation options in the U.S., with significant operational capacity. According to the Department of Energy (DOE) - Office of Energy Efficiency and Renewable Energy, the current commercial capacity consists primarily of facilities using direct-combustion technology. Future efficiency improvements will include the commercialization of high-efficiency gasification combined-cycle systems. Biomass gasification offers:

- Lower emissions and higher efficiencies than conventional biomass plants;
- Repowering potential for existing facilities; and
- Energy diversity.

Presently, biogasification technology is not effective on a commercial scale. While biomass integrated gasification combined cycle gas turbines (BIG/CCGT) are anticipated to be competitive in industrial cogeneration applications, grid-sited systems will be competing with low cost, lower emitting, natural gas based CCGT systems.

Even with these technology advances, the combustion of biomass, like combustion of fossil fuels, results in the generation of several hundred tons of air emissions each year. Emissions of NO_x can be comparable to those generated from coal and oil combustion and are one of the top air quality concerns in the region. The collection of biomass fuels can have significant and adverse ecological impacts. Agricultural waste handling can result in pollution of local water resources due to runoff, and harvesting biomass deprives local ecosystems of nutrients that forest or agricultural waste may otherwise provide.

Although technically feasible, generation of approximately 454 MW of power through biomass combustion would require the construction of numerous facilities throughout the region and result in significant detrimental environmental impacts.

3.2.2.4 Hydroelectric

Hydroelectric power may be classified by the type of facility (impoundment or diversion) or its size (large, small and micro). Impoundment facilities, typically large hydropower systems, use a dam to store river water in a reservoir. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level. Diversion facilities, often referred to as run-of-river facilities, channel a portion of a river through a canal or penstock and usually do not require the use of a dam.

Facilities range in size from large power plants that supply many consumers with electricity to small and micro plants. Large Hydropower Plants are defined by DOE as facilities that have a capacity to generate more than 30 MW. Small hydropower plants have the capacity to generate 0.1-30 MW. Finally, micro hydropower plants have the capacity to generate up to 0.1 MW.

3.2.2.4.1 Reliability

Hydroelectric reliability depends on the type of facility constructed. Impoundment facilities are the most common form of hydroelectric facilities since the use of a dam provides the capability of storing water during rainy periods and releasing it during dry periods. This results in the consistent and reliable production of electricity. Most large hydroelectric facilities require large hydrostatic heads to generate electricity, requiring the construction of large dams. This type of facility is well suited for grid connected electrical generation because they can adjust quickly to meet the electrical demand of a distribution system.

Run-of-river generating hydroelectric facilities, or those that use low dams or weirs, cannot store water. Thus, their electric output varies with seasonal flows of water in a river. Generally, a large volume of water must pass through a “low head” hydroelectric plant to produce a useful amount of power.

In New England, rainfall characteristics typically result in utilization rates of 40-50% on an annual basis for run-of-river hydroelectric sites (reservoirs are not created and run-of river systems do not have the same capacity as impoundment systems). For a run-of-river facility, the resulting average duty cycle is approximately 4,000 hours

per year (represented by an overall range of 1,000-7,000 hours per year). Reliability is increased when an impoundment facility is constructed in place of a run-of-river facility, but the environmental impacts are much more significant and often prohibitive, as discussed below.

3.2.2.4.2 Current Technology Status

Hydroelectric power is a fully commercialized technology that has evolved over a significant period of time. The actual amount of electricity that will ever be generated by hydroelectric power will be much less than the theoretical potential due to environmental concerns (i.e., flooding large areas of land) and very high construction costs.

Based on that assessment, it is not likely that there will be a significant increase in electrical capacity due to the construction of large impoundment facilities. The number of small hydroelectric facilities may increase in the future as research on low head turbines and production of standardized turbines lower the costs of hydroelectric power at run-of-river sites. In addition, improvements are being made to turbine design and management protocols which have shown improved fish and eel passage and survival rates. New computerized control systems and improved turbines may allow more electricity to be generated from existing facilities in the future. Finally, the use of inflatable weirs to regulate water level may increase the capacity factor of small run-of-river plants.

3.2.2.4.3 Ability to Serve Regional Needs

The best sites for hydroelectric plants are swift-flowing rivers or streams, mountainous regions, and areas with heavy rainfall. Accordingly, the majority of hydroelectric capacity in New England is located in New Hampshire, Maine and Vermont. Small and micro hydropower (1-30 MW) represents about 50% of the capacity, while large hydropower units (> 30 MW) represents the remaining 50%.

While only 20% of potential hydroelectric power has been developed in the US, unfavorable terrain and potential environmental impacts make many sites unsuitable for hydroelectric power plants. In Massachusetts, approximately 300 MW of technically developable hydropower has been identified in the form of small, mini, and micro projects but only 33% is considered environmentally feasible. On a regional level, Maine has the greatest untapped hydropower potential in New England, but most is in the form of large hydropower, which is unlikely to be developed due to environmental and ecosystem impacts.

The existing electrical transmission system grid in northern New England would be insufficient to carry additional loads generated from a large hydroelectric facility. Transmission lines would need to be constructed over long distances in order to carry electrical power generated at these remote sites to portions of the electrical distribution grid with sufficient capacity to handle the additional power. Additional infrastructure upgrades would also be necessary to transmit the power to primary load pockets.

3.2.2.4.4 Affected Environment

Hydroelectric power affects river ecology, and construction of impoundment facilities affects large areas of surrounding land that may be submerged under reservoirs. In addition to the effects on river populations, large plant and animal populations have the potential to be impacted. Construction of reservoirs destroys the natural ecosystem of flooded areas, displaces animal populations, may require relocation of human populations, and destroys or makes inaccessible natural resources and historical sites.

During the construction of hydroelectric facilities, there would be significant environmental impacts as the course of the river may be temporarily changed and the landscape is altered.

3.2.2.4.5 Environmental Impacts

While hydroelectric power does not emit atmospheric pollutants, it is not without environmental impacts, many of which are just being understood. Construction of impoundment hydroelectric plants, which are most commonly associated with large hydroelectric power generation, can result in flooding of vast areas of forested or agricultural land. For example, the La Grande project in Quebec (10,300 MW capacity) has already submerged

over 10,000 square kilometers of land. If future plans are carried out, the eventual area of flooding in northern Quebec will be larger than the country of Switzerland. While these reservoirs can be used for water supplies, irrigation, and recreation, in several cases they have flooded the homelands of native peoples, whose way of life had then been destroyed. Additionally, ecosystems may be threatened by hydroelectric development.[19]

Reservoirs can have other impacts on a watershed. Damming a river can alter the quantity and quality of water in the river downstream of the dam, as well as preventing fish from migrating upstream to spawn; this could include Atlantic Salmon (an ESA listed species). These impacts can be reduced by requiring minimum flows downstream of a dam and by creating fish ladders, which allow fish to swim past the dam. Silt is trapped by the dam and deposited in the reservoir, slowly decreasing the amount of water that can be stored and used for electrical generation. The river downstream of the dam is also deprived of silt, which serves to fertilize the flood plain during periods of high water.

Bacteria present in decaying vegetation can also convert elemental mercury, present in rocks underlying a reservoir, into a form that is water-soluble. Dissolved mercury accumulates in the bodies of fish and poses a health hazard to those who consume the fish, especially those who depend on the fish as a food source. The water quality of many reservoirs also poses a health hazard due to new forms of bacteria, which grow in many of the hydro rivers.

Finally, several studies have been conducted relative to greenhouse gas (GHG) emissions from hydroelectric reservoirs. Reservoirs emit a certain quantity of GHG due to decomposing vegetation. However, the amount of these emissions has been shown to be highly variable. At a reservoir in Brazil, GHG emissions were very high, but in the case of a reservoir in Canada, emissions are significantly lower. However, the studies indicate that clearing the vegetation in the area to be flooded can reduce emissions. More research is required to accurately quantify GHG emissions, but studies indicate there is some environmental impact.

Many of the environmental impacts seen in impoundment hydroelectric facilities are not present, or are present at significantly lower levels in run-of-river hydroelectric facilities. However, run-of-river hydroelectric facilities typically generate less electrical power and do so less reliably than impoundment hydroelectric facilities.

The construction of an impoundment hydroelectric facility requires a considerable amount of building materials, including concrete, sand, and steel. Mining of raw materials and the associated refining/production of finished materials, as well as transportation of finished materials to the site, create environmental impacts and require considerable amounts of energy.

3.2.2.4.6 Summary of Findings

Although hydroelectric power is a relatively low cost renewable energy source, it has the potential to adversely impact the environment, both on and off the river. The effects on rivers and fish populations are well documented. When impoundment facilities are constructed, large tracts of land are submerged. Habitats, agricultural land and historically significant sites may be destroyed.

The hydropower resources in the New England region are not sufficient or in feasible proximity to potential users to provide approximately 454 MW of new electrical power generation. There are a limited number of feasible sites in Massachusetts representing less than 10 MW of reasonably feasible potential in Massachusetts. Although there are more sites and a greater amount of feasible potential in the mountainous regions of Maine, New Hampshire and Vermont, the remote location and environmental impacts make development of these sites impractical.

3.2.2.5 Wave

Several mechanisms for converting wave energy into electricity have been developed, including tapered-channel systems that funnel waves into a turbine, underwater turbines powered by currents, float systems that rise and fall on the water's surface, driving pistons that convert the motion into energy, and oscillating water columns in

[19] Stuart Baird, M.Eng., MA "Energy Fact Sheet: Hydro Electric Power" Energy Educators of Ontario, 1993

which waves rolling into shore raise the water level inside a partially submerged concrete chamber built into the shoreline. The rising water forces the air trapped in the chamber through a hole and into the mouth of a turbine. When the waves recede, the falling water level in the chamber sucks air through the turbine in the opposite direction.[20]

3.2.2.5.1 Reliability

Wave power is among the least developed renewable technology, is still in the early demonstration stages, and is considered high risk.

Both offshore and onshore units are at risk of major storm damage. For example, a 500 kW on-shore system in Norway was destroyed by strong waves in 1988, when its steel structure weighing many tons was pulled from the concrete foundation. The turbine of a 40 kW onshore system in Japan was removed soon after a test run because the system didn't have the ability to work in strong waves. An offshore piston-type wave power system was destroyed twice by strong waves: the first time when the float separated from the submerged block, and the second time when the float was destroyed and sunk. The engine room roof of the 3 kW on-shore system was thrown off by strong waves immediately after completion of concrete work, and the air chamber was repeatedly destroyed by strong waves. The 20 kW power station designed to replace the 3 kW system, was damaged twice.[21]

3.2.2.5.2 Current Technology Status

There are about a dozen wave energy technologies being developed within the following five broad categories:

- Surge Devices;
- Heaving Float;
- Heaving and Pitching Float;
- Pitching Device; and
- Oscillating Water Column.

Despite its infancy, there are several working wave power demonstrations. As of 1995, 685 kW of grid-connected wave generating capacity was operating worldwide. In addition, economic feasibility studies have been performed for a 30 MW wave converter to be located at Half Moon Bay (California). Additional smaller projects have been discussed for Fort Bragg, San Francisco and Avila Beach. However, there are currently no firm plans to deploy any of these projects.

The Conservation Consortium of Yarmouthport, Massachusetts developed the OSPREY, an integrated system designed for offshore applications, with a total energy producing capacity of 3 MW. The OSPREY structure includes a 2 MW wave generator, a 1 MW WTG and aquaculture cages. The structure is designed to be sited five to 15 miles offshore in 15-18 meters of water. The 800-ton structure would be towed to the site and sunk, using sediment to anchor the unit. The final weight of the unit is 8,000 tons. To offset the cost of electricity transmissions, five to ten of these units would be needed. Therefore to produce 450 megawatts of power, approximately 160 units, altering 30 miles of coastal wave influence would need to be constructed.

The bulk of wave energy potential is offshore however offshore units have not been demonstrated for sufficient periods of time. Most of the industry's experience is with onshore facilities or demonstration units that have been located close to shore. Furthermore, units capable of producing larger amounts of electricity are not likely to be commercialized for several decades.

3.2.2.5.3 Ability to Serve Regional Needs

Wave energy conversion devices are in an early stage of development and are not yet commercially viable. Such devices are not expected to be available on a large scale within the near future due to limited research and lack of funding. As of 1995, only 685 kW of grid-connected wave generating capacity was operating worldwide

[11] Tracy Staedter, "Wave Power" Technology Review, January/February 2002

[21] You Yage and Yu Zhi, Guangzhou Institute of Energy Conversion, Ocean Energy Division

(based on the output of eight demonstration plants ranging in size from 20 kW to 350 kW). Wave power systems currently under consideration are less than 30 MW, which would require an impractical number of installations to achieve an output of approximately 454 MW.

Although a vast amount of wave energy is spread out along thousands of miles of coasts in favorable locations, the energy density can average 65 MW per mile of coastline, an amount that can theoretically lead to economical wave generated electricity[22]. Favorable wave energy sites are generally western coastlines facing the open ocean such as those on the west coast of North America and Northern Europe. New England is not located in one of the areas that are considered favorable for wave energy. Wave energy off the New England coast is significantly lower, making wave power economically unfeasible. It has been estimated that wave power densities in coastal New England waters are sufficient to produce only between five and 15 MW per mile of coastline (Hagerman, G. 2001).

3.2.2.5.4 Affected Environment

Wave facilities may be constructed on land, in shallow water, or in deeper waters, further offshore. The affected environment varies depending on the type of facility constructed. Wave power developments may, however, encompass large geographic areas, whichever type is constructed. In the New England region, where wave action is considerably less than that considered viable for commercial generation of electrical power, facilities would most likely be located offshore to maximize efficiency.

The potential visual impacts of offshore facilities may be a public concern. To an observer on the shore, individual devices within the plant would tend to be obscured by wave action, but when viewed from a high elevation they may create a visual impact. The construction of a land-based facility would require a large land area, resulting in visual impacts and limiting other land uses.

The construction of offshore wave energy conversion facilities could have an impact on the seabed. Significant structures need to be constructed to anchor wave energy conversion facilities to the seabed, potentially impacting aquatic species. Land based systems require significant modification of the shoreline, potentially impacting nesting areas for sea birds or other marine animals.

3.2.2.5.5 Environmental Impacts

Wave power plants can be based on land, in relatively shallow water (5-15 m depth), or in deeper offshore waters. Land and shallow water systems have achieved the greatest development progress to date. Land-based systems, however, involve significant shoreline modification and attendant environmental impacts, which may severely limit their deployment. As discussed above a utility scale installation would be expected to result in physical alteration of substantial areas of coastline. Likewise, shallow water systems are likely to be acceptable only at existing ports, or where construction of a new small-craft harbor has already been approved.

Despite their less-advanced development status, offshore systems have much wider deployment potential, since they don't involve shoreline modification or breakwater construction. Floating devices have been developed that use air or seawater working fluids, eliminating the risk of chemical pollution. High-pressure seawater is particularly attractive as a working fluid, since it can produce both electricity and fresh water.

The environmental impact at the coast near offshore wave power plants includes the reduction of wave energy levels. A five to ten percent withdrawal of wave energy offshore would correspond roughly to a three to five percent reduction in wave heights at the coast. The effects on waves as a result of wave conversion facilities may lead to changes in the shore and shallow sub-tidal areas, and subsequently the plants and animals living in the area.

[22] Stuart Baird, M.Eng., MBA "Energy Fact Sheet: Wave Power" Energy Educators of Ontario, 1993

3.2.2.5.6 Summary of Findings

Wave energy conversion devices are in an early stage of development and are not yet commercially viable. Currently, only small systems (5 MW and smaller) are under development. The high initial cost of construction provides a significant market barrier. Siting issues are also seen as a barrier. Most of the progress in wave power is occurring in countries with abundant coastline, such as Britain, Japan, Australia and New Zealand. In the U.S., wave energy demonstrations are being developed in California, where its viability is being assessed. Unlike the eastern coast of the U.S., the western coast offers the potential, due to larger waves, for this technology.

Even in areas where wave energy is considered technically viable based on wave conditions, development potential will be limited by environmental impacts on both the shoreline and seabed and marine populations inhabiting those areas. The lack of feasible sites for land or shallow water systems in this region and limited number of offshore sites and risks associated with and uncertainties in cost and performance for these systems also limit development.

3.2.2.6 Wind

Wind power is a technically proven energy technology that involves the harnessing of power provided by moving air. Wind turbine generators (WTGs) use aerodynamic forces to produce mechanical power that can then be converted to electricity.

3.2.2.6.1 Reliability

Wind power generation systems produce power intermittently because they are only operational when the wind is blowing at sufficient velocity and duration. The current generation of utility-scale WTGs has developed over the past 20 years. Advances in technology have resulted in improved turbine reliability, as well as lower installed costs, improved turbine performance, and reduced maintenance costs. These improvements have reduced concerns about intermittent operation due to low or variable wind speeds.

Design lifetimes of WTGs are approximately 20 years. The reliability of WTGs has increased steadily during the past decade as better designs have evolved, and modern turbines are now operating with a typical machine availability of 95-98%. Periodic major overhauls and replacement are required, including:

- Gearbox (years 10 and 20);
- Generator bearing (years 10 and 20);
- Rebuild pitch, hydraulic and yaw systems (year 20); and
- Blade replacement (year 20).

3.2.2.6.2 Current Technology Status

Available WTGs are being developed over a range of power outputs from kilowatt to multi-megawatt units. Large-scale generation of electricity requires a number of large machines to be grouped together in “Wind Parks” for economy and ease of operation. The machines are usually spaced five to ten rotor diameters apart to ensure they do not interfere with each other’s performance. As a result, a Wind Park of about 20 machines may extend over a large area, although the units occupy less than five percent of this area. Therefore, the bulk of the land area can remain in use (i.e., agriculture, grazing, recreational, etc.).

Due to the decreasing number of wind development sites with adequate wind regimes on the landmass, Europe has recently focused on developing large turbines for offshore Wind Parks. Because expensive foundations are required for offshore applications, the cost of such wind plants can be 30 to 60% higher than land based systems. However, due to stronger winds offshore, the higher electrical production will offset the higher installation costs over the life of the facility.

In general, most utility-scale WTGs on the market today are three-bladed systems that use asynchronous generators and sophisticated controls to monitor and regulate turbine operation in different conditions and the

quality of power delivered to the grid[23]. Recent developments that have contributed to current utility-scale turbine technology include:

- Improvements in the aerodynamics of WTG blades, resulting in higher capacity factors and an increase in the electrical power generated per square meter of swept area;
- Development of variable speed generators to improve conversion of wind power to electricity over a range of wind speeds;
- Development of gearless turbines that reduce the operating cost of the turbine;
- Development of lighter tower structures due to advances in aerodynamics and generator design (through reduction of the stresses and strains in the WTG). Lighter tower structures, which are also less expensive because of material cost savings, may be used;
- Smart controls and power electronics have enabled remote operation and monitoring of WTGs. Some systems enable remote corrective action in response to operational problems;
- Improvements to modeling and new computer simulations allow a wide array of system architectures to be designed for various applications, while simulating results using local wind regimes for particular sites; and
- WTG designs can be modified to optimize operation at a specific site. Factors that can be addressed include annual distribution of wind speed, annual variation in site temperature, frequency of lightning, and salty air in coastal regions.

3.2.2.6.3 Ability to Serve Regional Needs

In the U.S. alone, close to 1,700 new megawatts of wind generated power came on line in 2001. Wind Parks across the country are currently generating about 10 billion kilowatt-hours (kWh) annually, enough to power one million average American homes.

The economic viability of wind-generated electricity in a particular location is tied to the amount of wind available throughout the year (see Appendix 3-A). A standardized system has been established for classifying the wind resource based on wind power density, a measure in watts per square meter of how much energy is available at the particular site for conversion by a WTG. Seven different wind classes have been established, with higher classes corresponding to higher wind power densities. In general, wind classes three and above (wind speeds of 11 miles per hour or more) are necessary for producing electricity from wind. For large, utility-scale applications, wind classes four or greater are generally considered to be the minimum suitable wind regime for commercial viability for private development.

A number of excellent wind sites exist in the mountainous areas of northern New England and New York. Wind classes five and six can be found in the mountains of northern Maine, New Hampshire, Vermont, and New York. However, at this time the existing transmission infrastructure is not sufficient to carry electrical power from northern Maine to the other parts of New England. Location of any electrical generation facility in this area would require the construction of new transmission lines and/or upgrades to existing lines (see Appendix 3-D). Some wind classes three and four can be found elsewhere in the Northeast. To date, only several megawatts of wind power have been developed in the Northeast, although several multi-megawatt projects (10-30 MW) are in various stages of development including projects in, Searsburg, VT, Hoosac, MA, and Hull, MA as well as a number of small community initiated wind projects being considered as a result of the Massachusett's Technology Collaborative's (MTC) Community Wind Collaborative.

Wind power is relatively flexible and may be adapted to the situation at hand. Since individual units may be relatively small (500 kW or less) and can be installed in a very short time period (usually less than a few months), land-based Wind Parks can be sized to fit any amount of demand, and in general are limited only by the amount of land available, the wind resource, and available transmission infrastructure. As long as enough additional land is available and transmission infrastructure can accommodate the additional power, more turbines can always be added later to meet increases in electrical need.

[23] Louise Guey-Lee, Forces Behind Wind Power, Report prepared by the Department of Energy, February 2001

3.2.2.6.4 Affected Environment

Historically, all U.S. wind power generation has been land based. Land use and associated impacts are often identified as environmental concerns when siting wind power facilities. Large-scale applications such as utility scale Wind Parks require significant acreage, however the WTGs themselves occupy a small percentage of the land. Since the turbines are high in the air, the bulk of the land remains available for agriculture, grazing, or other existing uses. Construction of WTGs, access roads and transmission line corridors in mountainous or remote locations requires additional lands.

Similar to land use concerns with land based wind parks, as offshore wind projects have begun to develop in Europe, potential impacts to watersheet usage has been identified as an environmental concern. Since the WTGs are high in the air, the bulk of the watersheet remains available for existing marine uses, although the presence of the turbines requires that all mariners (including recreational boaters) be more attentive to the types of navigational equipment needed onboard to safely operate in and around the Wind Park, their vessel's position, and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the Wind Park.

3.2.2.6.5 Environmental Impacts

Wind power meets renewable portfolio standards and generates electricity with:

- No air emissions (in contrast to fossil fuel fired utilities and biomass plants);
- No fuel to mine, transport, or store (and none of the environmental impacts that are associated with these activities);
- No use of cooling water; and
- No water pollution.

Although wind is one of the most benign power sources, when not properly sited or designed wind power facilities may have environmental impacts. While wildlife and avian impacts may be site-specific concerns, new tower, blade and turbine technologies and careful siting can lessen environmental impacts. Because of the large sizes of "state-of-the art" wind turbines, the visual impact of the structures on surrounding viewsheds is often cited as an environmental impact requiring careful assessment.

In offshore applications additional environmental issues that may require review include: the potential for alteration to benthic habitat, impacts to the marine ecological community, physical oceanographic and geologic impacts, commercial fishing and recreational watersheet uses (including navigation).

As is the case with all energy options (renewable and non-renewable), some pollution is produced when WTGs are manufactured and installed. As noted above, recent advances in wind power have resulted in lighter weight structures that require less material and minimize energy consumption.

Decommissioning WTGs at the end of their design life is essentially the reverse of the construction process and presents few difficulties as it generally involves little in the way of hazardous waste, and entails the removal of scrap material and cabling, for recycling. The WTG foundations can generally be removed with relative ease without disturbing large areas. As a result, there is very little residual waste or land contamination from WTGs. Decommissioning impacts will be similar to or less than impacts from construction. For more detailed information on decommissioning of wind power facilities, please refer to Section 4.0.

3.2.2.6.6 Summary of Findings

Wind power is expected to be the leading renewable energy technology in terms of new additions between 2003-2013, is currently nearly economically competitive with conventional options (gas), and is expected to have the largest cost reduction of the renewable energy options at approximately 5% per year.[24] More than 20,000 commercial-sized WTGs have been erected worldwide over the last decade with a capacity of more than 2,000 MW. About 80% of these machines are located in California and are responsible for supplying one percent of the

[24] Navigant Consulting Inc. October 2003. "The Changing Face of Renewable Energy" Multi-Client Study. Public Release Document, www.navigantconsulting.com

state's electricity. Furthermore, WTG performance and reliability have improved. The result is that costs have fallen considerably and land-based wind power energy from locations with high wind density is nearly competitive with traditional fossil fuel generated electrical power. When properly sited, wind power is capable of producing emission-free electricity with minimal environmental impacts.

3.2.3 Summary of Findings and Comparison of Energy Generating Technologies

The following are are general comparisons to discuss the relative impacts of different energy generating technologies and specific impacts would vary according to site selection. Conventional power production technologies such as CCCTs are proven, reliable and efficient. However, fuel combustion produces unwanted air emissions which contribute to regional and global air quality issues. Biomass combustion technologies contribute to the same air quality issues as conventional plants and cannot produce large quantities of power in one location as a result of fuel availability and transportation requirements.

Renewable technologies that do not involve fuel combustion include solar, hydroelectric, wind, wave and tidal power production. Solar technology is not suitable for a utility-scale generation project in New England because of the lower direct insolation values and the inefficiency and high cost of solar energy collection cells. Wave and tidal technology require further development before they can be feasibly applied and even if the current technology was proven, New England would be a poor location for either of these facility types. Hydroelectric power is a viable technology but most available locations for production of hydroelectric power exist in the northern region of New England and the current transmission bottlenecks prevent the transfer of power in these northern regions to southern New England, where the demand for more power exists. It is also not possible to construct a single large hydroelectric facility which could provide approximately 454 MW of power to the region.

Wind power is a proven technology, widely used for commercial scale facilities. It utilizes a 100% renewable resource and significantly reduces the impact of power production on the environment. The wind resources in New England are generally favorable for commercial wind power development, and although finding adequate amounts of land area for a utility-scale development is challenging, recent technological advances in the wind power industry have made offshore development an economically viable option. Therefore, wind power appears to present the best utility-scale option for meeting New England's growing regional power demand. As discussed above due to limitations in technical feasibility and environmental concerns solar, biomass, hydro, and tidal generation are not considered reasonable alternatives at this scale of power generation. Please refer to Table 3-3.

3.3 No Action Alternative / Permit Denial

The objective of the No-Action Alternative / Permit Denial analysis is to establish a future baseline in relation to which the Project and its alternatives can be described and analyzed and its potential environmental impacts and mitigation measures can be assessed.

Under the No-Action Alternative / Permit Denial, the Cape Wind Project would not be developed. If the USACE were to deny the project (or the MEPA Secretary were to determine that the Final EIR was inadequate), this would be the No-Action Alternative. Future conditions/impacts would be as follows:

Electricity demand will continue to increase, and is projected to grow by 1.9% annually through 2025 (see Appendix 2.0-A), or approximately 46% over the 20 year projected life of the proposed Project. In the absence of extreme energy conservation measures, this ever-increasing demand for electricity will need to be met through increased supply, regardless of the development or denial of the Project. Meeting this increased demand with new or refurbished generation supply is likely to be further impacted by the retirement of the region's older fossil-fueled power plants (see Appendix 5.16-B).

Under the No-Action Alternative it is likely that fossil-fueled power plants will be constructed or refurbished to address the bulk of the electricity demand. As discussed above, natural gas fired power plants are likely to be chosen due to their relatively lower levels of air emissions as compared to oil or coal fired plants. The development of additional natural gas fired power plants will continue to increase the demand for natural gas which, as discussed in Appendix 2.0-A, when coupled with the facts that the New England region has no

indigenous supply of natural gas and the present pipeline capacity is marginally adequate and quickly becoming overburdened, will exacerbate an already volatile natural gas market. The expansion of use of Liquefied Natural Gas (LNG) can be expected if environmental and safety concerns can be addressed, however at higher costs than other sources of natural gas (see Appendix 2.0-A).

Under the No-Action Alternative the New England regional fuel supply portfolio is likely to remain heavily dependent on natural gas and foreign oil availability, and not likely to experience any marked change in diversity of fuel supply or self-sufficiency, which would be experienced with the addition of a utility scale renewable energy facility powered by an abundant local resource. The cost of electricity will continue to be highly dependent on the cost of the fuel used to produce it. As the supply and availability of natural gas continues to tighten, it is expected that fuel costs will continue to rise and ultimately the cost of electricity to the end-user will increase.

In the absence of the Cape Wind Project, alternative renewable energy technologies will continue to evolve and develop. As discussed above, much of the renewable energy technology is presently in the developmental stage, or is resource-limited in the New England region for utility scale applications. It is likely that small scale solar / photovoltaic, biomass and hydroelectric installations will be developed in New England over the next 20 years; however it is unlikely that any of these will be developed at a utility-scale capable of providing a regionally-significant new source of electrical energy over the long-term. In the absence of the Cape Wind proposal it is possible that another developer could attempt to advance a similar scale renewable energy project, although none have been advanced beyond conceptual discussions. Small scale, community based, wind energy projects will likely be developed throughout New England to serve specific community needs. However, under the No-Action Alternative, or if the permit is denied, it is likely that commercial development of offshore wind power in the United States, at a comparable size and scale of that proposed by the Applicant, will not advance significantly.

Under the No-Action Alternative it is unlikely that adequate amounts of new, renewable energy will be developed towards meeting the Renewable Portfolio Standards (RPS) for the states of Massachusetts, Connecticut and Maine. In the absence of significant amounts of new renewable energy generation, which is mandated by state law in the above states to increase over the next ten years, utilities will be required to pay a penalty / surcharge per MW hour (MWH). If adequate amounts of new renewable energy are not developed, and the RPS standards are not met, the increased costs of non-compliance are likely to be passed on to consumers through increased electric rates.

Under the No-Action Alternative the Project's generating capacity of 454 MW would likely be produced using conventional fossil-fueled technology – most likely natural gas. Rather than offset nearly 1,000,000 tons per year of carbon dioxide emissions with the installation of the Cape Wind Project (see Appendix 5.16-B), the No-Action Alternative would result in additional air emissions being released (see Table 3-1). Although air quality research and policy is expected to continue to evolve, including EPA national standards aimed towards improving the nation's air quality, under the No-Action Alternative any utility scale generation development is likely to involve internal combustion fired by fossil fuel, resulting in increased air emissions. Although attempts will continue to reduce the amount of emissions such as NOx, SOx, CO2 and other particulate matter known to contribute to health related impacts, the generation of electrical power will continue to produce air emissions in the absence of any emission-free utility scale power development.

Under the No-Action Alternative the following environmental impacts would be expected:

- The structures associated with the Project would not be built and the visual landscape of Nantucket Sound would remain unchanged;
- The visual landscape at one or more locations elsewhere in New England would change with the likely addition of one or more stacks and associated facilities from a natural gas fired power plant;
- WTG monopile foundation structures and ESP piles would not be installed in Nantucket Sound, and approximately 3.21 acres of sea bed would experience no direct impacts to the sea floor or benthic community;
- Nantucket Sound would not experience the temporary impacts to the seabed and benthic community expected to be associated with the Project's cable installation and construction vessel anchoring;
- The seabed and benthic community throughout Nantucket Sound will continue to experience regular, temporary disturbance associated with natural processes and commercial fishing trawlers;

- The watersheet area of Nantucket Sound would remain unchanged;
- Potential impacts to birds, fish, and other resources as a result of the Project (as described in Section 5) would not occur;
- Impacts to birds, fish, and other resources would occur to a greater or lesser extent (depending upon resource and location) as the result of the development and operation of a fossil fuel power plant elsewhere in New England; and
- Secondary environmental impacts related to fossil fuel production, transportation and storage will continue or increase (such as mining of coal, LNG transportation safety, oil spills from marine barges, natural gas pipeline construction etc.).

3.4 Wind Park Alternative Site Analysis

In order to identify, on a macro level, potential locations for siting of a utility-scale wind park capable of meeting the stated Project purpose, the initial analysis involved review of existing available wind resource mapping for New England (see Figure 3-1 and 3-2). General areas of high potential (such as mountainous regions of western Massachusetts, New Hampshire, Vermont and Maine, as well as offshore areas) were identified. Potential sites within these general areas were identified by the Applicant, and expanded through interagency meetings, the public scoping process of this EIS, the EIR comment process (including the MTC Stakeholder's process) and additional suggestions received by the USACE.

Preliminary screening criteria were initiated by the scoping comments, further developed in consultation with cooperating agencies, and then applied to a relatively long list of both onshore and offshore sites, in order to develop a list of reasonable alternative sites. These screening criteria were used to eliminate sites that were clearly not technically and economically feasible.

3.4.1 Preliminary Site Screening Criteria

The alternative site locations discussed below were screened to determine which sites should be eliminated from further consideration due to factors that would make them infeasible for development as utility- scale wind generation facility sites. The screening criteria to be applied to assess the feasibility of potential alternative sites were as follows:

- ***Wind power classification of 4 or greater.*** (Wind speeds >15.7 mph at 50 meters) as determined by the U.S. Department of Energy's National Renewable Energy Lab mapping of national wind resources. A wind power classification of 4 or greater is necessary for a commercial project to achieve a high enough capacity factor (average output) in order to produce an economically viable project. Please refer to Figure 3-1 for New England Wind Resource Mapping.[25] For a more complete technical discussion on wind power classifications as a siting criteria, please refer to Appendix 3-A.
- ***Sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system.*** New power generation sources must be located in proximity to existing transmission infrastructure that has available capacity to transmit the power to where it is needed. Most generation of this scale would likely require minor upgrades to the existing transmission system in order to access the grid.
- ***Commercially available land or permissible use of offshore watersheet area sufficient to accommodate a 200-1,500 MW wind energy project.*** The Applicant does not have the power of eminent domain or other easement taking powers, and must therefore be able to obtain commercial land rights to sufficient amounts of area. Government lands or lands with conservation restrictions may not be available for commercial development. Wind power facilities require a large amount of area due to the fundamental nature of wind movement and the conversion of wind energy to electricity. As wind passes through a turbine, wind energy is converted to electricity. After passing through the turbine, wind energy is reduced. A long trail of turbulent air is referred to as the "downwind wake." WTGs that are arranged in parks or grids need to be spaced at a sufficient distance from each other to minimize the effects of downwind wake losses at the downstream WTGs. The spacing between turbines allows the wind to smooth out and regain much of its laminer flow prior to reaching the next downstream WTG.

[25] Interactive Wind Mapping of New England. http://truewind.teamcamelot.com/ne/

Generally accepted planning guidelines for the wind power industry state that for land based sites with a wind power class of four or greater, 20 acres of open space is necessary to generate one MW, and for ridgeline based installations one mile of ridgeline can produce approximately ten MW of power. Sites with lower wind power classes require more land area per MW. Due to a number of factors, including the relative smoothness of an open water surface and the lack of topographical obstructions, the wind resources offshore are higher quality and can produce the same amount of power in less area than an equivalent land based site. The equivalent land to water area ratio for wind energy generation is approximately 1.2:1 for equivalent MW capacity.

- ***Engineering and design limitations:***
  - Commercially acceptable physical, geological and environmental site conditions;
  - Offshore water depths less than 50 feet mean low water with extreme storm wave (ESW) heights of less than 20 feet are generally accepted industry guidelines that define the limits of currently available and technically proven offshore WTG foundation designs. For a more complete technical discussion on extreme wave and water depth design implications, please refer to Appendix 3-B.
  - Practical construction and maintenance access for state-of-the-art (2.7 MW or greater) WTGs. Due to the large size of the WTG components (in particular the one-piece rotor blades which can be in excess of 150 feet in length) there are practical limitations and constraints to over-the-road or rail transportation during construction;
  - Practical construction and maintenance of overland and submarine electric transmission line interconnections; and
  - Use of Alternating Current (AC) transmission systems. High voltage alternating current (HVAC) transmission is commercially available and is feasible for use in offshore Wind Park installations as long as the distance is less than approximately 20 miles. As the distance increases, the losses increase significantly. The usual alternative to HVAC is high voltage direct current (HVDC); however, HVDC has yet to be used in offshore Wind Parks due to the cost and size of the conversion stations and the lack of commercial installations. For a more complete technical discussion on HVAC and HVDC technologies, please refer to Appendix 3-C.
- ***Legal/regulatory constraints***
  - State or federal land or water use exclusions; and
  - Avoidance of state or federally protected environmental resource areas.

3.4.2 Screening Analysis Process

Preliminary review has been conducted for alternative sites that were suggested through public scoping comments. Responding to questions and concerns which were raised during this early part of the alternatives analysis regarding technological constraints of this rapidly developing technology, a peer review of the siting criteria was conducted (see Appendix 3.0-E). Based upon these comments, the screening criteria have not been applied in a strictly pass/fail manner. The technology is evolving rapidly; there was no clear concensus on what is considered the current state of the art or what could be expected to be feasible in the reasonably foreseeable future. Reviewing the relative merits and/or detriments of these sites as a whole rather than on individual criterion results in a more subjective but more flexible screening of sites in order to determine which of these sites warrant more detailed review.

3.4.2.1 Upland

A number of upland sites were identified as potential alternative Wind Park sites warranting further evaluation through the public scoping process and meetings / consultations with the cooperating agencies. Eight of the upland sites were determined to be reasonable and were evaluated against the preliminary screening criteria. Table 3-4 summarizes this evaluation. A discussion of each site is provided below.

3.4.2.1.1 Massachusetts Military Reservation/Otis Air Force Base

The Massachusetts Military Reservation (MMR)/Otis Air Force Base in Sandwich, Massachusetts, Figure 3-3, was evaluated using the preliminary screening criteria with the following results:

- There are inadequate wind resources (mapped as Class 3) for a commercial scale wind power facility due to topography and existing structures. These same features would require any wind facility at the site to have taller towers that would be more visible and extend further into military airspace;

- There is sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system;
- The land area (approximately 22,000 acres overall) is sufficient to accommodate a 200-1,500 MW wind energy project; however, it is doubtful that the site would be commercially available due to the increased level of military activity since September 2001 and the renewal / extension of the National Guard lease. There has been increased military air traffic to and from the site since September 2001;
- The site has significant environmental resource issues including:
- Designation as an EPA Superfund National Priority Listed Site with contaminated water supply; and
- Proximity to Shawme-Crowell State Forest and Crane State Wildlife Management Area.
- Construction activities associated with the installation of the wind turbines could pose a significant disruption to protected wildlife habitat and limit the productivity of a public water supply implementation program within the Upper Cape Water Supply Reserve as stated in M.G.L. Chapter 47 of the Acts of 2002.
- Unexploded ordinance formerly used for military training may exist in open areas that would be considered for turbine siting.

3.4.2.1.2 Searsburg, Vermont

The possibility of expanding an existing six MW wind power facility in Searsburg, Vermont, Figure 3-4, was evaluated. This facility is composed of 11 550 kW WTGs sited along 0.6 miles of ridgeline, encompassing 35 acres. The site was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 4);
- There is sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system;
- The amount of commercially available land, in this case along a variety of ridgelines, is not adequate to accommodate a 200-1,500 MW wind energy project. This site could only accommodate an additional 30-40 MW of WTG installation along adjacent ridgelines and would require the acquisition of private lands which might not be available to the Applicant; and
- Expansion of this site would require use of property within the Green Mountain National Forest and would likely impact nearby Mount Snow ski area.

3.4.2.1.3 Princeton, Massachusetts

The possibility of expanding an existing three MW wind power facility composed of eight 40 kW WTGs in Princeton, Massachusetts, Figure 3-5, was evaluated. The site was evaluated using the preliminary screening criteria with the following results:

- The wind resources (mapped as Class 2-3) are not adequate for a commercial scale wind power facility;
- There is sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system;
- The amount of commercially available land, in this case along nearby ridgelines, is not adequate to accommodate a 200-1,500 MW wind energy project, and the site is located on private lands operated by Princeton Municipal Light Department that may not be available to the Applicant; and
- This site is located adjacent to the Wachusett Mountain State Reservation and Minns Wildlife Sanctuary.

3.4.2.1.4 Skinner/Kibby Townships, Maine

The Skinner/Kibby Townships area of northwestern Maine, Figure 3-6, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 5);
- There is not sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system. A north-south electrical transmission system constraint in northeast Massachusetts effectively “blocks” power generated in Maine and New Hampshire from being distributed to points south (see Appendix 3-D for a more detailed discussion of the transmission “bottleneck” issue);

- Topographical variability and the need to site turbines on the tops of intermittent ridgelines will require a significant amount of transmission line easement clearing resulting in significant habitat fragmentation;
- The amount of commercially available land, in this case along a variety of ridgelines, is not adequate to accommodate a 200-1,500 MW wind energy project; and
- This alternative would require upwards of 50 miles of new or upgraded roads and significant habitat disturbance and alteration.

3.4.2.1.5 Redington Pond/Black Nubble Mountain, ME

The Redington Pond/Black Nubble Mountain area of northwestern Maine, Figure 3-7, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 5);
- There is not sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system. A north-south electrical transmission system constraint in northeast Massachusetts effectively "blocks" power generated in Maine and New Hampshire from being distributed to points south (see Appendix 3-D for a more detailed discussion of the transmission "bottleneck" issue);
- Topographical variability and the need to site turbines on the tops of intermittent ridgelines will require a significant amount of transmission line easement clearing, in addition to WTG sites and access roads resulting in significant habitat loss and fragmentation;
- The amount of commercially available land, in this case along a variety of ridgelines, is not adequate to accommodate a 200-1,500 MW wind energy project;
- This alternative property site is currently being developed for a proposed wind project consisting of 29 1.75 MW WTGs (52 MW) over 220 acres along approximately five miles of ridgeline; and
- This alternative is located adjacent to the U.S. Navy Survival School and near an established ski area.

3.4.2.1.6 Connecticut Department of Transportation Site

The Connecticut Department of Transportation (DOT) Site located at the convergence of the Naugatuck and Housatonic Rivers in southwestern Connecticut, Figure 3-8, was evaluated using the preliminary screening criteria with the following results:

- The wind resources (mapped as Class 2) are not adequate for a commercial scale wind power facility;
- There is not sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission. The ISO-NE system is restricted in Connecticut with congestion in southwestern Connecticut due to a transmission system that is not adequate to reliably meet the area's power demand;
- There are inadequate amounts of commercially available open space land to accommodate a 200-1,500 MW wind energy project; and
- This alternative had only 18 acres of land available and is located in a developed, urban area.

3.4.2.1.7 Greenfield, Massachusetts

The City of Greenfield, Massachusetts landfill site, Figure 3-9, was evaluated using the preliminary screening criteria with the following results:

- The wind resources (mapped as Class 3) are not adequate for a commercial scale wind power facility. This alternative is located at the base of the Berkshire Mountains and is topographically blocked from the prevailing wind resources;

- There is sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system;
- The amount of commercially available open space land is not adequate to accommodate a 200-1,500 MW wind energy project. This alternative has only approximately 20 acres of available land; and
- The site is adjacent to the Deerfield River (wetlands/floodplain issues).

3.4.2.1.8 Hoosac Mountain Range, Florida MA.

The Hoosac Mountain Range area of western Massachusetts, Figure 3-10, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 4+);
- There is sufficient surplus electric transmission capacity to transport 200-1500 MW to load centers throughout the ISO-NE transmission system;
- High wind resource areas are limited to higher elevations and ridgelines;
- The amount of commercially available land, in this case along the ridgeline of the Hoosac Mountain Range, is not adequate to accommodate a 200-1,500 MW wind energy project;
- This alternative property site is currently being developed for a proposed wind project consisting of nineteen 1.5 MW WTGs capable of producing a maximum output of 28.5 MW. The developer is proposing to lease approximately 1000 acres in the towns of Florida and Monroe to accommodate the project;
- Topographical variability and the need to site turbines on the tops of intermittent ridgelines will require a significant amount of transmission line easement clearing, in addition to WTG sites and access roads resulting in significant habitat loss and fragmentation;
- This alternative is bordered by Florida State Forest, and Monroe State Forest lands.

3.4.2.1.9 Summary of Findings and Comparisons of Upland Alternatives

Preliminary review has been conducted for the upland alternative sites that were suggested through public scoping comments to determine which of these sites warrant more detailed review. Based upon comments received during the preliminary review of alternative sites and screening criteria, the screening criteria have not been applied in a strictly pass/fail manner. Reviewing the relative merits and/or detriments of these sites as a whole rather than on individual criterion results in a more subjective but more flexible screening of sites.

As this project is intended for large-scale power production, it became evident that several of the sites were too small to be considered further: Princeton, Searsburg, Greenfield, Hoosac and the CT Brownfield site. None of these sites are located in close enough proximity to each other to allow grouping of small sites to reach a scale reasonably close to that being proposed by the Applicant. Additionally, the wind power classification for the Princeton, CT Brownfield and Greenfield sites are less than 4 making them less likely to be economically viable for large-scale commercial wind power. Hoosac is currently under development for a smaller scale project by enXco Inc.

Several of the sites are constrained by the lack of surplus transmission capacity in the existing infrastructure. Based upon current conditions, it is unlikely that the sites in Maine-Skinner/Kibby and Redington/Black Nubble would be feasible due to the need to improve the transmission infrastructure in order to convey the power to the demand centers (see Appendix 3-D). Other power proposals in Maine have been hampered by this transmission constraint. The north-south constraint near the Maine/ New Hampshire border will likely take at least 5-6 years to be resolved, once ISO-NE determines a course of action. These sites are not considered to be feasible in the reasonably foreseeable future.

MMR, the only large land site, is not currently available to this private developer as it is an active military facility. However, a site does not need to be available to the permit applicant to be considered a reasonable alternative with respect to NEPA. Many of the upland sites were lacking in wind resource however the only site for which this was the only physical constraint was the MMR. The development costs of the MMR site may be somewhat

less than would normally be anticipated in site selection and planning due to the existing access and infrastructure. This may offset the lower anticipated wind speed allowing the site to be economically viable. Site-specific analysis of this site is warranted to further investigate the availability of the site, the potential environmental impacts, the costs and the engineering considerations.

3.4.2.2 Offshore

A number of offshore areas were identified as potential alternative Wind Park sites warranting further evaluation through the public scoping process and meetings/consultations with the cooperating agencies. Nine of the offshore areas were determined to be reasonable and were evaluated against the preliminary screening criteria identified in Section 3.4.1, above. Table 3-5 summarizes this evaluation. A discussion of each site is provided below.

3.4.2.2.1 Block Island, Rhode Island

The area around Block Island, Figure 3-11, was evaluated using the preliminary screening criteria with the following results:

- The wind resources (mapped as Class 3-4) are marginal for a commercial scale wind power facility;
- There is not sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are greater than 50 feet mean low water (reaching depths of over 100 feet relatively quickly);
- Open ocean exposure to the south results in ESW heights of approximately 50 feet;
- The interconnection distance would allow the use of AC transmission systems;
- The submarine cable system would involve at least two perpendicular crossings of existing submarine cable corridors;
- Project development in this area may seriously impact marine navigation. This area is located at the apex of the western entrance to Buzzards Bay, the western entrance to the Vineyard Sound channel, and the northern end of the main Buzzards Bay Shipping Lane;
- The seabed geology within this area indicates an abundance of boulders and rock outcroppings and would likely preclude embedment of the submarine cables, leaving them prone to mechanical damage; and
- The area is known for a high concentration of humpback whale sightings (NMFS, unpublished data). In addition, Block Island is reported by Waring (2001) to be a principal harbor seal and/or grey seal winter haulout location.

3.4.2.2.2 South of Martha's Vineyard, Massachusetts

The area south of Martha's Vineyard, Figure 3-12, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 5);
- There is sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are greater than 50 feet mean low water (reaching depths of over 100 feet relatively quickly);
- Open ocean exposure to the south results in ESW heights of approximately 28 feet;
- The interconnection distance would likely require the use of DC transmission systems;
- The potential presence of unexploded military ordinance near Nomans Land provides an unacceptable risk to construction, operation, and maintenance of a Wind Park;
- The entrance to Muskeget Channel is located to the northwest which provides marine access into and out of Nantucket Sound between Martha's Vineyard and Nantucket, and project development in this area may impact marine navigation;
- Highly variable and dynamic subsurface geological and hydrographic conditions exist in the area; and

- The area just south of Martha's Vineyard on Nomans Land is reported by Waring (2001) as a principal harbor seal and/or grey seal winter haulout location.

3.4.2.2.3 Cape Ann, Massachusetts

The area around Cape Ann, Figure 3-13, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 4);
- There is not sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are greater than 50 feet mean low water;
- Open ocean exposure to the east results in ESW heights of approximately 62 feet;
- The interconnection distance would allow the use of AC transmission systems; and
- The area is known for extremely high concentrations of Northern Atlantic right whale (NEFSC 2001) and humpback whale (NMFS, unpublished data) sightings. In addition, Waring (2001) reports that there is a principal harbor seal and/or grey seal winter haulout location just east of Cape Ann on "The Salvages".

3.4.2.2.4 Vinalhaven Island, Maine

The area around Vinalhaven Island, Figure 3-14, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 4);
- There is not sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are greater than 50 feet mean low water;
- Open ocean exposure to the east results in ESW heights of approximately 64 feet;
- The interconnection distance would allow the use of AC transmission systems;
- The area is located amongst several established shipping channels, and project development in this area may impact marine navigation;
- The seabed geology within this area indicates an abundance of shallow bedrock and rock outcroppings that would interfere with WTG foundation installation and embedment of submarine cables; and
- There have been several humpback (NMFS, unpublished data) and fin whale (NEFSC 2001) sightings in the area offshore of Maine. Waring (2001) also reports that there is a principal harbor seal and/or grey seal winter haulout location on Isles of Shoals, Maine.

3.4.2.2.5 Nantucket Shoals, Massachusetts

The area around Nantucket Shoals, Figure 3-15, southeast of Nantucket Island, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 6);
- There is sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are less than 50 feet mean low water;
- Open ocean exposure to the south and east results in ESW heights of approximately 65 feet;
- The 40+ mile interconnection distance is beyond the engineering and design criteria of approximately 20 miles for the feasible use of AC transmission (as previously described in Section 3.4.1) and would result in unacceptable electrical losses if AC transmission systems were utilized; and
- Several Northern Atlantic right whale sightings have been recorded immediately south of Nantucket (NEFSC 2001) and there has been a high concentration of humpback whale sightings to the east and northeast of the area (NMFS, unpublished data).

3.4.2.2.6 Nantucket Sound, Massachusetts

The area within Nantucket Sound, Figure 3-16, was evaluated using the preliminary screening criteria with the following results:

- There are adequate wind resources for a commercial scale wind power facility (Class 5);
- There is sufficient surplus electric transmission capacity to transport 200-1,500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible and the area is sufficient to accommodate a 200-1,500 MW wind energy project;
- Offshore water depths are less than 50 feet mean low water;
- The area is sheltered from open ocean exposure, with ESW height of approximately 17 feet;
- The interconnection distance would allow the use of AC transmission systems;
- Subsurface geological conditions are consistent and provide technically and economically feasible conditions for foundation/WTG construction and operation, as well as suitable conditions for submarine cable installations; and
- Sightings of right, fin, and humpback whales in Nantucket Sound are limited. Waring (2001) reports that there are principal harbor seal and/or grey seal winter haulout locations in certain areas of Nantucket Sound (Muskeget/Tuckernuck and Monomoy islands).

3.4.2.2.7 Boston Harbor and Vicinity, Massachusetts

The area within and around Boston Harbor, Figure 3-17, was evaluated using the preliminary screening criteria with the following results:

- The wind resources within Boston Harbor (mapped as Class 2-3) are inadequate for a commercial scale wind power facility. Outside of the inner harbor, further into Massachusetts Bay, there are adequate wind resources of Class 4 or greater;
- There is sufficient surplus electric transmission capacity to transport 200-1500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible (assuming issuance of MADEP Chapter 91 Waterways License);
- The area within the inner harbor is insufficient to accommodate a 200-1,500 MW wind energy project, however outside of the inner harbor (beyond the harbor islands) open watersheet is available;
- Offshore water depths in the areas beyond the harbor islands are greater than 50 feet mean low water,
- Open ocean exposure to the east results in ESW heights of approximately 75 feet in areas seaward of the harbor islands (based on data from USACE WIS stations 94 and 95);
- The interconnection distance would allow the use of AC transmission systems;
- The area is an extremely congested area for marine vessel traffic into and out of Boston Harbor. The approach area to the harbor is designated as a “Precautionary Area” and “Mariners are advised to exercise extreme care in navigating within this area”26; and
- The area lies within the approach to Logan International Airport and is likely to create navigational issues for aviation, in addition to the marine navigational issues noted above.

3.4.2.2.8 New Bedford Harbor and Vicinity, Massachusetts

The area within and around New Bedford Harbor, Figure 3-18, was evaluated using the preliminary screening criteria with the following results:

- The wind resources within New Bedford Harbor (mapped as Class 2-3) are inadequate for a commercial scale wind power facility. Outside of the inner harbor, further into Buzzards Bay, there are adequate wind resources of Class 4 or greater;
- There is sufficient surplus electric transmission capacity to transport 200-1500 MW to load centers throughout the ISO-NE transmission system;
- Use of the offshore watersheet is permissible (assuming issuance of MADEP Chapter 91 Waterways License);

[26] NOAA Marine Chart #13270 Boston Harbor

- The area within the inner harbor is insufficient to accommodate a 200-1,500 MW wind energy project, and expanding outside of the inner harbor into the open watersheet area of Buzzards Bay may impact commercial shipping transiting Buzzards Bay to and from the Cape Cod Canal;
- Buzzards Bay is part of the Cape and Island's Ocean Sanctuary;
- Water depths are generally less than 50 feet mean low water;
- The interconnection distance would allow the use of AC transmission systems; and
- The area within Buzzards Bay is relatively sheltered from open ocean exposure. ESW data is not readily available for the immediate area, with the closest available USACE WIS Stations (#83 and 84) over 20 NM south in more exposed water showing ESW of approximately 48 feet.

3.4.2.2.9 Portland Harbor and Vicinity, Maine

The area within and around Portland Harbor, Figure 3-19, was evaluated using the preliminary screening criteria with the following results:

- The wind resources within Portland Harbor (mapped as Class 2-3) are inadequate for a commercial scale wind power facility. Outside of the inner harbor, west of Long Island, there are adequate wind resources of Class 4 or greater;
- There is not sufficient surplus electric transmission capacity to transport 200 – 1,500 MW to load centers throughout the ISO-NE transmission system. A north-south electrical transmission system constraint in northeast Massachusetts effectively "blocks" power generated in Maine and New Hampshire from being distributed to points south (see Appendix 3-D for a more detailed discussion of the transmission "bottleneck" issue);
- Use of the offshore watersheet area is permissible;
- According to the Coast Pilot "Portland Harbor, at the western end of Casco Bay, is the most important port on the coast of Maine. The ice-free harbor offers secure anchorage to deep-draft vessels in all weather. There is considerable domestic and foreign commerce in petroleum products, wood pulp, paper, seafood products, and general cargo. It is also the Atlantic terminus of pipeline shipments of petroleum products to Canada." Much of the watersheet in the area is crisscrossed with cable and pipeline corridors, naval anchorage areas, oil transfer areas and navigational channels;
- The area within the inner harbor is insufficient to accommodate a 200-1,500 MW wind energy project, however outside of the inner harbor (beyond the harbor islands) open watersheet is available;
- Offshore water depths in the areas beyond the harbor islands are greater than 50 feet mean low water;
- Open ocean exposure to the east results in ESW heights of approximately 90 feet in areas seaward of the harbor islands (based on USACE WIS Station #100); and
- The interconnection distance would allow the use of AC transmission systems.

3.4.2.2.10 Summary of Findings and Comparison of Offshore Alternatives

Preliminary review has been conducted for the offshore alternative sites, which were suggested through public scoping comments, to determine which of these sites warrant more detailed review. Table 3-5 presents a summary of the findings. Based upon comments received during the preliminary review of alternative sites and screening criteria, the screening criteria have not been applied in a strictly pass/fail manner. Reviewing the relative merits and/or detriments of these sites as a whole rather than on individual criterion results in a more subjective but more flexible screening of sites.

All of the offshore sites, except the inner harbors of Boston, Portland and New Bedford, had reasonable wind resource potential.

Engineering constraints, most notably water depth and wave height, are some of the most difficult obstacles to successfully siting a wind facility offshore. The Nantucket Shoal site included relatively shallow areas but was expected to have large extreme storm wave (ESW) heights. The Cape Ann, Outer Boston Harbor, Vinalhaven Island, Block Island and Martha's Vineyard sites all have water depths of greater than 50 feet and ESW heights of greater than 50 feet. Existing offshore wind facilities in Europe have been constructed in relatively shallow water of less than 50 feet. However, the industry appears to be moving towards attempting to install offshore wind turbines in deeper water (see Appendix 3-F). The Martha's Vineyard site tended to be very deep, quickly reaching 100 feet but with an ESW height of 50.2 feet, the least of the deep water sites. It was determined that this area

south of Martha's Vineyard warranted a closer look. There were, however, additional concerns regarding the potential for unexploded ordinance in the area to the south of Martha's Vineyard. The area east of the Martha's Vineyard site, south of Tuckernuck Island, has similar ocean conditions without the additional concerns and is more likely to be feasible. This new area is being referred to as South of Tuckernuck Island. This site warrants further review and will provide some perspective on whether deeper water sites are currently feasible.

The Block Island, Cape Ann and Vinalhaven sites are constrained by the lack of surplus transmission capacity in the existing upland infrastructure that is unlikely to be resolved within the next few years. These sites are not considered to be feasible in the reasonably foreseeable future.

Inner Boston Harbor, Portland Harbor and New Bedford have insufficient area for large scale power production as stand alone sites. New Bedford is within a reasonable distance to Nantucket Sound to consider an analysis of combining it with a reduced footprint at Horseshoe Shoe to respond to the suggestion that sites should be combined to attain the large scale power production rather than eliminating sites due to size alone.

The three locations within Nantucket Sound, which were proposed by the Applicant, all have suitable conditions and warrant further review.

3.4.3 Detailed Analysis of Alternatives

Through the preliminary screening of 17 locations throughout New England, the USACE identified four Alternatives for additional environmental review and comparison purposes:

- Massachusetts Military Reservation: a Terrestrial Alternative
- Nantucket Sound (including the Applicant's proposed Alternative sub-site at Horseshoe Shoal, as well as two other sub-sites): an Offshore Shallow Water Alternative
- South of Tuckernuck Island: an Offshore Deeper Water Alternative
- Offshore of New Bedford, Massachusetts, combined with a reduced footprint at Horseshoe Shoal: a Combination Alternative

3.4.3.1 Introduction and Description of Alternatives

The intent of this alternatives analysis is not to select a preferred alternative. The Corps of Engineers public interest review includes an analysis of the practicability of using reasonable alternative locations and methods to accomplish the objectives of the proposed project. As there are currently no offshore wind power projects in United States waters, we have no previous experience on which to base the public interest review. This comparison of a range of alternatives will help provide the calibration for the weighing and balancing of the probable impacts and benefits of the proposed alternative in determining whether a permit for the Applicant's proposed site should be issued, and if so, under what conditions. This alternatives analyis is intended to provide a comparison of potential sites and does not include detailed engineering. It is anticipated that the potential impacts and benefits of the transmission line installation and any necessary ancillary facilities (construction staging areas) would be relatively similar for each of these alternatives. The four potentially feasible Alternatives for comparison purposes (see Figure 3-20) under consideration are defined and described in the following discussion.

Massachusetts Military Reservation

The Massachusetts Military Reservation (MMR) is a military training facility, which encompasses approximately 21,000 acres (85 km^2) of southeastern Massachusetts reaching into the Cape Cod towns of Mashpee, Sandwich and Bourne, and abutting the Town of Falmouth (See Figure 3-21). The Commonwealth of Massachusetts owns MMR and leases approximately 19,000 acres (77 km^2) to the U.S. Army, the U.S. Coast Guard and the U.S. Air Force. The Army and Air Force have then granted a license back to the Commonwealth to use a portion of the MMR under their control for National Guard Training. In addition to the legal complexities related to the large number of leases and licenses to agencies operating within MMR, on March 5, 2002, the Act "Relative to the Environmental Protection of the Massachusetts Military Reservation" (M.G.L. chapter 47 of the Acts of 2002) was

approved by the Senate and House of Representatives in General Court and signed into law by then Acting Governor Jane Swift.

This Act specifically states that 15,000 acres (61 km^2) within the MMR, delineated as the "Upper Cape Water Supply Reserve" shall be dedicated to: (a) the natural resource purposes of water supply systems, and (b) the use and training of the military forces of the commonwealth; provided that such military use and training is compatible with the natural resources purposes of water supply and wildlife habitat protection.

Portions of MMR have been used for military purposes since 1911. Presently, MMR is divided into three main areas:

- The industrial area in the southern part of the reservation where the U.S. Coast Guard, Army National Guard, and Air National Guard facilities are located. Aircraft runways, maintenance areas, access roads, housing, and support facilities are found in this 5,500-acre (22-km2) cantonment area.
- A 750-acre (3-km2) Veterans Administration Cemetery is located in the southwestern corner of the reservation.
- The northern portion of the MMR is comprised of approximately 15,000 acres (61 km2), also known as Camp Edwards, used primarily by the Army National Guard. This area contains the 2,200-acre (9-km2) Central Impact Area, associated military training ranges, and the U.S. Coast Guard Air Station Cape Cod.

It is the largely undeveloped northern 15,000 acres (61 km2) of the MMR which were considered for further analysis as a potentially feasible terrestrial Wind Park Alternative.

Nantucket Sound

Nantucket Sound encompasses the offshore waters bordered by the south coast of Cape Cod, the north and west shores of Martha's Vineyard, and the northern shore of Nantucket (see Figure 3-22). It is an area of roughly 550 square miles (1,424 km^2) of relatively shallow water depths (ranging from 0-70 feet (0-21.3 m)) and characterized by the sheltering effects of the surrounding islands.

Nantucket Sound has the potential for the Wind Park at three separate sub-site locations each of which are located on shoals with relatively shallow water depths and low extreme storm wave heights. Monomoy / Handkerchief Shoal sub-site is located in the northeastern corner of Nantucket Sound, Tuckernuck Shoal is located in the southern portion of the Sound, and Horseshoe Shoal – the Applicant's proposed Alternative- is located in the center of Nantucket Sound.

Nantucket Sound as a whole will be considered as the potentially feasible shallow water Alternative for the purposes of this analysis and comparison because of the similarities between the three sub-sites within Nantucket Sound.

South of Tuckernuck Island

The offshore area south of Tuckernuck Island, between Muskeget Channel to the west and the southwestern coast of Nantucket Island to the east, has been identified as a deeper water Wind Park site that would be feasible for comparison purposes (see Figure 3-23). The area has a variation in water depths from 15 to 100 feet (4.6-30.5 m), yet still benefits from some sheltering effects from open ocean waves due to Nantucket to the east.

New Bedford / Horseshoe Shoal

The offshore area outside of New Bedford Harbor was chosen as a sub-site for further analysis (see Figure 3-24) even though it could not accommodate a sufficient number of WTGs to be considered a feasible Alternative alone. In order to evaluate combining one or more locations to reach a project of the general magnitude being proposed, New Bedford is combined with the Horseshoe Shoal sub-site. The Horseshoe Shoal array is reduced by the approximate number of turbines that could be placed at the New Bedford sub-site. Most of the turbines in the line nearest the Cape Cod shore would be eliminated.

New Bedford is located on the southern shore of Massachusetts, on Buzzards Bay. The area identified as a potential Wind Park site is bordered on the east by the channel into New Bedford Harbor, by Clark's Cove to the north and to the south by the main channel running through Buzzards Bay to the Cape Cod Canal. Water depths in the area average 30-45 feet (9.1-13.7 m) and the wave regime is relatively sheltered with primary exposure in the southerly direction.

3.4.3.2 Environmental Resources Review

The USACE held a meeting with the cooperating state and federal agencies on November 7, 2003 to seek input as to what existing information was available to describe the existing conditions at each Alternative under consideration and what level of detail would be presented in the DEIS. Following the interagency meeting the USACE held resource specific meetings and / or teleconferences with cooperating agencies based on their areas of expertise to provide specific guidance as to what information was available to sufficiently describe the existing conditions and what level of analysis was to be presented in the following sections. A joint consultation meeting with all interested military parties was held at MMR on February 6, 2004 to discuss the implications of the terrestrial alternative at MMR. Please refer to the Massachusetts National Guard Environmental Readiness Center's Report of Issues and Concerns Regarding the Prospect of a Wind Energy "Farm" at the Massachusetts Military Reservation (March 10, 2004) (see Appendix 3-L).

3.4.3.2.1 Protected Avian Species and Avian Resources

This section describes avian resources and protected bird species that occur within the four Alternative Sites under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. The data and level of detail used for this section was determined through consultation with other resource agencies.

A review of existing information on avian resources has been conducted, consisting of a summary of the key species and resources documented to occur at each of the Alternative Sites. Available avian literature (Veit and Petersen, 1993; Appendix 5.7-A) and natural resource management plans (MAARNG, 2001) were used as part of this characterization to document species diversity and bird density at the alternative sites. During the period from 2001 through 2004, consultations with the Massachusetts Natural Heritage Endangered Species Program (MNHESP) and ornithological experts from the University of Massachusetts, CUNY College of Staten Island, and the Massachusetts Audubon Society were also conducted to gather additional avian habitat and species occurrence information.

In addition to true avian species, this section also addresses other flying creatures that might occur or have the potential to be impacted by the construction and operation of the Wind Park at the offshore alternative sites under consideration. Bats and insects for the upland alternative at MMR are discussed with other upland mammals and wildlife in Section 3.4.3.2.7.

Southeastern Massachusetts is included in the range of seven bat species (DeGraaf and Yamasaki, 2001). These species are the big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), northern myotis (*Myotis septentrionalis*), eastern pipistrelle (*Pipistrellus subflavus*), little brown myotis (*Myotis lucifugus*), silver haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*). Big brown bats and eastern pipistrelles migrate for short distances (generally less than 50 miles) from summer colonies to hibernation sites. Red bats and silver-haired bats migrate somewhat greater distance to more southerly locations as far away as the Gulf states while the hoary bat may migrate as far as Central America. However, none of these bats are federally or state protected species.

Due to their generally robust populations throughout their ranges, none of these bats are listed on the Massachusetts or federal lists of rare, threatened, or endangered species. Most of the seven bat species that occur in southeastern Massachusetts are uncommon to rare in the southeastern Massachusetts portion of their ranges and are not known to spend substantial periods over large bodies of open water such as Nantucket Sound (DeGraaf and Yamasaki, 2001). Thus, they are not likely to be present in great numbers at the offshore alternative sites (for additional information on bats please refer to Section 5.6).

Insects are other flying creatures that may be present in the vicinity of the alternative sites. Per the USFWS endangered species listings for Massachusetts[27] and confirmed in 50 CFR 17.11, the only Federally Listed Insects are limited to 3 species of beetles, as follows: Puritan tiger Beetle (*Cicindela puritana*) (Threatened), Northeastern beach Beetle (*Cicindela dorsalis dorsalis*) (Threatened), and the Endangered American burying beetle (*Nicrophorus americanus*). For more information on these species please refer to Section 3.4.3.2.7.

Massachusetts Natural Heritage fact sheets[28]) has the Northeastern beach beetle, puritan tiger beetle both state-listed as endangered and also has the elderberry long horned beetle (*Desmocerus palliates)* listed as a species of special concern. Since beetles are land dwelling organisms, they are not expected to be present at the offshore alternative sites.

Massachusetts Military Reservation (MMR)

This section describes avian resources and protected bird species that occur within the former Camp Edwards portion of the MMR, which is where the MMR Wind Park alternative is situated. The Integrated Natural Resources Management Plan prepared for MMR by the MAARNG (2001) was used as the basis for avian species and habitat characterization at the MMR Alternative Site.

Avian Species and Habitat

The MMR property is a large tract of mostly undeveloped land surrounded by dense residential and commercial development. The MMR property is the only terrestrial site, and contains several uncommon habitat types. As a result, the MMR Alternative Site is very different from the other three Alternative Sites with regard to avian species and their ecological requirements. The ecosystems within the MMR property support a total of eight state-listed avian species (See Table 3-6 for a listing of protected species). Ninety-four bird species have been documented in the Camp Edwards section of the reservation, including year round residents, summer/winter residents, and transient migrants (See Table 3-7 for the more common species). Many of these species use the MMR property for breeding (MAARNG, 2001).[29]

Five vegetation community types, which provide a variety of habitats for birds, occur within the Alternative Site area on the MMR property. These include: mixed woods forest; pitch pine scrub oak forest; hardwood forest; scrub oak barrens; and grasslands. The Alternative Site area is primarily forested, and the distribution of the scrub oak barrens and grasslands communities occur as very small isolated pockets within the Site. Extensive development of these forested habitat types outside of the MMR property has negatively affected bird species richness and abundance in the area (MAARNG, 2001).

A diversity of bird species visit and use the various habitat types found within the Alternative Site area on the MMR property during different times of the year. Birds using these forested habitats consist primarily of terrestrial species such as woodland hawks, grouse, quail, and mostly passerines. Because the occurrence of wetlands, ponds and other large aquatic systems is limited within the Alternative Site area, the use of the largely forested terrestrial habitats by waterfowl, wading birds, and other waterbirds is very limited, and would only include those species that would use the small isolated wetland systems that are available. The presence of bird species on the MMR property varies throughout the year, and birds are classified into different categories including: year round residents, summer residents (breeders), winter residents, and transient migrants that stay for varying lengths of time. Table 3-7 summarizes the common bird species that occur in the habitats found within the Alternative Site area.

Federally-Listed Species

Based on review of the Massachusetts List of Endangered, Threatened, and Special Concern Species (MNHESP, 2003) and the USFWS Threatened and Endangered Species Program (USFWS, 2003), there are no federally-listed species known to use the MMR property, and it is not protected habitat for federally-listed species.

[27] http://northeast.fws.gov/Endangered/
[28] http://www.state.ma.us/dfwele/dfw/nhesp/nhfactinv.htm
[29] Data collected during the annual Land Conditions Trend Analysis (LCTA), conducted each summer.

State-Listed Species

The Massachusetts Natural Heritage Atlas (2003 edition) indicates that the MMR Alternative Site is located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife (PH 1470/WH 39, WH 65, WH 74, WH 76, WH 166, WH 254, WH 263, WH 470). Eight avian species protected under the Massachusetts Endangered Species Act (M.G.L c.131A and regulations 321 CMR 10.00) have been observed at MMR (MAARNG, 2001). These species and their listing status include: common loon (*Gavia immer*) (Special Concern), northern harrier (*Circus cyaneus*) (Threatened), sharp-shinned hawk (*Accipiter striatus*) (Special Concern), upland sandpiper (*Bartramia longicauda*) (Endangered), barn owl (*Tyto alba*) (Special Concern), northern parula (*Parula americana*) (Threatened), vesper sparrow (*Pooecetes gramineus*) (Threatened), and the grasshopper sparrow (*Ammodramus savannarum*) (Threatened). Four of those species (northern harrier, upland sandpiper, vesper sparrow and grasshopper sparrow) are dependent upon grassland habitats the majority of which occur outside of the Alternative Site area (MAARNG, 2001). Common loons are found during winter in the southwestern section of the MMR, using the ponds of the Rod and Gun Clubs located outside the MMR Alternative Site (MAARNG, 2001). The barn owl has been observed occasionally on the cantonment area in an abandoned building which is again located outside of the Alternative Site area. The sharp-shinned hawk and northern parula occur in woodlands at the MMR property and are the two species that would be found using the forested habitats within the Project area. (MAARNG, 2001).

The Common Loon is more water-dependent than any other inland bird, only coming to the shoreline to breed and nest. In winter, the Common Loon inhabits oceans and bays. The common loon migrates in small flocks; its northbound migration period on Cape Cod averages from March 30th to June 3rd, southbound from September 1st to November 30th. Breeding and nesting takes place in the spring time, on islands or tall aquatic plants in large clear northern lakes and ponds. The greatest threats to the common loon include lead poisoning, induced by the ingestion of fishing sinkers lost by anglers; as well as acid rain causing lake contamination with metals such as mercury, which in turn reduces loons' reproductive success and renders them more susceptible to infectious disease. Additional threats are pesticides, shoreline development, and recreational boaters (MNHESP, n.d.(a)).

The Northern Harrier (or marsh hawk), typically inhabit wet meadows, grasslands, abandoned fields and coastal and inland marshes, mostly along the coast. The Northern Harriers that do not spend the winter in Massachusetts begin to migrate south in late August or early September. The rest spend the winter in coastal marshes on Cape Cod and the offshore islands. They are a rare and local breeder in Massachusetts, mainly on the islands off Cape Cod and occasionally inland as well (Veit and Petersen, 1993). Northern Harriers prey on a variety of small creatures but voles are a particularly important component of their diet; there is a direct correlation between the breeding success of Northern Harriers and the number of voles in their territory. The greatest threat to the Northern Harrier is the destruction of suitable habitat by reforestation of agricultural land and destruction of coastal and freshwater wetlands. In addition, in coastal areas human disturbance may cause some Harriers to abandon their nests (MNHESP, 1990a).

The Sharp-shinned Hawk preferably inhabits extensive mixed woodlands and coniferous forests containing spruce, such as the red spruce (*Picea rubens*) interspersed with white birch (*Betula papyrifera*). Juveniles begin migrating south by late September with the adult birds following in October or early November. In early April they migrate to and through New England to their northern breeding grounds. Breeding habitat is usually near open areas and in the vicinity of water. Preferred nesting sites are in coniferous woods and in groves containing white pine, pitch pine, spruce, hemlock and white cedar, although deciduous trees are sometimes chosen. There are a number of theories explaining the decline of the Sharp-shinned Hawk. One such theory is reproductive failure of the Hawk as a result of acid rain. Another theory is the control of the spruce budworm with the spraying of Fenitrothion. Both acid rain and spraying have been evident in the breeding forests of New England and the Canadian Maritime Provinces during the past 20 to 50 years. The rarity of the Sharp-shinned Hawk in Massachusetts may also be due to the lack of appropriate coniferous forests, which are required to support a large population. The red spruce habitat that this bird prefers is limited to the north central and western regions of the state (MNHESP, n.d.(b)).

The Upland Sandpiper inhabits large expanses of open grassy uplands, wet meadows, old fields and pastures. They need feeding and loafing areas as well as nesting areas. It winters in similar landscapes in South America. The Upland Sandpiper returns to its breeding habitat in Massachusetts mid-April to early May, usually the same area every year. The birds arrive already paired and nest in a grass-lined depression on the ground concealed by

arched grasses. On average 4 eggs are laid and are incubated by both parents. Incubating adults are well concealed and will tolerate close approach before abandoning the nest. The chicks leave the nest soon after hatching. The chicks feed on insects and are watched over by one or both parents. The parents do not defend the nest itself, but will drive other animals away if they approach the young. The young reach full size with full plumage when they fledge at 32 to 34 days. After fledging, families and individuals begin to mix and form flocks. Large flocks of Upland Sandpipers gather in July and begin the fall migration from Massachusetts in Late July and August. Currently, the greatest threat to the Upland Sandpiper is loss of habitat to development and succession of open lands to forest (MNHESP, 1986a).

The Barn Owl requires grassy habitats for foraging, such as fresh and salt water marshes and agricultural fields. They rarely occur apart from populations of the Meadow Vole (*Microtus pennsylvanicus*), a primary food source. Barn Owls are nocturnal birds that generally are monogamous and mate for life. They have a short life span of two years on average, so only breed once or twice during their lifetime. Courting behavior normally begins by March. Nesting sites can include hollow trees, cavities in cliffs or riverbanks and artificial structures such as nest boxes, old barns and bridges. On average 3 to 11 eggs are laid and are incubated by the female for 29 to 34 days. Initially only the male hunts but the female feeds the young, then after about two weeks the female assists in hunting. Barn Owls eat a variety of prey, mostly rodents and small mammals but prefer the Meadow Vole. Fledging occurs at about 60 days although the fledglings will roost in the nest cavity for several weeks. The Barn Owl's nesting success is closely dependent upon vole populations. When vole numbers are low, the owls produce fewer eggs and, unable to provide enough food, fledge fewer young. Common threats to the Barn Owl include predation, starvation due to severe winter or drought, collisions with vehicles and electrocution from power lines. Humans have primarily affected Barn Owls through habitat destruction, illegal shooting and nest disturbance (MNHESP, 1995).

The Northern Parula typically inhabits wet woodlands such as Red Maple (*Acer rubrum*) or Atlantic White Cedar (*Chamaecyparis thyiodes*) swamps, river margins, pond shores or even small depressions. This species migrates south in September and October and returns to Massachusetts in the beginning of May. It is more typically a migrant here than a summer resident. In the northeast, the Parula begins nesting in late May or early June. It usually nests in association with the moss-like lichen, Old-Man's Beard (*Usnea spp.*). The nest is generally in a hollowed out bunch of hanging *Usnea* lichen, in either a deciduous or conifer tree and may be lined with shredded moss and fine grasses. Upon completion the nest resembles a hanging pouch, with an opening at or near the top, at an average of 25 feet above ground. The same nesting site is often occupied in successive seasons. One clutch of 4 to 5 eggs is laid per year and is incubated for 12 to 14 days. The young fledge in another 11 to 12 days. Reasons for the decline of Northern Parula populations in Massachusetts are unknown, although the decline does coincide with the decline of its favored nesting material, *Usnea*, which may be sensitive to air pollution and acid rain. Additionally, its wintering grounds have experienced considerable destruction through deforestation and development (MNHESP, n.d.(c)).

The Vesper Sparrow (or bay-winged bunting) inhabits open areas such as cultivated fields, grasslands, fallow fields and pastures. Agricultural fields containing crops of corn, soybean, alfalfa, hay, timothy, wheat or strawberry may be occupied. The Vesper Sparrow favor farmed areas that are adjacent to fallow fields or contain uncultivated strips along fence-rows. These fallow areas provide nesting habitat, cover, foraging sites and singing perches. Vesper Sparrow habitats are typically sparsely vegetated with patches of bare ground, low vegetation and scattered shrubs or saplings. The typical diet for the Vesper Sparrow is insects and seeds. Nesting typically occurs in fallow fields and grasslands, on the ground within clumps of herbaceous cover that afford protection from predators. Such areas provide a safer haven for nests than other sections of active farmland, where human disturbance and crop harvesting can threaten nesting sparrows (NJ DEP website). An average of 2 clutches of 3 to 5 eggs are laid per year. The clutch is incubated by the female for 11 to 13 days and the young fledge in another 7 to 14 days (USGS website). Due to its dependence on habitats created by farming, the greatest threat to the Vesper Sparrow has been the decline of agriculture and the subsequent loss of nesting habitat (NJ DEP website).

The Grasshopper Sparrows typically inhabit sandplain grasslands, pastures, hayfields and airfields characterized by bunch grasses, where they eat, nest and sleep on the ground. The Grasshopper Sparrow requires a patchy grassland habitat with bare ground and low stem densities of bunch grasses such as Poverty Grass (*Danthonia spicata*), bluestem (*Andropogon spp.*) and fescue (*Fescue spp.*). Bare ground is especially important to this

species, as they run along the ground to escape predators and to forage for invertebrates, primarily grasshoppers. The Grasshopper Sparrows arrive in Massachusetts in late May and migrate to the wintering grounds by mid-September. Breeding occurs each summer with one brood being produced per year. Nests are walled domed structures made of grasses built at the base of clumps of grass. Females incubate the clutch (an average of 3 to 5 eggs) for approximately 12 days and the young leave the nest after 9 days and follow the parent on the ground until they fledge. Breeding activity diminishes by mid-August after which the families disperse. The greatest factors in the decline of the Grasshopper Sparrow have been loss of appropriate habitat to land development, changes in agricultural practices (early harvesting and fewer fallow fields) and the natural succession of shrubs and woods into abandoned fields (MNHESP, 1986b).

Nantucket Sound

This section describes avian resources and protected avian species for the Nantucket Sound Alternative Site (See Table 3-6 for a listing of protected species). Available avian literature (Veit and Peters, 1993; Appendix 5.7-A) was used as the basis for characterization of this Alternative Site. Consultations with ornithological experts from the University of Massachusetts (Hatch, 2001; Hatch, 2004) and the Massachusetts Audubon Society (Perkins et al., 2003) as well as avian field surveys were also considered as part of this characterization.

Avian Species and Habitat

The Nantucket Sound Alternative Site consists of open water with a number of shallow shoals (water depths between 6 and 30 feet (1.8 to 9.1 m)). The Alternative Site is a relatively protected area that attracts large numbers of birds each year, including a variety of waterbirds. The Site is used for differing durations by year-round, summer, and winter resident birds, as well as transient migrants (see Appendix 5.7-A). Some species fall into more than one of these categories. Perkins et al. (2003) identified a total of 13 bird species, and identified four birds to species group (loon, gull, jaeger, and shorebirds), during a summer/fall 2002 avian survey of Nantucket Sound. Data from this survey, conducted by the Massachusetts Audubon Society, is summarized in Table 3-8. Similarly, as shown in Table 3-8, 25 bird species were identified during spring/summer (2002) and winter surveys (2003) of Nantucket Sound (see Appendix 5.7-F and Appendix 5.7-K).

The Alternative Site is used by waterbirds such as scoters, eiders, long-tailed ducks, and loons that over-winter in the Sound (see Appendix 5.7-A). Seaducks are attracted to the area to feed on crustaceans and mollusks that are found on the shoals. Species such as loons and gannets dive for fish throughout the Sound. Many groups of these species migrate through the area during the spring and fall, while some stay throughout the winter. Long-tailed ducks are known to spend the night within the Sound, traveling in large numbers at dawn to Nantucket Shoals to forage (Veit and Petersen, 1993). The highest densities of birds during the winter are found in the eastern part of the Sound near Monomoy Island and in the southern section near Tuckernuck and Muskeget Islands (see Appendix 5.7-D).

The shoals of Nantucket Sound provide foraging opportunities for terns, gulls, and cormorants. The strong tidal currents in the area that flow across the shoals push prey close to the surface for foraging birds to pluck from the water. There are a few areas of exposed rock within the Sound that provide perching opportunities.

Several pelagic species, such as shearwaters, jaegers, and storm-petrels, visit Nantucket Sound during the summer (Veit and Petersen, 1993).

Although there are no nesting sites within Nantucket Sound, many species nest in close proximity on land and use the Sound for foraging. These include large numbers of shorebirds that nest on the shorelines of Cape Cod and offshore islands. The Sound is also traversed by millions of migrating passerines and other landbirds, some of which regularly travel to and from the mainland and adjacent islands (e.g., raptors, wading birds, and shorebirds).

Monomoy Island, at the northeastern limit of Nantucket Sound, attracts a large, diverse array of migratory shorebirds and landbirds that use the area as a stopover during the spring and fall. Monomoy also serves as a staging area for terns that build up in the late summer/fall. Many of these individuals cross Nantucket Sound, including roseate and common terns that nest nearby on Ram and Bird Islands, located approximately 20 miles to the west in Buzzards Bay.

Seaducks, loons, and other waterbirds use Nantucket Sound as a staging area before migrating to their nesting colonies in the spring (see Appendix 5.7-D). Many landbird species not mentioned above (but potentially represented by species discussed for the MMR Alternative Site) migrate over Nantucket Sound, typically at altitudes between 300 and 2,000+ feet (92 and 615+ m) (Kerlinger, 1995).

Federally-Listed Species

Although several federally-listed species (USFWS, 2003) were observed in the vicinity of Nantucket Sound during avian surveys (Appendix 5.7-F and Appendix 5.7-K; Perkins et al., 2003), the Nantucket Sound Alternative Site is not designated as critical habitat for threatened or endangered avian species. For example, the Roseate Tern (S*terna dougallii*) (Endangered) nests on Ram and Bird Islands, located approximately 20 miles (32 km) to the west in Buzzards Bay, and uses the Sound for foraging and short migratory flights to staging areas. A small number of roseate terns also nest on Monomoy Island, in the northeastern corner of Nantucket Sound. The piping plover (*Charadrius melodus*) (Threatened) nests on the shorelines surrounding Nantucket Sound and may cross the Sound during short flights to migratory staging areas and during migrations south to their wintering grounds. The nearest of these shorelines to the Alternative Site is approximately 4 miles (6.4 km) to the north on Point Gammon.

The Roseate Tern typically inhabits islands, coastal beaches and inshore waters. It has a preference for dense cover composed of herbaceous plants such as beach grass and seaside goldenrod. Roseate Terns arrive in Massachusetts in early May. They leave their nesting grounds at the end of August each year and congregate for about a month at a traditional site for roosting, feeding and teaching their young. Toward the end of September, they leave en masse and migrate south. In Massachusetts 1 to 2 eggs are laid between May 17 and June 12, younger birds lay later in the season. The Roseate Tern is a colonial nester. Nests consist of scrapes hidden under or next to vegetation and are often found in vegetative cover over 1 meter high. The Roseate Tern is not able to reproduce successfully if predators are present, they nest on islands in thick cover to try and reduce these threats. Both parents incubate the eggs and feed the young. The young hatch after 23 days, fledge at 25 days of age and remain dependent on the parents at least 6 weeks after fledging. A number of factors have contributed to the decline of the Roseate Tern. Foremost is the encroachment of Herring and Great black backed gulls on tern nesting grounds. Roseate Terns will not re-nest in areas where they have been unable to successfully raise a brood in previous years. Erosion, flooding and alteration of nesting substrates have also significantly reduced tern populations in the past. In addition, the Roseate Tern is affected by human activities in its wintering range, such as egg collecting and killing of the bird for food (MNHESP, 1988a).

The Piping Plover requires sandy coastal beaches which are relatively flat and free of vegetation. They prefer the dry, light colored sand found along the outer coastal shores. Water is a critical necessity for Piping Plover habitat, since the birds feed exclusively on organisms which live along the shoreline. Piping Plovers return to their breeding grounds in Massachusetts in late March or April, often to the same nesting areas and begin to migrate southward between late July and early September. As soon as the birds arrive at the breeding grounds males begin to set up territories and courtship begins. The male scrapes shallow depressions in the sand at potential nest sites and the female then chooses one of these sites, usually in a flat sandy area. The nest itself is a shallow depression lined with shell fragments and small pebbles with which to camouflage the eggs. The female will typically lay a clutch of 4 eggs over a period of a week. The eggs will be incubated by both parents for 3 to 4 weeks until they hatch. The chicks leave the nest within 2 to 3 hours of hatching and fly soon after. The chicks are brooded by their parents for 3 to 4 weeks and finally fledge 4 to 5 weeks after hatching, at which time they leave the nesting area. The greatest threat to the Piping Plover is habitat loss due to the development of coastal areas and waterways. Predation on eggs and young by the growing number of foxes, skunks, raccoons and other predators in suburban areas, is also a threat to Piping Plover populations. In addition, continual disturbance of nest sites from recreational use of beaches may lead some breeding pairs to abandon their nests. In many cases, people also may intentionally or accidentally destroy nests and eggs by walking or driving over them on the beach (MNHESP, 1990b).

State-Listed Species

The Massachusetts Natural Heritage Atlas (2003 edition) and an October 23, 2003 letter from the MNHESP indicated that portions of Nantucket Sound are located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife (PH 1612/WH 7510) for the roseate tern and common tern. The Priority

and Estimated Habitat designations apply to onshore, nesting areas on Nantucket. State-listed protected avian species found in the vicinity of the Alternative Site include: common loon (Special Concern), piping plover (Threatened), common tern (*Sterna hirundo*) (Special Concern), least tern (*Sterna antillarum*) (Special Concern), and the roseate tern (Endangered). Descriptions of the piping plover and roseate tern are provided above in the Nantucket Sound discussion under Federal Listed Species, and a description of the common loon is presented in the MMR discussion under State-Listed Species.

The Common Tern typically resides on islands and along barrier beaches along the coast. The birds that nest in Massachusetts leave in September and October to wintering grounds, they return in late April or early May. The Common Tern nests in colonies on sandy or rocky islands, sand dunes on barrier beaches and sometimes in salt marshes on sand spits and shingle beaches. They will select areas that have open ground for the nest and patches of vegetation as cover for the chicks. The nests are depressions in the sand or a shallow cup of dead grass. Between mid-May and mid-June the female will lay between 2 and 3 eggs. The eggs are incubated by both parents for about 22 days until they hatch. Both parents also care for the chicks, bringing fish for them to eat. The young fledge about 23 days after hatching but still depend on their parents for food for at least another 8 weeks. In the late summer most of the birds move to the outer beaches of Cape Cod or the Islands, where the families stay together until they migrate. The greatest threats to the Common Tern are human disturbance in South America (where they are killed for food) and predation. In addition, predation significantly limits the breeding success of the Common Tern. Examples of such predators are: the Great Horned Owl (*Bubo virginianus*), Red Fox (V*ulpes vulpes*), Norway Rat (*Rattus norvegicus*), and Herring Gulls (*Larus argentatus*). Terns have also suffered displacement by the increasing numbers of gulls (MNHESP, 1985).

The Least Tern typically inhabits coastal beaches and barrier islands. The birds that nest in Massachusetts arrive on their breeding grounds around May 10 and leave these grounds by early September. Between May 23 and June 10 nesting occurs in dry, exposed, un-vegetated areas on sand bars or ocean beaches in the area between the drift line and the upland. The substrate type is usually a mixture of sand, pebbles, shells and fine grained sand. The female forms a shallow scrape in the sand where she lays 2 to 3 eggs. The eggs are incubated by both parents for 20 to 23 days till they hatch. The chicks are active 24 to 36 hours after hatching and fledge in approximately 28 days. The young are fed by both parents. The greatest threat to the Least Tern is reproductive failure, which can be caused by predation (for example owls, gulls, red foxes, skunks and house cats), loss of nesting habitat to natural disaster (high tides, storms, high rainfall), development and human activity (such as use of off road vehicles and walkers). If the first clutch of eggs is lost, the terns will typically re-nest and can lay up to two additional clutches during that season (MNHESP, 1988b).

South of Tuckernuck Island

This section describes avian resources and protected avian species in the South of Tuckernuck Alternative Site (See Table 3-6 for a listing of protected species). Available avian literature (Veit and Petersen, 1993; Appendix 5.7-A) was used as the basis for characterization of this Alternative Site. Consultations with ornithological experts from the University of Massachusetts (Hatch 2001 and 2004) and CUNY College of Staten Island (Veit 2003) as well as avian field surveys were also considered as part of this characterization.

Avian Species and Habitat

The South of Tuckernuck Island Alternative Site consists of open water of depths ranging from approximately 40 to 100 feet (12 to 30 m). Compared to the Nantucket Sound Alternative Site, the South of Tuckernuck Island Site has fewer shoals and is less protected. Although the South of Tuckernuck Island Site may not support the density of birds found in Nantucket Sound and New Bedford Harbor, the area likely supports a similar suite of species to that of Nantucket Sound. As shown in Table 3-9, a total of 17 bird species were identified during a 2003 avian survey of this area (see Appendix 5.7-K).

The National Audubon Society annual Christmas Bird Counts (CBC) from nearby Tuckernuck Island (approximately three miles north of the Alternative Site) provided information on the species likely to use the general area (National Audubon Society, 2002). In winter, these species include seaducks (eiders, scoters, and long-tailed ducks) attracted to the area to feed on crustaceans and mollusks. In summer, these include pelagic species (shearwaters, storm-petrels, and jaegers). Other species of waterbirds such as loons (*Gavia Sp.*) and Northern Gannets (*Morus basanuss*) forage on fish in the area. Tens of thousands (250,000 observed during

2000 CBC Tuckernuck count) of long-tailed ducks (*Clangula hyemalis*) leave Nantucket Sound each day on foraging trips (Veit and Petersen, 1993). Many probably spend the day foraging in areas south of Tuckernuck, depending on the food availability. Terns and gulls are also likely to forage in the area, in particular gulls following fishing boats. Seaducks and other waterbirds such as loons use the area as a staging area before migrating to their nesting colonies in the spring and to wintering grounds further south. Other migratory birds such as landbird species likely pass over South of Tuckernuck Island typically at high altitudes during spring and fall migrations.

Federally-Listed Species

Although several federally-listed species (USFWS, 2003) were observed in the vicinity of South of Tuckernuck Island and Nantucket Sound during avian surveys (Appendix 5.7-F and Appendix 5.7-K; Perkins et al., 2003), the South of Tuckernuck Island Alternative Site is not designated as critical habitat for threatened or endangered avian species. Federally-listed species found in the area of the Alternative Site include the roseate tern (Endangered) and the piping plover (Threatened). Roseate terns may forage in the area in the spring before settling at their nesting colonies, and again in the fall before migrating south for the winter (Veit and Petersen, 1993). Piping plovers (Threatened) are known to nest on shorelines on Nantucket and Tuckernuck Islands and may cross the Alternative Site during their migration or movements between area beaches. Further descriptions of the piping plover and roseate tern are provided above in the Nantucket Sound discussion under Federal Listed Species.

State-Listed Species

The Massachusetts Natural Heritage Atlas (2003 edition) indicates that Nantucket and Tuckernuck Islands, approximately three miles north of the South of Tuckernuck Island Alternative Site, are located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife (PH 1737/WH 688, WH 1136). The Priority and Estimated Habitat designations along most of Nantucket and all of Tuckernuck Island apply to onshore, nesting areas for shorebirds and terns. Piping plovers (Threatened) are known to nest on shorelines on Nantucket and Tuckernuck Islands and may cross the Alternative Site during their migration. Three other state-listed avian species may utilize the South of Tuckernuck Island Alternative Site: common loon, roseate tern, and common tern. Common loons (Special Concern) are likely to be present as winter residents and migrating through in the spring and fall (Powers and Cherry, 1983). Roseate terns (Endangered) and common terns (Special Concern) are likely to forage in the area in the spring before settling at their nesting colonies, and again in the fall before migrating south for the winter (Veit and Petersen, 1993). Least terns (Special Concern) are known to nest nearby on Nantucket Island and may forage in the area, typically closer to shore (see Appendix 5.7-F). Additional information regarding the piping plover, roseate tern, common tern and least tern is provided above in the discussion of the Nantucket Sound Alternative. The common loon is described in further detail in the discussion of the MMR Alternative Site under State-Listed Species.

New Bedford / Horseshoe Shoal

This section describes avian resources and protected avian species for the New Bedford/Horseshoe Shoal Alternative Site, with emphasis on the New Bedford Harbor portion of the Site (See Table 3-6 for a listing of protected species). For information on the Horseshoe Shoal portion of this Alternative Site, please see the Nantucket Sound section, above.

Available avian literature (Veit and Petersen, 1993; Appendix 5.7-A) was used as the basis for characterization of the New Bedford/Horseshoe Shoal Alternative Site, where applicable. Consultations with ornithological experts from the University of Massachusetts (Hatch, 2001; Hatch, 2004) and the Massachusetts Audubon Society (Perkins et al., 2003) as well as avian field surveys were also considered as part of this characterization.

Avian Species and Habitat

The New Bedford Harbor/Buzzards Bay portion of this Alternative Site includes open water partially protected by land on three sides, with water depths ranging from 20 to 50 feet (6 to 15 m). Within the vicinity of the Alternative Site, large numbers of birds are attracted each year, including a variety of waterbirds and migrating shorebirds. The Alternative Site area is used for different durations by year-round, summer, and winter resident birds, as well as transient migrants (see Appendix 5.7-A). As shown in Table 3-10, an estimated 52 bird species,

including 27 that prefer open-water and 25 that prefer intertidal areas, are known to utilize the New Bedford Harbor area (Howes and Goehringer, 1996)

Due to its proximity to land, the New Bedford Harbor area has a higher species density than sites further from shore. In addition to wintering seaducks and waterbirds that are attracted to the high density of prey species, there are large numbers of ducks such as red-breasted mergansers (*Mergus serrator*), goldeneyes (*Bucephala* sp.*),* and buffleheads (*Bucephala albeola*) that are rarely found offshore. Other waterbirds that are abundant in the area include the double-crested cormorant (*Phalacrocorax auritus*) in summer, and great cormorant (*Phalacrocorax carbo*) during winter months. Loons and grebes (*Podiceps sp*) are also present in the winter, before migrating to their nesting grounds further north (Office of Coastal Zone Management, 2002).

Gulls and terns are likely to be present in larger numbers in Buzzards Bay than further offshore due to proximity to their nesting areas and their tendency to feed closer to shore (see Appendix 5.7-F). The largest breeding colonies of the state- and federally–listed roseate tern (Endangered) are located nearby on Ram Island (approximately 5 miles to the north-northeast of the Alternative Site) and Bird Island (approximately 11 miles to the north-northeast). These birds forage in Buzzards Bay and parts of Nantucket Sound throughout the breeding season and before departing for their wintering grounds. There are also significant numbers of common and least terns that nest in the area. Pelagic seabirds (shearwaters and storm-petrels) are summer visitors to the area as are wading birds (herons and egrets) that frequent the coastal shorelines (Office of Coastal Zone Management, 2002).

During the summer months, shorebirds are abundant breeders around Buzzards Bay (Office of Coastal Zone Management, 2002). Shorebirds typically remain close to shore except during short, daily, and long-distance migration. The state- and federally-listed piping plover (Threatened) nests nearby on beaches surrounding Buzzards Bay and may cross the Alternative Site an their way to their breeding grounds, during short flights to migratory staging areas, and during their migration south to their wintering grounds (see Appendix 5.7-H).

Seaducks and other waterbirds such as loons use Buzzards Bay and surrounding areas for staging before migrating to their nesting colonies in the spring (see Appendix 5.7-D).

Federally-Listed Species

The federally-listed (USFWS, 2003) roseate tern (Endangered) is found in the New Bedford/Buzzards Bay portion of the Alternative Site (Office of Coastal Zone Management, 2002). Buzzards Bay provides primary foraging habitat during the breeding season for this species. As previously discussed, some of the largest colonies of roseate terns nest on nearby islands within Buzzards Bay, with some estimates indicating that upwards of 50% of the breeding population occurs in Buzzards Bay. Piping plovers (Threatened) also utilize the area, in particular coastal shoreline areas, and may occasionally pass through the Alternative Site area (Office of Coastal Zone Management, 2002). Further description on these two species has been provided in the discussion of the Nantucket Sound Alternative under Federal Listed Species.

State-Listed Species

The Massachusetts Natural Heritage Atlas (2003 edition) indicates that portions of the Alternative Site are located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife (PH 1483/WH 2086) for foraging roseate, common, and least terns according to Massachusetts Division of Fisheries and Wildlife records. At least seven state-listed avian species are found in the vicinity of the Alternative Site. Common loons (Special Concern) are likely to be present as winter residents and migrating through in the spring and fall. Roseate (Endangered) and common (Special Concern) terns, the state-listed species, nest nearby, and Buzzards Bay is their primary foraging habitat during the breeding season. Least terns (Special Concern) nest nearby and forage in the area (Howes and Goehringer, 1996). Leach's storm-petrel (*Oceanodroma leucorhoa*) (Endangered) also nest nearby on Penikese Island and may forage in the area (Veit and Petersen, 1993). The state-listed Arctic tern (*Sterna paradisaea*) (Special Concern) has nested on Nashawena Island (approximately 10 miles to the south) as recently as 1991 (Veit and Petersen, 1993). Lastly, as mentioned above, piping plovers (Threatened) utilize the area (Howes and Goehringer, 1996).

Thorough descriptions of the roseate tern, common tern and least tern are provided above in the discussion of the Nantucket Sound Alternative. The common loon is described in further detail in the discussion of the MMR Alternative Site under State-Listed Species.

Leach's Storm-Petrel is an inhabitant of the open ocean (where it winters), coming ashore on rocky islands and coasts only to breed (MNHESP, n.d.(d)). Once breeding is over in September, the birds migrate to their wintering grounds (Canadian Wildlife Service). Atlantic birds winter off the coast of Brazil (New England Seabirds). Leach's Storm Petrel nests in large colonies, in shallow burrows underground or under a log or a board (MNHESP, n.d.(d)). The nest is a chamber, sometimes lined with a few twigs, located at the end of a narrow burrow dug in the topsoil by the male (Canadian Wildlife Service). The burrow can be from 1 to 3 feet in length (New England Seabirds). The single egg is incubated by both parents alternately and hatches at 38 to 46 days. The chick is fed planktonic crustaceans, drops of oil and small fish taken far out at sea (Canadian Wildlife Service). Both Parents feed the chick, coming in and out of the burrow only at night (New England Seabirds). The chick remains in the nest dependent on this diet for about 65 days (Canadian Wildlife Service). The greatest threat to the Leach's Storm-Petrel is limited nesting habitat, as well as competition and predation from other seabirds, particularly gulls (MNHESP, n.d.(d)). In addition, burrows can be collapsed by humans walking on them and nests are disturbed by dogs and feral cats (New England Seabirds).

The Arctic Tern typically inhabits sandy gravelly areas on islands and barrier spits. Occasionally they occur on mainland shores. In Massachusetts, Arctic Terns arrive on their breeding grounds in mid-May and depart as soon as the young can fly which is usually in early August. They typically feed on small fish, crustaceans, and other invertebrates and in some cases, flying insects (Hatch, 2002). The Arctic Tern nests in colonies ranging from several to tens of thousands of pairs. The female scrapes out a nest in the area beyond the high tide mark and occasionally uses dune grass to line it. A clutch of 1 to 2 eggs is laid between May 28 and June 15. The female is responsible for incubating the eggs and brooding and feeding the young. Incubation lasts for about 21 days and the young fledge 21 to 24 days after hatching. The greatest threat to the Arctic Tern population is predation and human disturbance. In Massachusetts, avian, insect and mammalian predation on eggs and chicks has occurred (MNHESP, 1988c).

Comparative Summary of Existing Resources

This section describes avian resources and protected bird species that occur within the four Alternative Sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

The MMR Alternative Site was the only terrestrial site evaluated for avian resources. The MMR Alternative Site had the highest documented diversity of bird species of the four Alternative Sites evaluated (MAARNG, 2001). Bird species diversity at the MMR Alternative Site was nearly twice that found at New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site, approximately three times as high as that found in Nantucket Sound, and approximately four times that of South of Tuckernuck Island. Avian field surveys of the South of Tuckernuck Island Site indicate lower species diversity at this Alternative Site than that found at the other three Alternative Sites (see Appendix 5.7-k). This may be due, in part, to the fact that the South of Tuckernuck Island Alternative Site was the only offshore Alternative Site located in the open ocean. The Nantucket Sound and New Bedford/Horseshoe Shoal Alternative Sites are relatively sheltered areas, relatively protected from open ocean exposure by surrounding landforms, with the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site closest to land.

All four Alternative Sites support either Priority/Estimated avian habitat or are in close proximity to such habitat areas. The South of Tuckernuck Island Alternative Site is the only one that does not fall within state-designated habitat. However, the closest land to the South of Tuckernuck Island Alternative Site (Tuckernuck Island and Nantucket Island) is designated Priority/Estimated habitat. The Priority/Estimated habitat in the New Bedford Harbor/Buzzards Bay portion of the New Bedford/Horseshoe Shoal Alternative Site is used for foraging and breeding by three protected species of tern (roseate, common, and least). Buzzards Bay represents an important breeding area for the roseate tern. Portions of Nantucket Sound are also located within Priority/Estimated habitat for two protected species of tern (roseate and common).

Of the four Alternative Sites, the highest number of protected bird species was reported at the MMR Alternative Site. Of the eight state-listed bird species observed at the MMR Alternative Site, two species (northern parula and sharp shinned hawk) are dependent on the forested habitats that are predominant within the Alternative Site area (MAARNG, 2001). Seven state-listed bird species have been observed in the vicinity of the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site. Five state-listed species have been observed in or near the Nantucket Sound Alternative Site, and three state-listed species have been observed in or near the South of Tuckernuck Island Alternative Site.

Two federally-listed bird species, the roseate tern (Endangered) and piping plover (Threatened), have been observed in the vicinity of the three offshore Alternative Sites. The largest breeding colonies of roseate tern are located near the New Bedford Harbor/Horseshoe Shoal Alternative Site on Ram and Bird Islands. In addition, the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site is the closest to populations of piping plover, which breed and forage along the beaches in this area. There are no recorded observations of federally-listed bird species at the MMR Alternative Site.

3.4.3.2.2 Geology and Soils/Sediments

This section describes geology and soils/sediments in the four Alternative Sites under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. The data and level of detail used for this section was determined through consultation with other resource agencies.

Available literature from site-specific and regional surveys and studies was used as the basis for this analysis. These included USGS geophysical and geological surveys, benthic reports for surficial marine sediments, and sea floor mapping, as well as Natural Resource (formerly Soil) Conservation Service soils surveys. Impact reports for the dredging of the New Bedford Harbor Superfund Site (MCZM, 2002) were also reviewed. A review of published USGS information sources regarding historic seismicity (the occurrence of past known earthquakes) and mapped faults in the vicinity of the Alternative Sites was also conducted.

A qualitative review of geology and soils/sediments has been conducted for each of the four Alternative Sites. The results of this review are presented below. Table 3-11 presents a summary of soil, surficial and bedrock geologic conditions at the four Alternative Sites.

From a geologic perspective, the Cape and Islands are relatively young lands, created largely by glacial and post glacial processes (Oldale, 2001). Advances and retreats of sediment-laden ice toward the end of the Wisconsinian-age glacial stage originally molded the present landscape in the late Pleistocene Epoch about 23,000 to 18,000 years ago. The movements of localized glacial ice lobes may have been influenced by the shape of the underlying lands, with major lobes occupying pre-existing topographic depressions, such as Buzzards Bay, Nantucket Sound, and Cape Cod Bay. Following glaciation, the landscape was further reworked by water-borne sediments during the gradual climatic warming that has occurred during the Holocene Epoch since that time.

Massachusetts Military Reservation

This section describes the geology and soils of the MMR Alternative Site.

Bedrock and Glacial Geology

Bedrock in the vicinity of the MMR Alternative Site is mapped as Proterozoic-age undivided granite, gneiss, and schist (Zen, 1983). Thick deposits of glacial sediments, as described below, cover the bedrock in the vicinity of the Alternative Site.

The west side of the MMR Alternative Site runs approximately along the Buzzards Bay Moraine, while the north side of the Site runs approximately along the Sandwich Moraine. These prominent ridges of unconsolidated glacial sediments were formed during late-stage re-advances of the Cape Cod Bay and Buzzards Bay glacial ice lobes (Oldale, 2001). The resulting, irregular hummocky topography atop the moraines was created when sediments washed out of the retreating ice surrounded remnants of melting ice blocks. The generally unsorted or poorly sorted (well-graded) morainal sediments contain a wide range of grain sizes.

The Buzzards Bay moraine deposits across the western leg of the Alternative Site contain mostly sand and gravel, with abundant very fine sand and clay. Glacial till and boulders are also present, forming a veneer on top of stratified drift deposits (USGS, 1986). The northerly portions of the MMR Alternative Site, located on the Sandwich Moraine, contain mostly sand and gravel, with abundant very fine sand, silt, and clay. Till and boulders generally occur on top of stratified drift.

The southeastern portion of the Alternative Site contains Mashpee Pitted Plain deposits downslope of the moraines. These stratified drift deposits were transported by meltwater off the ice lobes, and contain mostly sand and pebble to cobble gravel, with some boulders. The topography on the pitted plain is more level than on the moraines.

Soils

Soils that developed in the Buzzards Bay moraine deposits are primarily Plymouth-Barnstable soils within the Plymouth-Barnstable-Nantucket soil map unit (USDA, 1993). The soils are mapped as intermingled "PxC" (rolling and extremely bouldery) and "PxD" (hilly and extremely bouldery). These well drained soils developed on moraines with slopes ranging from 3 to 35 percent. Permeability is moderately rapid to very rapid. Due to rapid infiltration, the soils have limited capacity to filter or adsorb pollutants. Stones and boulders cover 3 to 15 percent of the land surface, which typically supports woodland. The soils are poor and unsuitable for cropland, hay, or improved pasture because the surface stones and boulders restrict the use of agricultural equipment.

Soils along the northeastern portions of the MMR Alternative Site are also within the Plymouth-Barnstable-Nantucket soils unit, but contain fewer surface boulders than the "PxC" and "PxD" soils to the west and southwest. The northeastern portion of the Alternative Site primarily contains intermingled soils "PvD" (Plymouth-Barnstable complex, hilly, very bouldery) and "BcC" (Barnstable-Plymouth complex, rolling). The soil characteristics are similar to those on the western portion of the Alternative Site.

The Mashpee pitted outwash plain is dominated by the Agawam and Enfield soil series. The Agawam series consists of very deep, well-drained soils formed in sandy, water-deposited materials. They are level to steep soils on outwash plains and high stream terraces. The Enfield series consists of very deep, well-drained loamy soils formed in a silty mantle overlying glacial outwash. They are nearly level to sloping soils on outwash plains and terraces. The excessively well-drained soils make the MMR property a significant groundwater recharge area.

Due to the historic and continuing use of the MMR area for military operations, the soil within portions of the site have been contaminated by metals, fuels, solvents and other chemical pollutants, although this has largely been associated with portions of MMR to the south of the Alternative Site. As a result of these conditions, the MMR has been designated a Superfund site (Air Force Center for Environmental Excellence, 2004). The potential also exists for unexploded ordnance and explosive residues in surface soils, although the area known as the Camp Edwards Impact Area where this is primarily the concern, is located to the east of the Alternative Site. Consultation with MMR personnel indicates that locating the Wind Park at MMR would require significant screening of sites, including cable and road corridors, for unexploded ordinance, which is a time consuming and expensive procedure (Cunha, 2004). Pollutants discharged at the surface have percolated down through the permeable soils and entered groundwater, forming plumes that are migrating generally westerly into Buzzards Bay and southerly toward Nantucket Sound. However, an explosives residue plume above USEPA health advisory levels is mapped as occurring under a portion of the Alternative Site (Air Force Center for Environmental Excellence, 2004). In addition, there is potential for small areas of contaminated soils (primarily explosives residue) within the Alternative Site due to on-site past military training activities and more extensive military training activities that occurred in the adjacent Impact Area.

Seismicity

No bedrock faults are mapped traversing the Alternative Site, although a fault (direction of movement unknown) is mapped as paralleling the south side of the Cape Cod Canal (Zen, 1983). One small earthquake (magnitude 3.0 to 3.9 on the Richter scale) has been recorded between 1638 and 1998, with the epicenter reported approximately 8 miles (12.8 km) northwest of the MMR Alternative Site (USGS, 2001).

Nantucket Sound

This section describes the geology and sediments at the Nantucket Sound Alternative Site.

The Nantucket Sound Alternative Site is within the Atlantic Coastal Plain physiographic province, an area of low-lying generally seaward thickening sediments between the New England uplands and the seaward edge of the continental shelf. The sand-rich landforms of Cape Cod and Martha's Vineyard partially surround and shelter Nantucket Sound, a broad passage of relatively shallow water, from the open Atlantic Ocean.

Bedrock Geology

Bedrock is deep beneath the Cape and Islands, and is not exposed as it is on the mainland to the west and north of Cape Cod. Bedrock is not mapped beneath Nantucket Sound on the *Bedrock Geologic Map of Massachusetts* (Zen, 1983). The map indicates that lithified (hard) bedrock beneath Cape Cod is metamorphic feldspathic gneiss and amphibolite of Proterozoic age. In Woods Hole, granite was penetrated at a depth of about 270 feet (82.4 m); in Harwich, metamorphic rock described as schist was found at a depth of 435 feet (105 m) (Oldale, 2001). A plan showing estimated depths to bedrock across Nantucket Sound is provided in Figure 3-25 (from Oldale, 2001).

The bedrock map indicates a buried Triassic-Jurassic rift basin, trending southwesterly from Monomoy Island to the west and southwest of Muskeget Island off western Nantucket. This feature is probably related to past rifting associated with the break-up of the super-continent Pangea, and the spreading of the basin now occupied by the Atlantic Ocean during the Triassic-Jurassic. A deep boring on Nantucket encountered igneous basalt, which may have been related to Triassic rifting of the early Atlantic Ocean (Oldale, 2001). Bedrock faults are likely associated with this failed rift basin, hundreds of feet beneath portions of the Tuckernuck Shoal area. No onshore bedrock faults adjacent to Nantucket Sound are mapped as trending offshore (Zen, 1983).

Maps show younger non-lithified Cretaceous and overlying Tertiary-age coastal plain sediments in bedrock beneath Martha's Vineyard and Nantucket (Zen, 1983). Some of these seaward thickening unconsolidated pre-glacial deposits are exposed at Gay Head on Martha's Vineyard, and may have been locally incised beneath Nantucket Sound by ancient pre-glacial drainage patterns.

Seismicity

A USGS compilation of known earthquakes over a 300-year period indicates that no earthquake epicenters with estimated magnitudes 3.0 or greater have occurred within 10 miles (16 km) of the Horseshoe Shoal and Tuckernuck Shoal sub-sites. One earthquake (estimated magnitude 4.0 to 4.9) has occurred approximately 6 miles (9.6 km) north of the Monomoy Handkerchief Shoal sub-site. No epicenters have been reported over this time period within the layouts of the sub-sites (USGS, 2001).

Glacial and Post Glacial Geology

During the development of Wisconsinian glaciation in the Pleistocene, ice blanketed New England, reaching as far south as the Cape and Islands (Uchupi et al., 1996; Oldale, 2001). As the glaciers advanced and grew to the south, ice movement pushed a variety of sediments and rocks up in front and beneath the ice. The arcuate roughly east-west oriented topographic highs of present-day Nantucket and Martha's Vineyard mark the terminal moraines, or southernmost extent, of two lobes of glacial ice, which began to retreat approximately 18,000 years before present (BP).

As the climate gradually warmed during the Holocene Epoch of the last 12,000 years, the glaciers once covering the Cape and Islands continued to melt and retreat. Meltwaters rushed off the ice, transporting and sorting the sediments they carried into the topographic lows south of the moraines, creating generally level outwash plains of stratified drift and temporary glacial lakes throughout what is now Nantucket Sound. As sea level continued its overall rise during the Holocene, these unconsolidated glacial sediments continued to be transported, eroded, deposited and reworked by marine, tidal, and wind-driven (aeolian) forces. The sediments provide the raw material for the beaches of the Cape and Islands, which continue to be shaped by fluvial and tidal marine processes today.

Sediment Conditions

Particle analysis of surface grab sediments collected during benthic studies in Nantucket Sound show sand-sized particles predominate, derived from relict glacial sediments (Poppe et al., 1989; Theroux and Wigley, 1998). Surface sediments in the western portions of the Tuckernuck Shoal area, close to the currents through Muskeget Channel, are mapped as more gravel-rich (Poppe et al., 1989), indicating a dynamic erosional environment. Finer-textured sediments are found in the protected bathymetric lows in the Sound, such as within the embayment surrounded by Horseshoe Shoal.

Geologic and geophysical information on underlying shallow sediments and surface geomorphology was collected throughout Nantucket Sound by the USGS over field seasons in 1976 and 1977, as reported in Miscellaneous Field Studies Map MF-1911 entitled *Maps Showing Geology, Shallow Structure and Bedform Morphology of Nantucket Sound, Massachusetts* (O'Hara and Oldale, 1987). The USGS dataset included 20 vibracores and 500 miles (800 km) of geophysical track lines, and included the Nantucket Sound Alternative Site.

Sand waves, indicating bedload transport of sandy sediments, were found on Horseshoe Shoals and Tuckernuck Shoals, but were absent at Monomoy and Handkerchief Shoals within the Nantucket Sound Alternative Site.

Two USGS vibracores (Nos. 4938 and 4939) were collected to a maximum depth of 16 feet along the southern limb of Horseshoe Shoals. The USGS logs indicated predominantly sands and shell fragments were recovered, with peat, charcoal and wood bits encountered in a zone below 8 feet (2.4 m) in No. 4939. At Tuckernuck Shoal, only one USGS vibracore was collected (No. 4937) within the Alternative Site area itself; the USGS log indicated the surficial sediments were shelly sands to the core's total depth of 13 feet (4 m). USGS vibracore No. 4926 was taken west of the Monomoy and Handkerchief Shoal Alternative Site, and recovered approximately 8 feet (2.4 m) of sands and shells, with some gravel near the base of the core. Grain sizes of the sands were not reported. These features typically reflect a previous shallow, intertidal and/or shoreline landscape position in which water levels gradually rose, or significant shoreline erosion and sediment mixing occurred from land sources. Glacially transported intermittent cobbles to boulders can be anticipated in shallow sediments across Nantucket Sound.

South of Tuckernuck Island

This section describes the geology and sediments at the South of Tuckernuck Alternative Site. The South of Tuckernuck Alternative Site is located on the continental shelf south-southwest of Tuckernuck and Nantucket Islands. The Site is west of an extensive area of shallow waters covering a broad sand and gravel ridge known as Nantucket Shoals, and east of Muskeget Channel, the deep water area between Martha's Vineyard and Nantucket. With the exception of the northwesternmost WTGs, this Alternative Site is located in deeper water than the other marine alternatives. Bathymetric contours on the NOAA chart indicate the sea bottom in this area of the continental shelf is relatively flat, sloping gradually down to the southwest.

Bedrock Geology

Lithified bedrock is expected to be at a depth of hundreds of feet below pre-glacial, glacial and post-glacial unconsolidated sediments. On Nantucket, a deep borehole penetrated Triassic basalt bedrock at approximately 1,500 feet (458 m) below the surface (Oldale, Revision 2001). This is likely reflective of the bedrock depths at the site as distance from the mainland increases. The bedrock was unconformably overlain (stratigraphic gap) by Late Cretaceous sediments, probably similar to those exposed near the base of the cliffs at Gay Head, Aquinnah on Martha's Vineyard. No onshore bedrock faults are mapped as trending offshore in the vicinity of this Alternative Site (Zen, 1983). The western side of a failed Triassic rift basin (described above) may be located at depth beneath the westernmost portion of this Alternative Site.

Sediment Conditions

The South of Tuckernuck Island Alternative Site is roughly south of the former maximum extent of Pleistocene glacial ice (Oldale and Barlow, 1986). Unsorted till, morainal, and stratified drift glacial sediments containing a wide range of grain sizes could be present in the area, overlain by outwash sediments transported and sorted by meltwater off retreating ice lobes to the north. Nantucket outwash plain sediments are exposed on Nantucket and Tuckernuck.

Particle analysis of surface grab sediments collected during benthic studies in Nantucket Sound show sand sized particles predominate, derived from relict glacial sediments (Poppe et al., 1989; Theroux and Wigley, 1998). Given the proximity of these islands to the Alternative Site, finer-grained sediments containing silt and clay could also be expected South of Tuckernuck Island, indicating depositional sediment environments in some locations. The area was also exposed at some stages of ice retreat, when the land surface would have been subject to erosion, which cut intermittent channels into the substrate. Glacial sediments in the vicinity of the Alternative Site may be around 60 feet thick (Uchupi et al., 1996).

The northwest portion of the Alternative Site is located south and southeast of Muskeget Channel between Martha's Vineyard and Nantucket. Strong currents in and around this channel, as well as ocean currents, likely continue to shape the geomorphology of the sea bottom in this area. Migrating sand waves and shoals may be present, especially in shallow water on the northwest portion of the Alternative Site. Coarse-grained armor-type bottom sediments, often encountered in channels swept clean of fine-grained material, can also be expected.

As reported in Uchupi et al. (1996), complex patterns of linear ridges and troughs aligned with tidal and storm currents are characteristic of the Nantucket Shoals to the east. Some vibracore samples collected from the western edge of Nantucket Shoals, approximately 8 to 10 miles (13 to 16 km) east of the South of Tuckernuck Alternative Site in the Nantucket Shoals, recovered coarse to fine quartz sand and shell fragments in the upper seven feet. At other core locations, sands also contained appreciable amounts of silt and clay, generally at the base of the vertical section sampled. Borings drilled southeast of Nantucket as part of the Texas Tower project encountered approximately 90 feet of fine sand overlying a silt of unknown thickness (the borehole penetrated approximately 66 feet (20 m) of silt) (Uchupi et al., 1996). Lenses of gravel to coarse sand and medium to fine silty sand were encountered in another nearby boring. These conditions reveal alternating sequences of high and low energy sediment deposition during glacial stagnation and retreat.

Seismicity

No earthquake epicenters have been reported over a 300-year time period within or in the vicinity of this Alternative Site (USGS, 2001).

New Bedford / Horseshoe Shoal

This section describes the geology and sediments at the New Bedford/Horseshoe Shoal Alternative Site. For information on the Horseshoe Shoal portion of this Alternative Site, see the Nantucket Sound section, above.

The portion of the New Bedford/Horseshoe Shoal Alternative Site discussed below is in the outer reaches of New Bedford Harbor. The New Bedford Harbor and its approaches are part of the Acushnet River tidal estuary, which discharges into the larger Buzzards Bay estuary. The Alternative Site is within the Outer Harbor Operable Unit of the 18,000-acre (73 km^2) New Bedford Harbor Superfund Site, designated in 1982 (see Figure 3-26). The Superfund site contains sediments contaminated primarily by metals and organic compounds, including polychlorinated biphenyls (PCBs). Since 1994, PCB-contaminated sediments have been removed from portions of the Acushnet River estuary, with assessment and remediation continuing. No material is planned for removal in the vicinity of the New Bedford/Horseshoe Shoal Alternative Site, as shown on Figure 3-26 (MCZM, 2002).

Bedrock Geology

The structural geology of the outer New Bedford Harbor is complex. The Bedrock Geologic Map of Massachusetts (Zen, 1983) shows the presence of a major subsurface east-west oriented bedrock structural fold in the vicinity of the Outer Harbor. The crest of the fold runs roughly along the southern portions of West Island and Sconticut Neck to Clark's Point. Bedrock outcrops may occur at these locations. The axis of the fold plunges down to the west. Based upon a review of the Bedrock Geologic Map, most of the Alternative Site appears to be located on the southern flank of the fold just off the crest. While bedrock is probably shallower east of the shipping channel, bedrock may be encountered at relatively shallow depths in the vicinity of the Alternative Site. The bedrock is mapped as Proterozoic metamorphic biotite gneiss, overlain by undivided granite, gneiss, and schist. Test borings that penetrated bedrock in the vicinity of the Alternative Site recovered rock described as pre-Mesozoic granitic gneiss, which is consistent with the bedrock map (Summerhayes et al., 1977). A layer of glacial till and/or gravelly sediment less than 10 feet (3.1 m) thick typically cover the bedrock, which is then overlain by

sands and finer-grained silts and clays. An inferred north/south-trending bedrock fault is mapped as extending from onshore to offshore areas just east of the New Bedford alternative site (Zen, 1983).

The NOAA navigation chart for this area (NOAA Chart 13230, 2001) shows a number of named ledges and rocks both east and west of the shipping channel. In the vicinity of the Alternative Site, these include North, Bents, Great and Negro Ledges, and Decatur, Church, Phinney, and Hursell Rocks. Some of these features may be bedrock outcrops or glacially-deposited boulders. Depth to bedrock is mapped as between 8 to 24 feet (2.4 to 7.3 m) below sea bottom surrounding North Ledge and Bents Ledge (Science Applications International Corporation, 2000). Information regarding bedrock depths in the southern part of the Alternative Site was not found.

Glacial Geology

Generally perpendicular to this east-west bedrock structural fold is the NNW-SSE-trending Acushnet River embayment and adjacent sub-parallel coves and embayments. These steep-sided drowned valleys were formed during the late Tertiary or Pleistocene as a well-developed drainage system carved into continent shelf sediments (Summerhayes et al., 1977). The valleys are often separated by broad flat shelves, such as those found southwest of Clark's Cove. Tills were then deposited across the area by advancing Late Pleistocene glaciers, with fluvial gravels and sands deposited over the tills as the glaciers melted and retreated. The subsequent marine transgression of the last 10,000 years slowly flooded the valleys, creating the present day embayments of this area.

Sediment Conditions

Regionally, sediments within Buzzards Bay range from silts and muds in areas of deeper bathymetry associated with a depositional environment, to sands, gravels, and boulders in nearshore and shallower areas resulting from higher energy currents. Fine sands predominate in depositional areas along the northern side of the Bay, with coarser sand found around rocky exposures around New Bedford Harbor (Howes and Goehringer, 1996; Theroux and Wigley, 1998).

As is typical of harbors, New Bedford Harbor now acts as a sediment sink, both for fine-grained silts and clays discharged by the Acushnet River, and for sediments transported landward by bottom currents created by wave and tide energy (Summerhayes et al., 1977; Howes and Goehringer, 1996). Construction of the hurricane barrier across New Bedford Harbor has reduced tidal flushing in the Inner Harbor, increasing sedimentation there. Seaward of the barrier in the Outer Harbor, silts and clays continue to accumulate in the marine depressions, creating a soupy clay-rich 3.9 to 7.9 inches (10 to 20 cm) thick layer with turbid near-bottom waters.

Historical industrial land uses of the New Bedford Harbor area resulted in the introduction of pollutants to the harbor waters, with PCB and metals-rich waste historically discharged into New Bedford Harbor. In addition, since 1920, sewage has been discharged into the harbor from a municipal wastewater facility at Clark's Point. Industrial air pollution fallout rapidly becomes affixed to the fine-grained sediments that blanket the area. Copper, lead, and zinc have been detected in fine-grained Outer Harbor sediments (Summerhayes et al., 1977), as well as low levels of PCBs at concentrations not planned for removal (MCZM, 2002). In general, there is a gradual migration of contaminants out of coastal harbors until an area is reached that allows settling and is no longer influenced by freshwater flows of coastal rivers. PCB levels at the Alternative Site are not anticipated to be elevated due to the distance of the site from the source areas and the trend of decreasing PCB levels with distance (EPA, 2001).

Analysis of grab samples reported by others indicates surface sediments in the Outer Harbor area contain various mixtures of gravel, sand, and silt-clay. Much of the area west of the navigation channel had a relatively high proportion of fine-grained sediment (greater than 50 percent silt-clay), which is easily mobilized when disturbed. Regionally, surficial sediments in the vicinity of the Alternative Site have been mapped as fine to medium sands just south of Clark's Point, with silt predominating south of the mouth of the navigation channel (Science Applications International Corporation, 2000). Coarse sand may be encountered along the southernmost portions of the Alternative Site.

Seismicity
Two small earthquakes (each with magnitudes between 3.0 and 3.9 on the Richter scale) have occurred within 10 miles (16 km) of the New Bedford alternative site over a 300-year time period from 1638 to 1998 (USGS, 2001).

Comparative Summary of Existing Resources

This section analyzes the geology and soils/sediments at the four alternative sites. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

All of the Alternative Sites include thick underlying pre-glacial, glacial and post glacial unconsolidated sediments above bedrock. The New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site has a greater number of possible bedrock outcrops than the other sites due to its location and the relative thin cover of glacially deposited sediments. The MMR Alternative Site is the only upland site included in the alternatives analysis and, as such, differs from the offshore sites in terms of its composition of glacially-deposited material. Glacial deposits in the MMR Alternative Site tend to be morainal, comprised of mixed till with hummocks and kettles. The three offshore Alternative Sites were also subject to glacial processes, in addition to transport by ocean hydrodynamic forces. The Nantucket Sound and South of Tuckernuck Island Alternative Sites were more influenced by sandy outwash deposits than the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site. The South of Tuckernuck Island Alternative Site contains unsorted till, morainal, and stratified drift glacial sediments containing a wide range of grain sizes. Sand waves occur at both of these sites, indicating bedload transport of sandy sediments by bottom currents. The New Bedford Harbor Alternative Site, as a largely sediment-depositional environment, is dominated by fine sands and silts, which have become contaminated by numerous releases of pollutants that remain bound to Harbor sediments.

A USGS compilation of earthquakes (USGS, 2001) indicated no earthquake epicenters have occurred between 1638 and 1998 within 10 miles (16 km) of two of the three offshore Nantucket Sound sub-sites, and the South of Tuckernuck Island Alternative Site. One small earthquake has occurred within ten miles of the MMR alternative site and two small earthquakes (all with magnitudes between 3.0 and 3.9 on the Richter scale) have occurred within ten miles of the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals alternative site. One earthquake (magnitude 4.0 to 4.9) has occurred within 10 miles (16 km) of the Monomoy Handkerchief Shoal alternative site. No epicenters have been reported as occurring within the actual layouts of these alternative sites (USGS, 2001).

No bedrock faults are mapped as traversing the MMR alternative site, although a bedrock fault is mapped paralleling the southern side of the Cape Cod Canal. Bedrock is not mapped in offshore Massachusetts areas (Zen, 1983) although no onshore bedrock faults are shown as continuing offshore in the vicinity of all the offshore alternative sites except New Bedford. An inferred north south-trending bedrock fault is mapped as extending from onshore to offshore areas just east of the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals alternative site (Zen, 1983). There may be ancient faulting associated with a failed Triassic rift basin in eastern Nantucket Sound, hundreds of feet below the Tuckernuck Shoal sub-site.

3.4.3.2.3 Oceanography

This section describes water depth, tide/current, and wave conditions in the four alternative sites under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Water depth and tide/current data were gathered from available NOAA sources for the offshore sites. Wave conditions for the offshore Alternative Sites were characterized by using USACE Wave Information Study (WIS) wave hindcasting and extremal analysis data[30] and models for a variety of return periods. Information for each of the Alternative Sites is presented below.

Massachusetts Military Reservation

Review of oceanographic resources for this Alternative Site was unnecessary because the MMR Site is located in an upland location.

[30] http://www.frf.usace.army.mil/wis/

Nantucket Sound

This section describes water depths, tides, and currents, and wave conditions for the Nantucket Sound Alternative Site. Three potential siting areas located within Nantucket Sound are included in this alternative: Horseshoe Shoal, Tuckernuck Shoal, and Monomoy-Handkerchief Shoal.

Nantucket Sound separates the south shore of the Cape Cod mainland and the islands of Nantucket and Martha's Vineyard. The Sound is approximately 23 miles (36.8 km) long (east-west direction) and between 6 and 22 miles (9.6 and 35.2 km) wide (north-south direction) (NOAA, 1994).

Water Depths/Bathymetry

In general, the bathymetry in Nantucket Sound is irregular, with a large number of shoals present in various locations throughout this glacially formed basin. Charted water depths in the Sound range between one (1) and 74 feet (0.3 and 22.6 m) at Mean Lower Low Water (MLLW) (Figure 3-22).[31]

Water depths for the Horseshoe Shoal area are as shallow as 0.5 feet (0.15 m) at MLLW. Measured depths of 60 feet (18.3 m) at MLLW occur between the northern and southern legs of the shoal. On the southern leg of the shoal, an east-west trending natural channel feature exists, with measured water depths approaching 50 feet (15.3 m) at MLLW. The proposed WTGs would be located in water depths generally between 8 and 55 feet (2.4 and 16.8 m) at MLLW.

Water depths for the Tuckernuck Shoal area are generally irregular due to the presence of numerous shoals in the area (Tuckernuck Shoal, Long Shoal, Edwards Shoal, Cross Rip Shoal, Norton Shoal, and Hawes Shoal). The majority of the Tuckernuck Alternative Site area has water depths less than 30 feet (9.2 m) at MLLW, with the shallowest charted water depth being 3 feet (0.9 m) at MLLW. The deepest charted water depth in the area is 74 feet (22.6 m) at MLLW. The proposed WTGs would be located in water depths generally between 12 and 60 feet (3.7 and 18.3 m) at MLLW.

Water depths for the Monomoy-Handkerchief Shoal area are generally deeper than 30 feet (9.2 m) at MLLW. There are three shoals in the area with depths between 20 and 30 feet (6.1 and 9.2 m) at MLLW. The proposed WTGs would be located in water depths generally between 31 and 51 feet (9.5 and 15.6 m) at MLLW, with the exception of 15 WTGs, which would be located in shallower waters of between 21 and 29 feet (6.4 and 8.8 m) at MLLW.

Tides and Currents

Strong, reversing, semidiurnal tidal flows drive currents in Nantucket Sound. Wind-driven currents are only moderate because of the sheltering effect of Nantucket and Martha's Vineyard. The tidal range and diurnal timing vary because of the semi-enclosed nature of the Sound and the regional variations in bathymetry. Typical tidal heights are in the range of one to four feet, with tidal surges of up to approximately 10 feet (3.1 m) recorded during hurricanes (Bumpus et al., 1973; Gordon and Spaulding, 1979). Times of high and low tides vary across the Sound by up to two hours.

Tidal flow and circulation within the Sound generates complex currents, forming an ellipse during the two tidal cycles each day. The complex bathymetry of Nantucket Sound forces the tidal ellipses to take different shapes in different regions of the Sound. Just off the coast of the south shore of Cape Cod, there is a strong rectilinear, semi-diurnal tidal flow approximately parallel to the coast (Goud and Aubrey, 1985). The tidal current flows to the east during the flood tide (incoming) and to the west during the ebb tide (outgoing). Peak tidal currents often exceed two knots (Bumpus et al., 1973). The intensity of tidal flow, in general, decreases from west to east. There is a slow net drift of the water mass toward the east in the Sound. The net drift is about 2,150 square feet (200 m^2) per tidal cycle, or roughly five percent of the total easterly and westerly tidal flows (Bumpus et al., 1973).

[31] Water depths, referenced to MLLW for the Nantucket Sound Wind Park Alternatives, are shown on NOAA Chart No. 13237 (Nantucket Sound and Approaches, 38TH Edition, March 3, 2001).

Estimated Wind-Generated Wave Conditions

Because there is no extensive source of wave data within Nantucket Sound, the available wind data and analytical models were used to characterize wind-generated waves at the Nantucket Sound Alternative Sites (Appendix 5.2-A and Appendix 5.2-B). Fetch length (the distance over which wind acts on the water surface), average water depth, and wind speed are the major factors affecting the magnitude and period of wind-generated waves in this area. The wave model used these factors to estimate wave height and period under different conditions. Typically, larger waves are generated as wind speed, water depth, and fetch length increase. Fetch is restricted within Nantucket Sound due to surrounding landforms. Within the Tuckernuck Shoal area, fetch is restricted to the south by Martha's Vineyard, Muskeget, Tuckernuck, and Nantucket Islands, as well as shallow shoals. The fetch is open to Nantucket Sound to the North. At the Monomoy-Handkerchief Shoal area, fetch is restricted to the north by Cape Cod and to the east by Monomoy Island. The fetch is open to the Nantucket Sound to the south. At the Horseshoe Shoal area, fetch is restricted to the north by Cape Cod and to a lesser extent to the southwest by Martha's Vineyard.

Wave model simulations were performed using the ACES *Wind Speed Adjustment and Wave Growth* model to estimate significant wave height (average height of the highest one-third of waves in a sea state); peak period (the period that characterizes the majority of the waves in a sea state); and peak direction (Appendix 5.2-A and Appendix 5.2-B). The results represent wave conditions at the center of each of the potential siting areas in Nantucket Sound. Generally, the model indicates that Horseshoe Shoal is exposed to the largest waves from the easterly directions, Tuckernuck Shoal is exposed to the largest waves from the northerly directions, and Monomoy-Handkerchief Shoal is exposed to the largest waves from the south and west directions. Wind-generated significant wave heights within each site generally range from less than one foot to nearly four feet, with relatively short spectral peak wave periods between two and four seconds. Individual wave heights can be higher; substantially higher waves will be present during storms. The wave data that is presently being collected at the SMDS will provide valuable data for ground-truthing wave modeling results at the Horseshoe Shoal site.

A shoaling coefficient and wave breaking criteria were applied using the model results to obtain a distribution of the wave heights over the shoals (Appendix 5.2-A). Generally, wave height changes in the shallow portions of the shoal due to wave shoaling and breaking, while wave period remains constant.

It is also possible that longer period waves enter Nantucket Sound from the Atlantic Ocean. Therefore, a conservative estimate of long period swell conditions was developed for the Nantucket Sound Alternative Site. The average wave height of offshore waves approaching from easterly through southeasterly directions east of Monomoy within the Atlantic Ocean was used for this analysis. The average height for these offshore waves is 4.5 feet (1.4 m), and the average wave period is eight seconds. A shoaling coefficient was used to modify the ocean swell and estimate resulting wave heights and distribution at Horseshoe Shoal. Offshore waves are likely to be modified substantially by the complex, shallow shoal structure separating Nantucket Sound from the Atlantic Ocean, as well as by the relatively narrow gaps between Monomoy Island and Nantucket Island to the east and between Nantucket Island and Martha's Vineyard to the south. Although these features would typically serve to dissipate ocean swell effects, these factors were not included, resulting in a relatively conservative analysis.

Extremal analysis was performed for the Horseshoe Shoal area to estimate wave height and period characteristics for the 2-, 10-, and 50-year return periods. These were estimated for both locally generated and offshore waves using a computer model entitled "Extrm2: Extremes Program." The extreme storm wave is defined, for this effort, as the average height of the highest one percent of all waves in the spectrum. The results are shown in Table 3-12.

The extremal analysis results for Horseshoe Shoal are expected to be similar for the other Nantucket Sound sub-alternative locations due to their relative proximity to Horseshoe Shoal and the similar bottom conditions.

For this analysis, the 50-year return extreme storm wave height has been chosen as the design extreme storm wave height as it is the offshore wind industry standard (Appendix 3-B).

South of Tuckernuck Island

This section describes water depth, tide/current, and wave conditions in the South of Tuckernuck Island Alternative Site. This Site is located in the Atlantic Ocean between Nantucket Shoals, the south shore of Nantucket, and Muskeget Channel.

Water Depths/Bathymetry

Water depths for the South of Tuckernuck Island Alternative Site generally increase in a southwesterly direction.[32] The extreme northwest edge of the Site is located in water depths between 10 and 25 feet (3.1 and 7.6 m) at MLLW. The majority of the Site has water depths greater than 30 feet (9.2 m) at MLLW, and over half of the area has depths greater than 60 feet (18.3 m) at MLLW. The proposed WTGs would be located in water depths generally between 60 and 90 feet (18.3 and 27.5 m) at MLLW, with the exception of the 12 WTGs in the northwest edge of the array, which would be located in water depths of between 10 and 25 feet (3.1 and 7.6 m) at MLLW.

Tides and Currents

Tidal height and range information specific to the South of Tuckernuck Island Alternative Site are not available due to its offshore location. The closest NOAA tide stations that are located in similar conditions to those at the alternative location are located at Wasque Point on Chappaquiddick Island (No. 1055) and at Tom Nevers Head on Nantucket (No.1039). The mean tidal range at these stations is 1.1 feet (0.3 m) and 1.2 feet (0.4 m), respectively. The spring tidal range at both of these stations is 1.4 feet (0.4 m). Given the open sea location of the alternative, it is expected that tidal ranges at this location will be similar to that at these two NOAA tidal stations.

NOAA has a tidal current station (No. 1716) that is located within the South of Tuckernuck Island Alternative Site. Tidal currents at this station are ebb dominated. The maximum ebb tidal current at this station is 1.0 knots (1.85 km/hr), and it sets up in a westerly direction. The maximum flood tidal current at this station is 0.5 knots (0.93 km/hr), and it sets up in an easterly direction.

A second NOAA tidal current station (No. 1816) is located to the northwest of the South of Tuckernuck Island Alternative Site between Mutton Shoal and Muskeget Rock. The flood dominated tidal currents at this station are influenced by the presence of Muskeget Channel, and consequently set up in northeasterly (flood) and southwesterly (ebb) direction. The maximum flood tidal current at this station is 1.3 knots (2.4 km/hr), and the maximum ebb tidal current is 1.0 knots (1.85 km/hr). However, the United States Coast Pilot for Region 2 (Cape Cod to Sandy Hook) notes tidal currents from 2 to 5 knots (3.7 to 9.3 km/hr) may occur in this channel (NOAA, 1994).

Estimated Wind-Generated Wave Conditions

The fetch at this Alternative Site is restricted to the northwest by Martha's Vineyard, and to the north and east by Muskeget, Tuckernuck and Nantucket Islands, and shallow shoals. The fetch is open to the Atlantic Ocean to the south and west, so the largest waves are likely to come from those directions.

There is no extensive source of wave data from the South of Tuckernuck Island Alternative Site, so wave conditions for this area were estimated using data from USACE Wave Information Studies (WIS) Stations 87 and 86 (located approximately 5.5 miles (8.8 km) east and 7.5 miles (12 km) west of the proposed ESP location, respectively). WIS wave data were generated by numerical simulation of past wind and wave conditions, a process called hindcasting[33]. The WIS hindcast period of 1976-1995, which includes hurricanes, was used to estimate wave conditions at this Alternative Site. The WIS hindcast method provides information useful in comparisons with the ACES method but does not require quite as specific of data for input parameters, requires less time, and ultimately was performed as part of this alternatives analysis, which was added to the EIS months after the performance of the ACES modeling for the Horseshoe Shoal site.

[32] Water depths, referenced to MLLW, for this Alternative Site location are shown on NOAA Chart No. 13237 (Nantucket Sound and Approaches, 38TH Edition, March 3, 2001).
[33] http://www.frf.usace.army.mil/wis/

Using the WIS wave data from Stations 86 and 87, extremal analysis was performed for the South of Tuckernuck Island alternative to estimate wave height and period characteristics for the 2-, 10-, and 50-year return periods. These were estimated using a computer model entitled "Extrm2: Extremes Program." The extreme storm wave is defined, for this effort, as the average height of the highest one percent of all waves in the spectrum, and is approximately 1.67 times the significant wave height. The results are shown in Table 3-13.

For this analysis, the 50-year return extreme storm wave height has been chosen as the design extreme storm wave height. For the South of Tuckernuck Island Alternative Site, the design extreme storm wave height is 52.5 feet (16.0 m) (the larger value of the two WIS stations).

New Bedford / Horseshoe Shoal

This section describes water depth, wind, tide/current, and wave conditions for the New Bedford/Horseshoe Shoal Alternative Site.

The New Bedford portion of this alternative is located on the westerly side of Buzzards Bay. Buzzards Bay indents the south shore of Massachusetts, and extends in a northeasterly direction from Rhode Island Sound. The bay is separated from Vineyard Sound by the Elizabeth Islands, which form the south side of the bay (NOAA, 1994).

The Horseshoe Shoal portion of this alternative is described above in the Nantucket Sound Alternative.

Water Depths/Bathymetry

Water depths in the New Bedford/Horseshoe Shoal Alternative Site generally increase in a southeasterly direction.[34] Several ledges and rocks with depths as shallow as one foot (0.3 m) at MLLW (Great Ledge) are scattered in the alternative location. Between Clarks Point and Phinney Rock, charted water depths are generally less than 30 feet (9.2 m) at MLLW. Charted water depths increase to as deep as 47 feet (14.3 m) at MLLW in the area just south of Negro Ledge. The majority of the proposed WTGs would be located in water depths between 31 and 41 feet (9.5 and 12.5 m) at MLLW. The remaining proposed WTGs would be located in water depths of between 22 and 28 feet (6.7 and 8.5 m) at MLLW.

Tides and Currents

Tidal height and range information specific to the New Bedford/Horseshoe Shoal Alternative Site are not available due lack of site specific monitoring. The closest NOAA tide stations that are located in similar conditions to those at the alternative location are located at Dumpling Rocks (No. 1139, located 1 Nautical Mile (NM) (1.85 km) away), Penikese Island (No. 1103, located 5 NM (9.3 km) away), the north side of Quicks Hole (No. 1099, located 6 NM (11.1 km) away), Kettle Cove (No. 1105, located 5.5 NM (10.2 km) away), and the west side of West Island (No. 1129, located 4 NM (7.4 km) away). The mean tidal range at these stations ranges between 3.4 and 3.8 feet (1 and 1.2 m), with an average of 3.6 feet (1.1 m). The spring tidal range at these stations is between 4.2 and 4.7 feet (1.3 and 1.4 m), with an average of 4.5 feet (1.37 m). Given the location of the Alternative Site between these five NOAA tide stations, it is expected that tidal ranges at this location will be similar to that at these NOAA tidal stations.

NOAA has two tidal current stations located near the Site. Tidal currents at the station southeast of West Island (No. 2126) and southeast of Dumpling Rocks (No. 2101) are ebb dominated. The maximum ebb tidal current at these stations is 0.8 knots and 1.1 knots (1.5 and 2 km/hr), respectively. The ebb current sets up in a southeasterly direction. The maximum flood tidal current at these stations is 0.7 knots and 0.8 knots (1.3 and 1.5 km/hr), respectively. The flood current sets up in a northwesterly direction.

Estimated Wind-Generated Wave Conditions

There is no extensive source of wave data in the area of the New Bedford/Horseshoe Shoal Alternative Site, so wave conditions for this site were estimated using data from NOAA National Data Buoy Center (NBDC) Station BUZM3 which is located approximately 11 miles (17.6 km) southwest of the Alternative Site location. This station lies in the path of the longest open fetch for the Site. Therefore, wave data from this Site is inferred to represent

[34] Water depths referenced to MLLW for this alternative location are shown on NOAA Chart No. 13230 (Buzzards Bay, 45TH Edition, March 17, 2001).

an estimate of the largest waves the Site may experience. WIS Stations are far offshore of this Site and, therefore, would not be representative of this Site.

At Station BUZM3, the average significant wave height during the 1990 to 2001 period was approximately 3 feet (0.9 m), and the average wave period was approximately 4.8 seconds.

Annual extreme significant wave heights are available at this location for 1990-1992 and 1997-2001. These values were used as input to the "Extrm2: Extremes Program" to estimate significant wave heights for the 2-, 10-, and 50-year return periods. This information was then used to estimate the extreme storm wave height (H_1) for the station. The extreme storm wave is defined, for this effort, as the average height of the highest one percent of all waves in the spectrum, and is approximately 1.67 times the significant wave height. It should be noted that these estimates are based on the minimal data set available at Station BUZM3, and as such, should be interpreted only as very general estimates. The results are shown in Table 3-14.

For this analysis, the 50-year return extreme storm wave height has been chosen as the design extreme storm wave height. For the New Bedford Harbor area of this alternative, the estimated design extreme storm wave height is approximately 33.8 feet (10.3 m).

Comparative Summary of Existing Resources

This section describes water depth, tide/current, and wave conditions in the four alternative sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

Mean water depths are greatest at the South of Tuckernuck Island Alternative Site, intermediate at the Nantucket Sound Alternative Site and shallowest at the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site. The greatest change in bathymetry exists at the South of Tuckernuck Island Alternative Site, where water depths change from 95 feet (30 m) in the southern portion to 7 feet (2.1 m) MLLW in the northern portion. The average tidal range is greatest at the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site (up to 4.6 feet (1.4 m)) and least at the South of Tuckernuck Island Alternative Site (up to 2 feet (0.6 m)). Tidal currents are strongest in the northern portion of the South of Tuckernuck Island Site near the Muskeget Channel, and nearly as high within portions of Nantucket Sound, and least at the New Bedford Harbor portion of the New Bedford/Horseshoe Shoals Alternative Site. Wave heights are greatest at the South of Tuckernuck Island Alternative Site because of the open fetch towards the south, intermediate at the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site, and least at the Nantucket Sound Alternative Site, which has limited fetch in essentially all directions.

3.4.3.2.4 Protected Marine Species

This section describes protected marine species in the three offshore alternative sites under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. The data and level of detail used for this section was determined through consultation with other resource agencies. The same marine species were studied for each of the three offshore alternative sites based on marine species use in these areas. These include three federally-listed endangered species of cetaceans, three federally-listed endangered or threatened species of marine reptiles, and the gray seal, a state-listed Species of Special Concern. The federally-listed endangered/threatened species are protected under the Federal Endangered Species Act (ESA) and the state-listed species of special concern are protected under the Massachusetts Endangered Species Act (MESA). Other marine mammal species protected under the Marine Mammal Protection Act (MMPA) that may occur in the area, including the harbor seal, are also discussed in this section (See Table 3-6 for a listing of protected species).

Massachusetts Military Reservation

The MMR Alternative Site is located in an upland environment. Therefore, a review of marine protected species is not applicable.

Nantucket Sound

This section describes protected marine species in the Nantucket Sound Alternative Site area.

Federally-Listed Threatened and Endangered Species

The following three federally-listed endangered species of cetaceans may occur in Nantucket Sound: humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), and Northern Atlantic right whales (*Eubalaena glacialis*). The primary feeding grounds for whales are located to the north-northeast in Stellwagen Bank, Cape Cod Bay, and the Gulf of Maine. The distribution of whales is often closely correlated with the distribution of their food sources. Nantucket Sound does not support high densities of food sources for these whale species. Based on historic sightings, information, and observations of whale migration and movement (see Appendix 3-G), Nantucket Sound does not appear to be an important area for these species of whales. Additional detail on these three endangered whale species is provided in Appendix 3-G.

The following three federally-listed endangered or threatened species of marine reptiles are known to occur in Nantucket Sound: loggerhead turtles (*Caretta caretta*), Kemp's ridley turtles (*Lepidpchelys kempii*), and leatherback turtles (*Dermochelys coriacea*). Loggerhead turtles and leatherback turtles can be expected to be present in Nantucket Sound when water temperatures are favorable, from early summer through late fall. Their presence is partially dictated by water temperature, since they lack the ability to regulate body temperature. Kemp's ridley and loggerhead sea turtles typically cannot withstand lengthy periods at temperatures below 73.8^{o}F (23.2^{o}C) and 67.1^{o}F (19.5^{o}C), respectively; however, leatherbacks have some thermoregulatory mechanism and have been found in colder northern waters (Howes and Goehringer, 1996). Leatherbacks are more commonly reported in Massachusetts waters than other sea turtle species; densities are likely associated with inshore concentrations of jellyfish. Kemp's ridley turtles occasionally visit Massachusetts waters, and are known to be occasionally cold stunned in Cape Cod Bay during fall and winter months. Because Kemp's ridley turtles have been observed feeding in shallow waters of Vineyard Sound, Buzzards Bay, and in the eastern Bays of Long Island, New York in summer months (Carr 1967; Lazell 1980; Morreale and Standora, 1989), they may also be present in Nantucket Sound during the summer and fall. Additional detail on these three protected sea turtle species is provided in Appendix 3-G.

State-Listed Threatened and Endangered Species

There are no state listed threatened and/or endangered species located in the Project area. However, the gray seals (*Halichoerus grypus*) are common in the waters of Nantucket Sound. The gray seal is protected under the Massachusetts Endangered Species Act (MESA) and is listed as a Species of Special Concern by the Commonwealth of Massachusetts. Gray seals have known breeding and pupping grounds in Nantucket Sound at Monomoy and Muskeget Islands (Waring et al., 2001; Waring, 2001). During summer and winter avian surveys conducted by Cape Wind's consultant, several hundred gray seals were observed on sandbars in the Muskeget Island area. Additional detail on the gray seal is provided in Appendix 3-G.

Marine Mammals

In addition to those previously discussed, several other species of marine mammals that are protected under the MMPA but are not threatened or endangered species may occur in the waters of Nantucket Sound. The harbor seal (*Phoca vitulina concolor*) is the most abundant marine mammal throughout New England and is commonly found in Nantucket Sound. Some of the other species that could be present in Nantucket Sound include the harp seal (*Phoca groenlandica*), hooded seal (*Cystophora cristata*), white-sided dolphin (*Lagenorhynchus acutus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), harbor porpoise (*Phocoena phocoena*), long-finned pilot whale (*Globicephala melas*), and minke whale (*Balaenoptera acutorostrata*).

Nantucket Sound serves as an important overwintering habitat for harbor seals. Harbor seals pup in New Hampshire, Maine, and Canadian waters in the spring and summer, but many juveniles overwinter in Nantucket Sound. Adults may be found in the Sound year-round. Extensive sand spits on Muskeget, Tuckernuck, and Skiff Islands (west side of Muskeget Channel off Martha's Vineyard) have been identified by the U.S. Fish and Wildlife Service (USFWS) as preferred haul-out points for large numbers of harbor seals (USFWS, 2001). Additional detail on the harbor seal and the other marine mammals listed above is provided in Appendix 3-G.

South of Tuckernuck Island

This section describes protected marine species in the South of Tuckernuck Island Alternative Site area.

Federally-Listed Threatened and Endangered Species

The same three federally endangered species of cetaceans (humpback whales, fin whales, and Northern Atlantic right whales) that are listed under the Nantucket Sound section may also occur in the South of Tuckernuck Island area. The primary feeding grounds for whales are located to the north-northeast in Stellwagen Bank, Cape Cod Bay, and the Gulf of Maine. The distribution of whales is often closely correlated with the distribution of their food sources. The South of Tuckernuck Island Site contains some of the bathymetric and oceanographic features that favor dense aggregations of whale prey species, but these are not developed to the extent that they are farther north around Stellwagen Bank, Jeffreys Ledge, Browns and Bacaro Banks, and in the Great South Channel (Kenney and Winn, 1986). Therefore, the preferred foods of whales occur in the South of Tuckernuck area with far less abundance and frequency than in high-use areas farther north. Based on historic sighting information and observations of whale migration and movement (see Appendix 3-G), the South of Tuckernuck Island Site does not appear to be an important area for these species of whales. However, there have been more recorded sightings of Northern Atlantic right whales in the South of Tuckernuck area than in Nantucket Sound or Buzzards Bay (Appendix 3-G). Additional detail on these three endangered whale species is provided in Appendix 3-G.

The same three federally endangered or threatened species of marine reptiles (loggerhead turtles, Kemp's ridley turtles, and leatherback turtles) that are listed under the Nantucket Sound section are known to occur in marine areas throughout New England, and could also be present in the South of Tuckernuck Island area. Loggerhead turtles and leatherback turtles can be expected to be present in this area when water temperatures are favorable, from early summer through late fall. Leatherbacks are more commonly reported in Massachusetts waters than other sea turtle species, and densities are likely to be associated with inshore concentrations of jellyfish. Kemp's ridley turtles occasionally visit Massachusetts waters, and are known to occasionally be cold stunned in Cape Cod Bay during fall and winter months. Because Kemp's ridley turtles have been observed feeding in shallow waters of Vineyard Sound, Buzzards Bay, and in the eastern Bays of Long Island, New York in summer months (Carr 1967; Lazell 1980; Morreale and Standora, 1989), they may also be present in Nantucket Sound and in the South of Tuckernuck area during the summer and fall. Additional detail on these three protected sea turtle species is provided in Appendix 3-G.

State-Listed Threatened and Endangered Species

There are no state listed threatened and/or endangered species located in the South of Tuckernuck Island Alternative. However, the gray seal a Massachusetts Species of Special Concern protected under the Massachusetts Endangered Species Act (MESA), is common in New England waters, including the South of Tuckernuck Island area. Gray seals have known breeding and pupping grounds in Nantucket Sound at Monomoy and Muskeget Islands. The Muskeget Island breeding colony is located north of the South of Tuckernuck Island Site (within 4.5 miles (7.2 km)); however, the Monomoy Island breeding colony is located more than 20 miles (32 km) from the South of Tuckernuck Site. During summer and winter avian surveys conducted by Cape Wind's consultant, several hundred gray seals were observed on sandbars in the Muskeget Island area. Additional detail on the gray seal is provided in Appendix 3-G.

Marine Mammals

In addition to the threatened, endangered or special concern species, several other species of marine mammals protected under the MMPA may occur in the waters surrounding the South of Tuckernuck Island Site. The species that could be present in the South of Tuckernuck area include the harbor seal, harp seal, hooded seal, white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

Of these species, the harbor seal is the most commonly observed species in this area and could be present in the South of Tuckernuck area year-round. Harbor seals pup in New Hampshire, Maine, and Canadian waters in the spring and summer, and not in the vicinity of the Alternative Site. However, extensive sand spits on Muskeget, Tuckernuck, and Skiff Islands (west side of Muskeget Channel off Martha's Vineyard) have been identified by the USFWS as preferred haul-out points for large numbers of harbor seals (USFWS, 2001). This outer Nantucket Sound area (including the South of Tuckernuck area) may support larger numbers of fish for seals to prey on, since many species of finfish migrate to deeper waters during their overwintering periods. The haul-out sites on

Tuckernuck and Muskeget Islands are within approximately 4.0 and 4.5 miles (6.4 and 7.2 km) (respectively) of the South of Tuckernuck Alternative Site. Additional detail on the harbor seal and the other marine mammals listed above is provided in Appendix 3-G.

New Bedford / Horseshoe Shoal

This section describes protected marine species in the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative Site. For information on the Horseshoe Shoal portion of this alternative, please see the Nantucket Sound section, above.

Federally-Listed Threatened and Endangered Species

The same three federally endangered species of cetaceans (humpback whales, fin whales, and Northern Atlantic right whales) that are listed under the Nantucket Sound and South of Tuckernuck Island sections have the potential to occur in the New Bedford/Buzzards Bay portion of this Alternative Site. Buzzards Bay is not considered a high-use habitat for whales (Buzzards Bay Project National Estuary Program, 1991; Howes and Goehringer, 1996). According to Howes and Goehringer (1996), the absence of topographical and oceanographic features that concentrate prey species and the Bay's shallow waters may be the cause of their general absence. However, there have been a few individual sightings of whales in the Bay in this century, although they tend to be near the entrance to Buzzards Bay, typically off Cuttyhunk, at least 8.5 miles (13.6 km) from the Alternative Site (Figure 3-27), rather than in the Bay itself (Howes and Goehringer, 1996). These occasional sightings may be the result of the proximity of Buzzards Bay to the southwest Gulf of Maine and Cape Cod Bay (Buzzards Bay Project National Estuary Program, 1991). Additional detail on these three endangered whale species is provided in Appendix 3-G.

The same three federally endangered or threatened species of marine reptiles (loggerhead turtles, Kemp's ridley turtles, and leatherback turtles) that are listed under the Nantucket Sound and South of Tuckernuck Island sections are known to occur in the New England region and have the potential to occur in the New Bedford/Buzzards Bay portion of this Alternative Site. Sea turtles are transient species occasionally found in Buzzards Bay and possibly in the vicinity of New Bedford Harbor (NBHTC, 1998). These species of sea turtles may visit the Buzzards Bay area in the summer after migrating from southern overwintering regions. Of these species, the leatherback is the species most frequently encountered in Buzzards Bay (Crocker, 2003), generally from July through November (Buzzards Bay Project National Estuary Program, 1991); however, some loggerheads are also found in Buzzards Bay every year (Crocker, 2003). In 2001, there were seven leatherback strandings within Buzzards Bay and two entanglements along the Elizabeth Islands (Crocker, 2003). From 1984 to 1987, 14 leatherback sea turtles were stranded around Buzzards Bay (Howes and Goehringer, 1996).

The Kemp's ridley turtle is known to frequent areas adjacent to Buzzards Bay and is often reported (caught in fishing nets or stranded) within Cape Cod Bay; however, sightings within Buzzards Bay are rare (Buzzards Bay Project National Estuary Program, 1991). There have been historical reports of sightings and strandings of Kemp's ridley sea turtles in the early 1900's, 1930, and one report of a single loggerhead stranded in this area in 1984 (Howes and Goehringer, 1996). According to Crocker (2003), loggerhead turtles are occasionally found in Buzzards Bay every year. There may be greater use of Buzzards Bay by sea turtles than shown in the sightings and strandings reports, given the difficulty of observing sea turtles at sea and the restriction against net fishing within Buzzards Bay, which is a major source of sightings in other regions (Howes and Goehringer, 1996). Additional detail on these three protected sea turtle species is provided in Appendix 3-G.

State-Listed Threatened and Endangered Species

There are no state listed threatened and/or endangered species located in the New Bedford Alternative. However, the gray seal, a Massachusetts Species of Special Concern protected under the Massachusetts Endangered Species Act (MESA), is common in New England waters and has the potential to occur in the New Bedford/Buzzards Bay portion of this Alternative Site. The gray seal has been occasionally observed in Buzzards Bay in very small numbers (NBHTC, 1998; Buzzards Bay Project National Estuary Program, 1991). Some gray seals have been observed using haul out sites along the Elizabeth Islands (Figure 3-27), approximately 8.5 miles (13.6 km) south of this Alternative Site. According to Crocker (2004), suitable habitat and human activity likely restricts significant gray seal utilization within Buzzards Bay. Additional detail on the gray seal is provided in Appendix 3-G.

Marine Mammals

In addition to those listed marine mammals previously discussed, several other species of marine mammals protected under the MMPA could occur in the New Bedford/Buzzards Bay portion of this Alternative Site. According to the Buzzards Bay Project National Estuary Program (1991), the harbor seal is the most abundant marine mammal throughout New England and the only marine mammal species commonly found in Buzzards Bay. Buzzards Bay is not considered a high-use habitat for whales, dolphins, or porpoises. However, these species have occasionally been observed or stranded in the Bay, because of its proximity to the southwest Gulf of Maine and Cape Cod Bay. Some of the other species that could be present in Buzzards Bay include the harp seal, hooded seal, white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

The harbor seal is the only one of these species that is commonly found in Buzzards Bay. The harbor seal can be present in Buzzards Bay and the Elizabeth Islands from mid-October to May (NBHTC, 1998). According to NBHTC (1998), during the winter and early spring, 300 to 400 of these seals can be present in the Bay. These harbor seals use many haul out sites on the outer portions of the Bay along the Elizabeth Islands. These sites include Woods Hole Passage, Lackeys Bay, Tarpaulin Cove, Robinsons Hole, Quicks Hole, Gull Island, and Cuttyhunk outer harbor (Crocker, 2004) (Figure 3-27). Occasionally, harbor seals are observed on the Weepecket Islands (Crocker, 2004). These areas are located from 5.7 to 10 miles (9.1 to 16 km) south of the Alternative Site in New Bedford. No reproduction occurs in Buzzards Bay, since the harbor seal pups in late May to mid June, primarily along the Maine coast (Crocker, 2004). Additional detail on the harbor seal and the other marine mammals listed above is provided in Appendix 3-G.

Comparative Summary of Existing Resources

This section describes protected marine species in the three offshore alternative sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

The same federally-endangered or threatened whale species and sea turtle species, state-protected seal species and other federally protected marine mammals have the potential to occur at all three of the offshore alternative sites. However, some of the sites have historically higher sightings of these species or are located in closer proximity to key habitat used by these species. There have been more recorded sightings of whales, primarily Northern Atlantic right whales, in the vicinity of the South of Tuckernuck Island Site compared to the other two offshore alternative sites. In addition, the South of Tuckernuck Island and Nantucket Sound Sites are within close proximity to important breeding and pupping grounds for the state-protected gray seal and important haul out sites for the harbor seal. The South of Tuckernuck Island Site is located within 4.5 miles (7.2 km) of the Muskeget Island gray seal breeding colony and harbor seal haul out sites on Tuckernuck, Muskeget and Skiff Islands. The Nantucket Sound Site is within close proximity to the Monomoy and Muskeget Island breeding grounds for gray seals and haul out sites for harbor seals. The Horseshoe Shoal Site within Nantucket Sound and the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site are located more than 7 miles (11.2 km) from gray seal breeding colonies or haul out sites for gray seals and harbor seals.

There are no data that indicate greater or lesser utilization by sea turtles at any of the three offshore alternative sites.

3.4.3.2.5 Fisheries

This section describes finfish resources, Essential Fish Habitat (EFH), commercial fisheries, and recreational fisheries in the three offshore alternative sites under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. The data and level of detail used for this section was determined through consultation with other resource agencies.

A qualitative review of finfish resources was conducted consisting of a summary of the key species and resources documented at each of the three offshore alternative sites. Massachusetts Division of Marine Fisheries (MDMF) research trawl data was used for the Nantucket Sound and New Bedford/Horseshoe Shoal Sites. NMFS research

trawl data was used for the South of Tuckernuck Island Site. Information readily available in the literature or anecdotal information was used to supplement these data, as appropriate. Catch per Unit Effort (CPUE) was not calculated for the three offshore alternative sites, because it was not considered appropriate to compare CPUE from NMFS surveys and MDMF surveys (Brown, 2003). The two surveys use different gear, towing times, and towing speeds. Therefore, a qualitative list of species collected in research trawls provides a sufficient level of information about the fauna that generally occur in each site to allow for appropriate comparison of alternative sites.

USACE, in consultation with NMFS, determined that an analysis and comparison of specific EFH life stage designations, habitat characteristics, and the manner in which these characteristics affect EFH and EFH species for the three offshore alternative sites would be an appropriate and adequate level of detail for this alternatives analysis. Appendix 3-H contains detailed descriptions for the life history stages of species that have designated EFH for the three offshore alternative sites. Comparison of the three offshore alternative sites is based on existing literature, commercial fishery databases, and anecdotal assessments of commercial fisheries/fishing. Although there is a NMFS and MDMF commercial fisheries statistical area that includes the South of Tuckernuck Island Site, NMFS and USACE agreed that obtaining commercial landings data from this statistical area would not be useful since it is such a large geographical area compared to the size of the South of Tuckernuck Island Site. Instead, a qualitative overview of commercial fishing activities, type of fisheries and gear used (if available) are presented for each of the three offshore alternative sites.

The presentation of recreational fisheries information is based on summarizing the key fishing activities that may occur at each of these sites. To characterize the Nantucket Sound and South of Tuckernuck Island Sites, USACE used NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) data from Dukes, Barnstable, and Nantucket counties and results from the recreational (party boat/charter boat) intercept survey (Battelle, 2003) for Nantucket Sound and the surrounding area. For the New Bedford/Horseshoe Shoal Site, information to characterize existing recreational fishing/fisheries is from existing published literature, primarily the Buzzards Bay disposal site documents.

Massachusetts Military Reservation

The MMR Alternative Site is located in an upland environment, and no facilities are likely to affect streams or ponds at this Site, or any associated fishery. Therefore, a review of fisheries resources is not applicable and was not conducted.

Nantucket Sound

This section describes finfish resources, Essential Fish Habitat, commercial fisheries, and recreational fisheries in the Nantucket Sound Alternative Site.

Finfish Resources

The waters of Nantucket Sound support a diverse fish community. Both commercial and recreational fishing are conducted in the Sound. During the summer months, a temperature gradient forms off the east coast of Cape Cod that demarcates the location of the cold-water fishes to the north and warmer water fishes to the south (Freeman and Walford, 1974). This gradient is variable, and tends to oscillate north and south along a 20 to 40 mile (32 to 64 km) section of the Cape Cod shoreline. This temperature gradient that is observed along Cape Cod allows Nantucket Sound to serve as a migratory pathway for many warm-water species that pass through the Sound moving into Cape Cod Bay and Massachusetts Bay. The area also serves as a northern border for several summer migrants including scup, northern fluke, and black sea bass.

The MDMF conducts bi-annual research trawl surveys to collect fishery-independent information on abundance and distribution of fish and invertebrates from Massachusetts' waters. This data was obtained from trawl locations within the boundaries of the alternative sites in Nantucket Sound to characterize finfish resources in Nantucket Sound.[35] Common finfish and squid species collected during the spring trawl surveys included black

[35] Since 1978, MDMF has conducted trawl surveys in May and September of each year. These surveys provide a good long-term characterization of finfish resources in sampled areas, but do not represent the abundance and distribution of finfish over the entire year. The sampling program is based on a stratified random design. The coastal waters are stratified into geographic zones (strata) based on depth and

seabass (*Centropristis stria*), little skate (*Leucoraja erinacea*), longfin squid (*Loligo pealei*), Northern searobin (*Prionotus carolinus*), summer flounder (*Paralichthys dentatus*), windowpane (*Scopthalmus aquosus*), winter flounder (*Pseudopleuronectes americanus*), and winter skate (*Leucoraja ocellata*). Common finfish and squid species collected during the fall trawl surveys included black seabass, bluefish (*Pomatomus saltatrix*), butterfish (*Peprilus triacanthus*), little skate, longfin squid, Northern searobin, scup (*Stenotomus chrysops*), smooth dogfish (*Mustelus canis*), summer flounder, and winter skate (See Table 3-15a). In general, finfish catch numbers were lower during the spring surveys than during the fall surveys.

Many of the finfish species observed in Nantucket Sound exhibit migratory behaviors as water temperatures change. During the winter and early spring, certain species concentrate on the shoal areas in Nantucket Sound to feed and/or spawn; others will move off the shoals into channels or deeper waters. For example, winter flounder are known to move off the shoals into channels and deeper waters during the summer months when the shallow waters on the shoals heat to higher temperatures. Winter flounder are known to move back to the shoal areas in autumn when water temperatures begin to cool. In May, water temperatures in Nantucket Sound are still cool, and winter flounder are likely to be more common than in September, when water temperatures can remain warm. The MDMF research trawl data supported this observation, indicating that winter flounder were less common in the fall trawl surveys than during the spring trawl surveys. Summer flounder, on the other hand, are found on the shoals when water temperatures are warmer and move to deeper areas when the shoal waters become cooler.

Essential Fish Habitat

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). "Waters" in the above definition refer to the physical, chemical and biological properties of aquatic areas that are currently being used or have historically been used by fish. "Substrate" refers to sediment, hard bottom, or other underwater structures and their biological communities.

Habitat within the Nantucket Sound Site has been designated EFH for 19 federally managed fish and three federally managed invertebrates. These species include: Atlantic butterfish, Atlantic cod (*Gadus morhua*), Atlantic mackerel (*Scomber scombrus*), Atlantic sea herring (*Clupea* harengus), black sea bass, bluefin tuna (*Thunnus thynnus*), blue shark (*Prionace glauca*), cobia (*Rachycentron canadum*), king mackerel (S*comberomorus cavalla*), little skate, longfin squid, pollock (*Pollachius virens)*, scup, shortfin mako shark (*Isurus oxyrhinchus*), short-finned squid (*Illex illecebrosus*), Spanish mackerel (*Scomberomorus maculatus*), summer flounder, surf clam (*Spisula solidissima*), windowpane, winter flounder, winter skate, and yellowtail flounder (*Limanda ferruginea*).

EFH designations are generally based on the physical and biological characteristics of the waters or substrates in an area. A summary of the water depths, bottom types and other habitat characteristics for Nantucket Sound is presented below. More detailed information related to these habitat characteristics are discussed in Sections 3.4.3.2.2, 3.4.3.2.3, 3.4.3.2.6, and 3.4.3.2.15.

Water depth within the Nantucket Sound Alternative Site ranges between 6 feet (1.8 m) and 74 feet (22.6 m) below MLLW, with an estimated average depth of approximately 45 feet (NOAA, 2001a). The magnitude of the annual temperature range in Nantucket Sound averages 64.4°F (18°C) in offshore waters and 71.6°F (22°C) in nearshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C) (Theroux and Wigley, 1998). The substrate characteristics of Nantucket Sound consist mainly of sand-sized particles and a low TOC content (see Section 3.4.3.2.2 and 3.4.3.2.6).

A detailed EFH description for each life history stage of species with designated EFH in the offshore alternative sites is provided in Appendix 3-H. A comparison table of designated EFH species for the offshore alternative sites is provided in Table 3-15b.

area. Pre-determined trawl locations are allocated in proportion to the area of each stratum and then selected randomly within each stratum. The gear type and methods used during the survey are more effective at collecting demersal and semi-pelagic species. True pelagic species (e.g., Atlantic mackerel) and highly migratory species (e.g., bluefin tuna) are not frequently caught in bottom trawls. Therefore, the MDMF research trawls may not represent accurate abundance and distribution for these pelagic specie

Commercial Fisheries

Nantucket Sound supports a commercial fishery for various finfish species, squid, shellfish (including conch), and lobster. The top species of finfish and squid landed by commercial fishermen in Nantucket Sound, as reported from NMFS vessel trip reports from 1994 through 2001, include: squid, Atlantic mackerel, black sea bass, summer flounder, scup, menhaden, butterfish, tautog, winter flounder, and bluefish. Gear types used by commercial fishermen in Nantucket Sound for harvesting finfish species include: otter trawls, gill nets, fish weirs, pound nets, seines, various types of pots/traps, as well as hand lines. Finfish landings reported for the specific gear types from NMFS vessel trip reports indicate that the greatest landings were from otter trawls. Hand lines, fish pot/traps and fish weirs also produced significant catches.

Two of the main commercial fisheries in Nantucket Sound include the squid and summer flounder (fluke) fisheries. The commercial long-finned squid fishery opens on April 23 and ends May 31 of each year (MDMF, 2001a). The fishery can be extended by the MDMF Director for up to 2 weeks (to June 14) if squid size remains large and bycatch of other species remains low based on observer data (MDMF, 2001a). The commercial fluke fishery generally opens around the first week of July and lasts from 4 to 8 weeks. The beginning and length of the season depends on many factors including population presence and filled quotas, but it usually occurs in July and August (MDMF, 2001a). For both the squid and fluke fisheries, mobile gear renders the most success, and the otter trawl is the most popular method.

Species collected from fish weirs in Nantucket Sound generally include migratory pelagic species such as albacore tuna (*Thunnus alalunga*), amberjack (*Seriola sp*), Atlantic mackerel, bluefish, bonito (*Sarda sarda*), king mackerel, Spanish mackerel, as well as more resident demersal and groundfish species such as summer flounder, winter flounder, witch flounder, sea bass, butterfish, menhaden (*Brevoortia sp*), scup, weakfish (*Cynoscion regalis*), various herrings, and squid. Fish weirs are nets that are set off the beach or on sandbars (0 to 3 miles (4.8 km) out). Use of fish weirs is licensed by the towns and, therefore, takes place within the three-mile limit of state waters. Some of the top species landed in fish weirs in Nantucket Sound include: Atlantic mackerel, squid, and scup (MDMF data). Fish weirs or pound nets are the preferred method for fishing Atlantic mackerel, usually in springtime.

Although there is a low gill net fishing effort in Nantucket Sound, they do not appear to be used with any consistency. The species collected using this type of gear include: cod, haddock (*Melanogrammus aeglefinus*), hake (*Urophycis sp*), summer flounder, winter flounder, witch flounder, yellowtail flounder, monkfish (*Lophius americanus*), pollock, tautog (*Tautoga onitis*), cusk (*Brosme brosme*), various skates, and dogfish.

Both scup and black sea bass are important fisheries in Nantucket Sound. Many commercial fishermen have licenses for the harvesting of these species using fish pots. The commercial scup and black sea bass fishery does not have defined openings and closures. Filled quotas largely define seasons. A ‘season’ for either of these species can be broken up into several smaller seasons with different catch limits within a single year. Generally, sea bass landings are highest in May and June and scup landings are highest in June. The preferred methods of fishing for these species are stationary, i.e., pots and fixed nets (MDMF, 2001a).

Striped bass (*Morone saxatilis*) is another important fishery in Nantucket Sound. This fish is harvested both recreationally and commercially in the region. The commercial fishery for this species is a hook and line fishery and the season runs from July through September. MDMF monitors the striped bass that are landed and sold to market as well as those that are caught and released, or kept by the fishermen. Striped bass landings sold to market appear to be greatest during the month of July. By September, far fewer striped bass are typically landed and sold to market.

Shellfishing

Various species of shellfish are harvested commercially from Nantucket Sound. Shellfish harvested in this area include mussels, quahogs, bay scallops, surf clams, soft shell clams, and conch. Conch is the generic term for various species of whelk such as the knobbed whelk (*Busycon carica*), channeled whelk (*Busycotypus canaliculatus*), and lightning whelk (*Busycon sinistrum*), which are common gastropods in the Sound. Several species of conch are important fisheries in Nantucket Sound and are harvested commercially with fish pots, rakes or different types of shellfish dredges. Conch landings from fish pots have shown a general decline from 1992 through 2000 (MDMF data). According to MDMF data, shellfishing pressure, gauged by the number of licenses

issued, appears to have declined over these years as well. Surf clams (*Spisula solidissima*) and mussels are also commonly harvested species in Nantucket Sound (MDMF data).

Ocean quahogs (*Artica islandica*), Northern quahogs (*Mercenaria mercenaria*), bay scallops (*Aequipecten irradians*), sea scallops (*Placopecten magellanicus*), and soft shell clams (*Mya arenaria*) are also harvested in Nantucket Sound, but account for less of the total shellfish landings (MDMF data). Although northern quahogs seem to account for a low percentage of commercial shellfish landings in Nantucket Sound, they are reported as abundant in shallow coastal estuaries that empty into Nantucket Sound (MacKenzie, 1997) and are an important fishery within Massachusetts (MDMF, 2001b). In 2001, MDMF instituted a regulated permit for this species. According to MDMF staff (MDMF, 2001b), a heavily populated northern quahog area exists in the shoals to the east of Horseshoe Shoal. This area is referred to as the "quahog grounds" and is specifically targeted by commercial fishers (MDMF, 2001b).

Bay scallops occur in shallow waters of Nantucket Sound, primarily in areas near seagrass beds. According to MDMF (2001b), while bay scallops are a negligible fishery within Massachusetts, sea scallops are a commercially viable species in the state, bringing in $30-$85 million annually. Sea scallops occur offshore in the Mid-Atlantic, Georges Bank, and the Gulf of Maine, with the area of greatest abundance being Georges Bank (Packer et al., 1999). Sea scallops comprised a negligible percentage of the total shellfish landings in Nantucket Sound reported to MDMF from 1990 through 2000.

American Lobster Fishery

The American lobster (*Homarus americanus*) is found throughout New England, and a commercial fishery for this species exists in all coastal states from Delaware to Maine. Commercial permits for American lobster are issued for both inshore fishermen (within the three-mile territorial limit) and offshore fishermen (outside of the three-mile territorial limit).

A relatively small lobster fishery exists within the waters of Nantucket Sound. McBride and Hoopes (2001) report that the Nantucket Sound lobster fishery supplied only 0.4% (of nearly 10 million pounds (4.5 million kg)) of the total Massachusetts inshore waters harvest in 1999. The yield from adjacent areas was low, with each contributing less than 4% of the total harvest. Areas along the northern coast above Cape Cod Bay overwhelmingly produced the highest catches. Based on this catch data, it does not appear that the lobster stock is plentiful south of Cape Cod, and no data have been found which indicate the presence of a significant lobster population in Nantucket Sound.

Lobsters migrate inshore and offshore in response to changes in water temperature. Therefore, although the commercial season for lobster is open year-round in Nantucket Sound, peak landings occur during the summer months from June through August and into September, when water temperatures are warmer and lobsters are likely to be more abundant.

Recreational Fisheries

Because of its diverse fish community and its location adjacent to several vacation destinations (i.e., Cape Cod, Nantucket, and Martha's Vineyard), Nantucket Sound and the waters around the islands of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities. NMFS monitors recreational fishing throughout the country using a Marine Recreational Fisheries Statistics Survey (MRFSS). These surveys are conducted through telephone or face-to-face interviews with recreational anglers at various ports. NMFS interviewers record the county where anglers reported they participated in recreational fishing activities. Surveys question anglers as to where they fished, how long they fished, what types of gear they used, and what species they caught. For the purposes of characterizing recreational fishing in Nantucket Sound, interview data from three counties surrounding Nantucket Sound (Barnstable, Dukes, and Nantucket) were obtained from 1990 through 2001. It is assumed that at least some portion of the anglers surveyed from these counties were fishing within Nantucket Sound. A summary of key results from these MRFSS surveys is provided below.

The recreational fishing pressure for Nantucket Sound is highest during the warmer months (i.e., June through September) when more tourists are vacationing in the region. According to the MRFSS survey results, the mean number of hours spent recreational fishing in these three counties was greatest during July/August and is also

high in May/June and September/October. Very few hours were spent fishing in March and April. A negligible amount of recreational fishing occurs in the November to March period.

The majority of recreational anglers surveyed in the MRFSS program for these three counties reported using hook and line gear, and fishing from a private/personal or rented boat. Fishing from shore[36] was also commonly reported. The number of anglers reporting the use of party/charter boats[37] was much lower than those reporting the use of private boats or fishing from shore.

Common species caught by the recreational anglers surveyed by NMFS interviewers include: bluefish, Atlantic mackerel, scup, striped bass, winter flounder, summer flounder, menhaden, and tautog. The greatest numbers of fish caught by individual anglers were reported from those using private/rental boats. Anglers fishing from party/charter boats also reported catching large numbers of fish. Those anglers fishing from shore reported the lowest numbers of fish.

To better estimate the party boat and charter boat industry in Nantucket Sound, a telephone survey to registered party/charter boat captains in the region was conducted from September through November 2002 (Battelle, 2003). A total of 30 party and charter boat captains were surveyed. Twenty-seven of the 30 respondents were operators of charter boats, while only three were party boat operators. The number of anglers fishing from party boats and charter boats varied depending on the size of the vessel. Most charter vessels could accommodate five to six passengers; most of the party boats could take between 20-30 anglers per trip.

Both party and charter boats operators said that the most sought-after species on fishing excursions are striped bass, various tunas, and scup. Bluefish, bonito, sea bass, sharks, and cod were also common species caught by anglers aboard these vessels. As anticipated, most of the species are caught from May through September, since more people tend to engage in fishing activities using party and charter boats during these months.

The party and charter boat captains were also questioned on specific areas they take anglers to fish. The majority of the party boat and charter boat captains reported that for short (half-day trips) they did not take their anglers to the alternative sites in Nantucket Sound. The captains reported that the areas they fished most often included Squibnocket, Elizabeth Islands, Vineyard Sound, South Beach, Nauset, Buzzards Bay, Stage Harbor, Old Man, shoreline areas near Dennis/Harwich, Canyons, regions south of Martha's Vineyard, Nantucket Shoals, Muskeget Channel, and Great Point. The areas around Monomoy Island and those around Tuckernuck Island were also fished on half-day trips, but not as frequently as the locations listed above.

For full day trips aboard party boats and charter boats, the captains reported fishing the shoal areas around Monomoy Island, Tuckernuck Island, and Horseshoe Shoal in Nantucket Sound. The majority of full-day trips reported by the captains were taken to the shoal areas around Monomoy Island. Other full-day trips reportedly occurred in areas east of Monomoy Island, south of Martha's Vineyard, and regions southeast of Nantucket.

South of Tuckernuck Island

This section describes finfish resources, Essential Fish Habitat, commercial fisheries, and recreational fisheries in the South of Tuckernuck Island Alternative Site.

Finfish Resources

The South of Tuckernuck Site is an area between Martha's Vineyard and Nantucket. Various fish species may migrate through this area during seasonal migrations into and out of Nantucket Sound and offshore waters as water temperatures change.

[36] Includes any structure such as a pier, dock, or structure built over the water; any rock wall built out into the water or parallel to the shore to restrain currents or protect a harbor; a breakwater device; bridges; causeways; beaches; or banks.

[37] A party boat (often referred to as a head boat) is a boat on which fishing space and privileges are provided for a fee. The vessel is operated by a licensed captain and crew. A charter boat is also operated by a licensed captain and crew, however, the anglers are part of a pre-formed group that "charters" the boat, captain and crew for a specific price and time.

NMFS spring and fall research trawl survey data was obtained from trawl locations within the boundaries of the South of Tuckernuck Alternative Site (Figure 3-23) to characterize finfish resources in this area[38]. These data indicate that common finfish and squid species collected during the spring trawl surveys included: winter skate, little skate, spiny dogfish (*Squalus cubensis*), ocean pout (*Macrozoarces americanus*), winter flounder, longhorn sculpin (*Myoxocephalus octodecimspinosus*), windowpane, Atlantic herring, red hake (*Urophycis chuss*), and Northern sand lance (*Ammodytes dubius*). Common finfish and squid species collected during the fall trawl surveys included: spiny dogfish, little skate, smooth dogfish, long-finned squid, round herring (*Etrumeus teres*), winter skate, scup, winter flounder, windowpane, silver hake (*Meruccius bilinearis*), butterfish, and Northern searobin (see Table 3-15a). In general, the spring surveys had lower catch numbers but higher catch weights than the fall surveys.

Essential Fish Habitat

Habitat within the South of Tuckernuck Island Site has been designated as EFH for 28 federally-managed fish species and four federally-managed invertebrate species. These species include: Atlantic butterfish, Atlantic cod, Atlantic mackerel, Atlantic sea herring, black sea bass, bluefin tuna, blue shark, cobia, common thresher shark (*Alopias vulpinus*), dusky shark (*Carcharhinus obscurus*), haddock, king mackerel, little skate, long-finned squid, monkfish, ocean pout, ocean quahog, red hake, sandbar shark (*Carcharhinus plumbeus*), scup, shortfin mako shark, short-finned squid, Spanish mackerel, spiny dogfish, summer flounder, surf clam, whiting (*Merluccius bilinearis*), windowpane, winter flounder, winter skate, witch flounder (*Glyptocephalus cynoglossus*), and yellowtail flounder.

As discussed in the Nantucket Sound section, above, EFH designations are generally based on the physical and biological characteristics of the waters or substrates in an area. A summary of the water depths, bottom types and other habitat characteristics for the South of Tuckernuck Island Site is presented below. More detailed information related to these habitat characteristics are discussed in Sections 3.4.3.2.2, 3.4.3.2.3, 3.4.3.2.6, and 3.4.3.2.15.

Water depth within the South of Tuckernuck Island Alternative Site ranges between 15 feet (4.6 m) and 93 feet (28.4 m) below MLLW, with an estimated average depth of approximately 70 feet (21.4 m) (NOAA, 2001a). The magnitude of the annual temperature range at the South of Tuckernuck Island Site averages 62.6°F (17°C). The minimum temperature at this site is reported to be 35.6°F (2°C) and the maximum is reported to be 64.4°F (18°C) (Theroux and Wigley, 1998). The substrate characteristics of the South of Tuckernuck Island Site consist mainly of sand sized particles and a low TOC content. Finer-grained sediments containing silt and clay could also be expected at this site (see Section 3.4.3.2.2 and 3.4.3.2.6).

A detailed EFH description for each life history stage of species with designated EFH in the offshore wind park alternative sites is provided in Appendix 3-H. A comparison table of designated EFH species for the offshore alternative sites is provided in Table 3-15b.

Commercial Fisheries

Conversations with NMFS port agents indicated that specific information on commercial fishing in the South of Tuckernuck Island Site is not readily available. However, based on the location of this area, information regarding the type of commercial fishing activities that could occur in this area can be extrapolated. Although the South of Tuckernuck area is beyond the three-mile state territorial limit, it is still fairly close to shore from a commercial fishing perspective. Any commercial fishing activities in this area would generally be seasonal (April through October), with smaller commercial fishing boats targeting certain species as they move into and out of the surrounding sounds with the warmer and colder weather (Mahoney, 2003). The larger vessels that fish for cod and other fisheries would typically fish 20 to 50 miles (32 to 80 km) offshore (Mahoney, 2003), further from shore than the South of Tuckernuck Island Site.

[38] The spring survey is usually conducted between March and April and the fall survey between September and October. These surveys provide a good long-term characterization of finfish resources in sampled areas, but do not represent the abundance and distribution of finfish over the entire year. The bottom trawl gear has a very low efficiency for fast swimming and highly migratory species such as mackerel and bluefin tuna. These species generally exhibit a pelagic distribution and spend little time near the bottom. Therefore, the NMFS research trawls may not represent accurate abundance and distribution for these pelagic species.

The primary commercial fishing locations can change from year to year depending on environmental factors that affect the distribution of fish. Some areas may produce significant catches one year but not the next year. There is not always one particular area where commercial fishermen catch their fish, and commercial fishermen typically do not readily share precise information on the location of their fisheries catch. However, some of the fish species that may be caught by commercial fishermen in the vicinity of the South of Tuckernuck site might include fluke, black seabass, scup, and bluefish (Mahoney, 2003; Spenle, 2003). There may also be a commercial fishery for long-finned squid in this area, depending on squid distribution and permitted areas for squid fishing during a given year (Mahoney, 2003). See the commercial fisheries section for Nantucket Sound, above, for more detail on the long-finned squid and fluke commercial fisheries seasons. For both the squid and fluke fisheries, mobile gear renders the most success, and the otter trawl is the most popular method.

Likely fishing gear used in the South of Tuckernuck area for harvesting finfish species includes otter trawls and hook and line. Similar to Nantucket Sound, this area is probably not an area where gill nets are used extensively. In addition, this area may be too deep for the extensive use of fish pots, and it is outside of both Vineyard Sound and Nantucket Sound where these pots are more actively used (Mahoney, 2003). It is also unlikely that fish weirs are used in this area since they are typically set in nearshore waters, just off of beaches and sandbars.

Shellfishing

According to Whittaker (2004), during the late 1980s and early 1990s areas in the Tuckernuck and South of Tuckernuck vicinity may have been fished for ocean quahogs, but this activity is drastically reduced today. There is a possibility of some conch fishing in this area, although it is likely too deep for the consistent deployment of conch pots. In addition, this area is outside of both Vineyard Sound and Nantucket Sound, where fish and conch pots are more actively used (Mahoney, 2003).

American Lobster Fishery

Commercial permits for American lobster are issued for both inshore fishermen (within the three-mile territorial limit) and offshore fishermen (outside of the three-mile territorial limit). The South of Tuckernuck Alternative Site is located outside of the three-mile territorial limit within MDMF statistical reporting Area 16. According to McBride and Hoopes (2001), Area 16 has some of the highest landings for lobster of all offshore reporting areas in Massachusetts (1,000,001 to 2,000,000 lbs. (453,593 to 907,185 kg) in 1999). The South of Tuckernuck Island Alternative Site, however, comprises an extremely small portion of this large statistical area. The offshore area along the northern coast above Cape Cod Bay produced the highest landings. Based on this landings data, it does appear that the South of Tuckernuck area could support a significant lobster population; however, because the statistical reporting area is so large, it is not possible to determine if and how much of the South of Tuckernuck site contributes to the lobster catch in statistical Area 16.

Lobsters migrate inshore and offshore with response to changes in water temperature. Offshore landings are more evenly distributed during the year compared to inshore landings, with offshore potmen landings peaking in the autumn and mobile gear landings peaking in the winter months (McBride and Hoopes, 2001).

Recreational Fisheries

The popular vacation destinations of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities in the waters surrounding these islands. As discussed in the recreational fisheries section for Nantucket Sound, NMFS conducts recreational fisheries statistics surveys through the MRFSS program. For the purposes of characterizing recreational fishing in the South of Tuckernuck Island Site, interview data from the three counties surrounding Nantucket Sound (Barnstable, Dukes, and Nantucket) can also be used to characterize recreational fishing activities in the general region surrounding Tuckernuck Island. Data from these three counties were obtained from 1990 through 2001. It can only be assumed that at least some portion of the anglers surveyed from these counties were, in fact, fishing within or in the vicinity of the South of Tuckernuck alternative site. The key results from the MRFSS surveys conducted in these three counties over this timeframe is provided in the recreational fisheries section for Nantucket Sound above and summarized below.

The MRFSS survey results indicate that recreational fishing in the three counties was greatest during July/August and was also high in May/June and September/October. Very few hours were spent fishing in March and April. The majority of recreational anglers reported hook and line as gear type used for recreational fishing activities, and most recreational anglers reported fishing from a private/personal or rented boat as the type or mode of

recreational fishing. Fishing from shore was also commonly reported. The reported use of party/charter boats was much lower than the use of private boats or fishing from shore.

Common species caught by the recreational anglers surveyed by NMFS interviewers include: bluefish, Atlantic mackerel, scup, striped bass, winter flounder, summer flounder, menhaden, and tautog. The greatest numbers of fish caught by anglers were reported from those using private/rental boats, followed by party/charter boats. Those anglers fishing from shore reported the lowest numbers of fish.

To better estimate the party boat and charter boat industry in the Nantucket Sound area, a telephone survey to registered party/charter boat captains in the region was conducted from September through November 2002 (see the recreational fisheries section for Nantucket Sound). In addition to providing information on Nantucket Sound and offshore areas, some of the captains interviewed during these surveys provided information on fishing activities in the vicinity of Tuckernuck Island.

Both party and charter boat operators mentioned that the most sought-after species are striped bass, various tunas, and scup. Bluefish, bonito, sea bass, sharks, and cod were also common species caught by anglers aboard these vessels. As anticipated, most of the species are caught on trips during the months of May through September.

The party and charter boat captains were also questioned on specific areas they take anglers to fish. The majority of the party boat and charter boat captains reported that for short (half-day trips), the areas they fished most often included: Squibnocket, Elizabeth Islands, Vineyard Sound, South Beach, Nauset, Buzzards Bay, Stage Harbor, Old Man, shoreline areas near Dennis/Harwich, Canyons, regions south of Martha's Vineyard, Nantucket Shoals, Muskeget Channel, and Great Point. The areas around Monomoy Island and those around Tuckernuck Island were also fished on half-day trips, but not as frequently as the locations listed above.

For full day trips aboard party boats and charter boats, the captains reported fishing the shoal areas around Monomoy Island, Tuckernuck Island, and Horseshoe Shoal. The majority of full-day trips reported by the captains were taken to the shoal areas around Monomoy Island. Other full-day trips reportedly occurred in areas surrounding Tuckernuck Island, areas east of Monomoy Island, areas south of Martha's Vineyard, and regions southeast of Nantucket.

New Bedford / Horseshoe Shoal

This section describes finfish resources, Essential Fish Habitat, commercial fisheries, and recreational fisheries in the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative Site. For information on the Horseshoe Shoal portion of this alternative please see the Nantucket Sound section, above.

Finfish Resources

Many fish species utilize the New Bedford Harbor/Buzzards Bay portion of the Site during part or all of their life cycles. Many of the fish in Buzzards Bay are migratory and move along the southeastern New England coast and into the Bay in summer and often through the Cape Cod Canal into Cape Cod Bay (Carey and Haley, 2002). Howes and Goehringer (1996) reviewed available information and identified the following 10 fish species as dominant species found in Buzzards Bay waters: scup, butterfish, winter flounder, alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), Atlantic menhaden (*Brevoortia tyrannus*), black sea bass, tautog, bluefish, and striped bass (Table 3-15a). These species and other species found in the Bay include resident and non-resident (migratory) species. Buzzards Bay contains many coves, small embayments, salt marshes, and tidal flats, and represents a significant spawning ground for southern New England (Howes and Goehringer, 1996). Large numbers of anadromous fish species such as American shad, striped bass, and alewives migrate into tributaries of Buzzards Bay every year during spawning seasons. Studies (NBHTC, 1998) indicate that nearly 50 species of finfish use the waters of Buzzards Bay.

MDMF bi-annual spring and fall research trawl survey data was obtained by Carey and Haley (2002) from trawl locations in Buzzards Bay. This information was reviewed to help characterize finfish and squid resources in the New Bedford Harbor/Buzzards Bay portion of this alternative. Carey and Haley (2002), with collaboration from CZM and DMF biologists, compiled a list of select species that occur in Buzzards Bay from the MDMF trawl data.

A species was categorized as a "select species" if it was within the top 80% of the total catch in numerical abundance in either season and was determined to be a representative species of Buzzards Bay. Select species identified following this approach included: alewife, Atlantic herring, bay anchovy (*Anchoa mitchilli*), black sea bass, blueback herring, bluefish, butterfish, cunner (*Tautogolabrus adspersus*), little skate, long-finned squid, Northern sea robin, scup, striped anchovy (*Anchoa hepsetus*), summer flounder, tautog, weakfish, windowpane, and winter flounder. In general, fall finfish catch numbers were greater than spring finfish catch numbers with abundance totals of 572,879 fish representing 69 species in the fall and 50,356 fish representing 49 species in the spring (Carey and Haley, 2002).

Essential Fish Habitat

Habitat within the New Bedford/Horseshoe Shoal Alternative Site has been designated EFH for 23 federally-managed fish species and three federally-managed invertebrate species. These species include: American plaice (*Hippoglossoides platessoides*), Atlantic butterfish, Atlantic cod, Atlantic mackerel, Atlantic sea herring, black sea bass, bluefin tuna, bluefish, blue shark, cobia, haddock, king mackerel, little skate, long-finned squid, red hake, sandbar shark, scup, shortfin mako shark, short-finned squid, Spanish mackerel, summer flounder, surf clam, windowpane, winter flounder, winter skate, and yellowtail flounder (Table 3-15b).

As discussed in the Nantucket Sound section, above, EFH designations are generally based on the physical and biological characteristics of the waters or substrates in an area. A summary of the water depths, bottom types and other habitat characteristics for the New Bedford portion of this Alternative Site is presented below. More detailed information related to these habitat characteristics are discussed in Sections 3.4.3.2.2, 3.4.3.2.3, 3.4.3.2.6, and 3.4.3.2.15.

Water depths in the New Bedford portion of this alternative area range between 15 feet (4.6 m) and 48 feet (14.6 m) at MLLW, with an average depth of approximately 25 feet (7.6 m) (NOAA, 2001b). The magnitude of the annual temperature range in New Bedford Harbor averages 69.8°F (21°C) in nearshore waters, and just slightly less in offshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C) (Theroux and Wigley, 1998). The substrate characteristics of the New Bedford portion of this alternative consist of fine sands, silts, and clays and a moderately high TOC content (see Sections 3.4.3.2.2 and 3.4.3.2.6.

Commercial Fisheries

The majority of commercial fishermen who have their homeport in Buzzards Bay fish offshore, outside of the alternative area, for lobster, scallops and groundfish (Colburn et al., 2002). They typically fish on Georges Bank, Nantucket Shoals, and the Great South Channel for sea scallops, Atlantic cod, haddock, winter flounder, mackerel, and other species (NBHTC, 1998).

Commercial finfish trawling and use of nets has been banned in New Bedford Harbor and Buzzards Bay since the early 1800's (Howes and Goehringer, 1996). This ban does not include fish potting and angling. In addition, a small portion of the Alternative Site is located within Area II (see Figure 3-28), an area closed to the taking of bottom feeding fish (eel, scup, flounder, and tautog) as a result of PCB contamination (NBHTC, 1998).

Some of the commercial finfish that are fished in Buzzards Bay include scup and black sea bass using fish pots. Angling for fluke and scup also occurs in portions of Buzzards Bay (Colburn et al., 2002). Commercial angling for striped bass using hook and line occurs in the Bay, but mainly around the Elizabeth Islands, especially Cuttyhunk and also around the Weepecket Islands (Figure 3-27) (Colburn et al., 2002). Once a year, starting in early to mid-May, a group of 12-30 boats (termed the "mosquito fleet") commercially fish using hook and line primarily for scup and black sea bass. These species are fished and then sold to the New York market and also to smaller informal markets in Fairhaven and New Bedford (Colburn et al., 2002). These finfish are commercially fished between April and mid-November, with the highest abundance and harvesting occurring during the warmer summer months (Colburn et al., 2002).

Shellfishing

Since finfish trawling and use of nets has been banned in New Bedford Harbor and Buzzards Bay, commercial fishing in this area has focused on shellfisheries (NBHTC, 1998). According to NBHTC (1998), a number of

commercially important species of shellfish are present in the outer portion of New Bedford Harbor; however, due to contamination, only a few of these species support active fisheries in the Harbor estuary.

The most important species harvested from this area is the northern quahog (Howes and Goehringer, 1996; NBHTC, 1998) which supports both commercial and recreational shellfish fisheries year-round in Clarks Cove and other areas of outer New Bedford Harbor and Buzzards Bay, primarily along the perimeter of the Bay (Howes and Goehringer, 1996). According to Whittaker (2004), both the northern quahog and whelk (conch) are fished commercially within the boundaries of the New Bedford portion of this Alternative Site. Presently, there are approximately 5 boats that intermittently fish for northern quahogs in the deeper waters of this area.

Other types of commercial shellfishing in Buzzards Bay include pot fisheries such as lobster (discussed below) and conch. The central area of Buzzards Bay is used extensively for whelk (conch) potting (Colburn et al., 2002). The majority of whelks captured with pots are the channeled whelk, since knobbed whelks are not easily captured in pots according to Colburn et al. (2002). Conch are harvested between mid-April and mid-December, with highest harvest activity between August and November.

Soft-shelled clam and bay scallop support small commercial fisheries (NBHTC, 1998); however, according to Howes and Goehringer (1996), the bay scallop still sustains an important commercial fishery in parts of Buzzards Bay, including Clarks Cove (Figure 3-27, directly north-northwest of the New Bedford portion of this Site). Although specific locations for scallop dredging in Buzzards Bay varies from year to year, the scallop set is generally centered on Cleveland Ledge (Colburn et al., 2002), north of the New Bedford portion of this Alternative Site (Figure 3-27). The scallop fishery, however, has declined in recent years, potentially as a result of high levels of copper in the sediments (Howes and Goehringer, 1996). Limpets are taken in an informal, unregulated fishery (NBHTC, 1998). Although blue mussels are present in the outer portion of New Bedford Harbor, they are not abundant enough to support a fishery.

American Lobster Fishery

Commercial permits for American lobster are issued for both inshore fishermen (within the three-mile territorial limit) and offshore fishermen (outside of the three-mile territorial limit). The New Bedford/Buzzards Bay portion of this Site is located within the three-mile territorial limit in MDMF statistical reporting Area 14. McBride and Hoopes (2001) report that the Buzzards Bay lobster fishery supplied 2.87% (of nearly 10 million pounds (4.5 million kg)) of the total Massachusetts territorial harvest in 1999. The greatest harvest of lobster from territorial waters was from the Boston Harbor vicinity, which contributed 24.04% of the territorial harvest in 1999.

Buzzards Bay is a spawning ground for lobsters (Howes and Goehringer, 1996). In Massachusetts, peak lobster harvesting occurs between July and November (McBride and Hoopes, 2001). Although lobstering is an important fishery within Buzzards Bay, lobsters may not be taken from the New Bedford portion of Buzzards Bay due to PCB contamination. Most of the New Bedford portion of this alternative is closed to commercial and recreational lobster fishing as a result of this contamination (NBHTC, 1998). This closure was enacted by the Commonwealth of Massachusetts in September 1979 and is still in effect today. As shown in Figure 3-28, the New Bedford portion of this Alternative Site is located primarily within Areas II and III, which are both closed to the taking of lobsters.

Recreational Fisheries

Recreational fishing is popular in Buzzards Bay and outer New Bedford Harbor (NBHTC, 1998). This area supports a highly developed recreational fishery through numerous marinas, launch sites, bait and tackle shops, and charter boat operations (Colburn et al., 2002). Highest activity is reported to occur at the entrance to the Cape Cod Canal, well northeast of the New Bedford Harbor portion of this Site (Figure 3-27). Anglers reported that the strong currents at the entrance to the Canal create ideal conditions for recreational angling for scup, striped bass, bluefish, tautog, weakfish, black sea bass, and fluke (Colburn et al., 2002). Another popular area for recreational fishing is near the Elizabeth Islands (Figure 3-27) along the southeastern margin of Buzzards Bay (Colburn et al., 2002), well south of the alternative site. Recreational anglers in this area generally focus on access to structure such as submerged rocks, shoals and holes (Colburn et al., 2002). Therefore, the relatively flat center of the Bay is not frequently fished recreationally.

Popular recreational fishing areas closer to the New Bedford portion of this alternative include the Hurricane Barrier, jetties along Clarks Point, and Fort Phoenix (Figure 3-27) where rod and reel fishermen fish from shore for striped bass, bluefish, tautog, and scup (NBHTC, 1998). Little and Big Egg Island and the Butler Flats lighthouse, just northeast of the alternative site, are popular recreational areas fished using small boats. These areas are fished for bluefish, tautog, and other species (NBHTC, 1998). The margins of the Bay from Westport to Marion (includes New Bedford area) are also targeted areas mainly for scup and tautog (Colburn et al., 2002).

The largest recreational fishing group in the Buzzards Bay area use pleasure boats that are moored and trailered from various launch sites, harbors and marinas around the Bay (Colburn et al., 2002). "Six-pack" charters[36] also operate in Buzzards Bay and generally target striped bass and bluefish. Many of these charters fish around the islands and beyond Buzzards Bay, although some also fish within Buzzards Bay. A specialized charter operation focusing on light tackle sport fishing (fly fishing, etc.) fishes in part of Buzzards Bay, but usually well north or west of the alternative site. A few large-scale charters, operate within Buzzards Bay. These large-scale boat charters primarily target scup, black sea bass, tautog, and fluke (Colburn et al., 2002).

For all types of recreational fishing, the highest fishing activity occurs during warmer months from April to November with increased intensity between May and October and highest intensity in July (Colburn et al., 2002).

Comparative Summary of Existing Resources

This section describes finfish resources, Essential Fish Habitat (EFH), commercial fisheries, and recreational fisheries in the three offshore alternative sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

All three of the offshore alternative sites contain various finfish species including migratory and resident species, benthic and pelagic species. The New Bedford portion of the New Bedford/Horseshoe Shoal Site is closer to spawning grounds utilized by several anadromous fish species such as American shad (*Alosa sapidissima*), striped bass, and alewives than the other two offshore alternative sites. All three offshore sites generally contain similar finfish species; however, the South of Tuckernuck Island Site contains the greatest number of fish species since it has habitat that is preferred by species that typically occur in deeper, cooler waters. However, this is tempered somewhat by the presence of the additional habitat diversity represented by rock ledge at the New Bedford site.

With the exception of pollock, all the species with designated EFH in the Nantucket Sound Alternative Site also have designated EFH for one or more life stages at the other two offshore alternative sites. The habitat characteristics of the Nantucket Sound Alternative Site generally fall in a range between the two other offshore alternative sites. Specifically, the Nantucket Sound alternative is relatively shallower and warmer than the South of Tuckernuck Island Site and relatively deeper and cooler than the New Bedford/Horseshoe Shoal Site. This may explain why, aside from the EFH designation for pollock, there are no designated EFH species or life stages that are unique to the Nantucket Sound Alternative Site. The substrate characteristics of Nantucket Sound are similar to those at the South of Tuckernuck Island Site, but substrate did not seem to play a role in distinguishing which species had designated EFH at the three offshore alternative sites.

Many of the species with designated EFH in the South of Tuckernuck Island Site also have designated EFH for one or more life stages at the other two offshore alternative sites. However, the South of Tuckernuck Island Site has the most species and life stages with designated EFH unique to this Site. There are eight species (common thresher shark, dusky shark, monkfish, ocean pout, ocean quahog, spiny dogfish, whiting, and witch flounder) that have EFH life stage designations only at the South of Tuckernuck Island Site and not at the other two offshore alternative sites. There are also eight life stages of certain species that only have designated EFH at this Site. The habitat requirements for these species/life stages typically are waters that have a deeper depth range and cooler temperatures. The South of Tuckernuck Island Site was found to be generally deeper and cooler than both the Nantucket Sound Alternative Site and the New Bedford/Horseshoe Shoal Alternative Site and therefore contains the habitat preferred by these species/life stages. The sand-sized substrate type at this Site is similar to substrates found in Nantucket Sound, but coarser than the sediments found in the New Bedford portion of the

[36] "Six pack" charters or "six packers" refer to the smallest scale charter operations in the Bay generally involving boats 18 to 24 feet in length with "six" referring to the maximum number of passengers. It is primarily a catch-and-release fishery focused on sport rather than subsistence fishing.

New Bedford/Horseshoe Shoal Site. Substrate did not seem to play a role in distinguishing which species had designated EFH at the three offshore alternative sites.

The New Bedford portion of this Alternative Site is generally shallower and warmer than the South of Tuckernuck Island Site and the Nantucket Sound Site. In addition, the substrate in the New Bedford portion of this Site is predominated by fine sands, silts, and clays and a moderately high TOC content, in contrast to the coarser sand-sized sediments and low TOC content at the other two offshore alternative sites. Despite these differences, there are very few species or life stages of species that have designated EFH only at this Site. Most of the species and life stages with designated EFH at the New Bedford/Horseshoe Shoal Alternative Site also have designated EFH for one or more life stages at the other two offshore alternative sites. Only one species, the bluefish, has designated EFH unique to this Site. The EFH habitat description for bluefish assigns EFH to bluefish mainly in estuaries within the mixing and seawater zones, more characteristic of the New Bedford portion of this Site. Other life stages that had EFH designations unique to the New Bedford portion of the Site also typically had habitat requirements that are commonly found in estuaries or mixing zone areas.

A detailed EFH description for each life history stage of species with designated EFH in the offshore wind park alternative sites is provided in Appendix 3-H. A comparison table of designated EFH species for the offshore alternative sites is provided in Table 3-15b.

All three offshore alternative sites are used for commercial and recreational fishing. However, commercial finfish trawling and use of nets has been banned in New Bedford Harbor and Buzzards Bay since the early 1800's (Colburn, et al., 2002; NBHTC, 1998; Howes and Goehringer, 1996); therefore, the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative does not have active commercial finfish fisheries except for commercial pot or hook and line fisheries. With the more open ocean aspects of the South of Tuckernuck Island Site, the segment of the recreational fishing community with smaller boats probably does not venture to this site as frequently as the more protected waters of New Bedford Harbor or Nantucket Sound.

3.4.3.2.6 Benthos

This section describes benthic habitat, benthic community composition and abundance, and shellfish resources in the three offshore alternative sites under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Available literature from site-specific studies by reputable benthic experts was used as the basis for the resource characterization. The data and level of detail used for this section was determined through consultation with other resource agencies.

A qualitative review of benthic resources was conducted for each of the three offshore alternative sites consisting of a detailed summary of the habitat variables that most influence benthic community composition (i.e., water depth, temperature, and clarity; sediment grain size; and total organic carbon content), as well as benthic species composition and organism abundance and diversity. The results of this review are provided below, followed by a comparative summary of site resources. Note that information regarding commercial shellfishing and the lobster fishery was provided in Section 3.2.3.2.5.

Massachusetts Military Reservation

The MMR Alternative Site is located in an upland environment. Therefore, there are no benthic resources associated with the MMR Site. The several small ponds found within the boundaries of the MMR Alternative Site would be avoided by all construction and operation activities, and therefore the freshwater benthic species or habitats do not warrant characterization.

Nantucket Sound

This section describes benthic habitat, benthic community composition and abundance, and shellfish resources for the Nantucket Sound Alternative Site.

Benthic Habitat

As discussed in Section 3.4.3.2.3, water depth within the Nantucket Sound Alternative Site ranges between 6 feet (1.83 m) and 74 feet (22.6 m) at MLLW, with an estimated average depth of approximately 45 feet (13.7 m) (NOAA, 2001b). This is, in general, shallower than the South of Tuckernuck Island Site and, on average, deeper than the New Bedford portion of the combined New Bedford/Horseshoe Shoal Site. The relatively shallow and clear waters of the Sound allow light penetration sufficient for photosynthesis. The magnitude of the annual temperature range in Nantucket Sound averages 64.4°F (18°C) in offshore waters and 71.6°F (22°C) in nearshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C), which is relatively warmer than the South of Tuckernuck Island Site and relatively cooler than the New Bedford/Horseshoe Shoal Site (Theroux and Wigley, 1998).

Bottom sediments in Nantucket Sound are subject to wave energy on a regular basis due to relatively shallow waters. The prevalence of sand waves in Nantucket Sound (Section 3.4.3.2.2) indicates that sediment shifting is an ongoing process in the Sound, which tends to influence benthic community composition (e.g. Mauer and Wigley, 1984).

Sediment grain size and total organic carbon (TOC) content are two variables shown to influence the composition of benthic communities and the abundance of benthic organisms. The composition of the bottom sediments of Nantucket Sound is well known, having been documented in over 20 different studies. In general, as discussed in (Section 3.4.3.2.2), Nantucket Sound is dominated by sand-sized particles (Pratt, 1973), with the exception of the Tuckernuck Shoal area, which is dominated by gravelly sand (Poppe et al., 1989; Theroux and Wigley, 1998). The NOAA nautical chart for the Nantucket Sound Alternative does not show any areas of rock within or immediately adjacent to the site boundary.

Not all benthic organisms are influenced by sediment grain size in the same direction or to the same degree; however, the general trend is for increasing numbers and diversity with increasing sediment grain size (Wigley and McIntyre, 1964; Theroux and Wigley, 1998; Rhoads and Germano, 1986; Zajac et al., 2000), particularly with regard to the smaller size fractions (silt-clay, sand-silt, and sand).

The content of TOC in sediment has been attributed to the presence of microscopic organisms such as benthic bacteria, diatoms, and other meiofauna (Rhoads, 1974; Driscoll, 1975). Consequently, a seasonal variation in the organic content of the sediment is observed that is due largely to variations in the standing crop of benthic organisms (Driscoll, 1975). The TOC content of sediments in Nantucket Sound is reported to be low, with a TOC content of less than 0.5% throughout most of the open water area (Theroux and Wigley, 1998). This is in contrast to the TOC content found to exist in sediments of many bays and estuaries, which often exceeded 2% (Theroux and Wigley, 1998). In general, sediment with very low TOC (<0.5%) typically supports a macrobenthic community that is less abundant and less diverse (Theroux and Wigley, 1998).

Benthic Community Composition and Abundance

Based on literature reviewed, Nantucket Sound is generally reported as a moderate to highly productive area for benthic invertebrates, with densities of benthic organisms typically ranging between 1,000 and 5,000 individuals/m^2. Benthic organism biomass had a much broader range, spanning very low productivity to moderately high productivity, typically ranging between 1 and 500 grams/m^2 (Mauer and Wigley, 1984; Theroux and Wigley, 1998). The relatively high productivity areas are most likely attributable to the relatively shallow water depths and the predominantly sandy bottom that characterize much of Nantucket Sound, as discussed above. Although density and biomass of the benthic community is reportedly high, faunal diversity (i.e., numbers of species and numbers of individuals per species) in Nantucket Sound is reported to be lower than the diversity observed in the rest of the Southern New England Shelf (Sanders, 1968). This may be attributable to the sandy substrate of Nantucket Sound which is dynamic and mobile in the relatively shallow waters, as indicated by ripple marks and sand waves. The magnitude and frequency of sand movements has a marked influence on the diversity and abundance of the benthic communities (Pratt, 1973). Organisms living on or in these sandy sediments are dominated by those that are adapted for movement or settlement in sand and recovery from burial (Pratt, 1973; Mauer and Wigley, 1984).

Literature reviewed indicates that the most abundant taxa in the Nantucket Sound benthic fauna are crustaceans and mollusks, followed by polychaete worms (Theroux and Wigley, 1998; Avery et al., 1996). Among the

crustaceans, the amphipods are reported to be by far the most abundant. The sandy sediments of Nantucket Sound are reported to support a diverse assemblage of amphipod species dominated by haustoid species that are reported to be suspension feeders (Pratt, 1973).

In general, the benthic fauna of Nantucket Sound is reported to be only moderately diverse (Pratt, 1973), with several researchers reporting that less than five faunal groups typically comprise more than 75% of the organisms collected (Sanders, 1959; Sanders, 1968). Table 3-16 lists the dominant benthic taxonomic groups and the corresponding densities (number of individuals/m^2) occurring within Nantucket Sound according to the report prepared by Theroux and Wigley (1998).

Shellfish Resources

MDMF research trawl survey data was obtained from trawl locations within the boundaries of the alternative sites in Nantucket Sound to help characterize shellfish resources in this area. These data indicate that common shellfish species collected during these surveys included the channeled whelk, lady crab (*Ovalipes ocellatus*), Atlantic rock crab (*Cancer irroratus*), and spider crab (*Libinia emarginata*) in both the spring and fall trawl surveys, and the knobbed whelk in the fall trawl surveys. Commercial shellfishing and lobstering are discussed in Section 3.4.3.2.5.

According to MDMF (2001b), there is a heavily populated area of northern quahog in the shoals east of Horseshoe Shoal. Bay scallops are reported to occur in shallow waters of Nantucket Sound, primarily in areas near seagrass beds. Also, two species of large gastropod whelks (knobbed whelk and channeled whelk) are abundant in the coastal waters of Nantucket Sound (Davis and Sisson, 1988).

South of Tuckernuck Island

This section describes benthic habitat, benthic community composition and abundance, and shellfish resources for the South of Tuckernuck Island Alternative Site.

Benthic Habitat

Water depth within South of Tuckernuck Island Alternative Site ranges between 15 feet (4.6 m) and 93 feet (28.4 m) at MLLW, with an estimated average depth of approximately 70 feet (21.4 m) (NOAA, 2001a). The magnitude of the annual temperature range at the South of Tuckernuck Island Site averages about 62.6°F (17°C). The minimum temperature at this site is reported to be 35.6°F (2°C) and the maximum is reported to be 18°C (64.4°F), which is slightly cooler than either the Nantucket Sound Site or the New Bedford/Horseshoe Shoal Site (Theroux and Wigley, 1998).

Benthic community composition and abundance is influenced, in part, by water depth. Deeper, typically cooler, waters, such as those found in some areas of the South of Tuckernuck Alternative Site, are reported by several researchers to generally support lower marine benthic organism abundance (Mauer and Wigley, 1984) and biomass (Theroux and Wigley, 1998), although in the waters of southern New England, only a slight (<10%) decrease in abundance and biomass occurs in depths greater than 75 feet (22.9 m) (Theroux and Wigley, 1998). Average water depths are greater in the South of Tuckernuck Island Alternative Site than the other two offshore alternative sites; therefore, it is likely that there would be more deposit-feeding species and fewer suspension-feeding species at the South of Tuckernuck Island Site, particularly in the deepest areas of the Site. In addition, the deeper areas of this Site (those areas with depths greater than 75 feet (22.9 m)) would likely be characterized by organisms prevalent in stable substrates, since there would be fewer disturbances due to less wave energy reaching the bottom in these areas than the other offshore alternative sites. Consequently, this community would be expected to have a greater number of taxa, a characteristic of stable sand substrates.

The composition of the bottom sediments at the South of Tuckernuck Island Alternative Site has been documented in several studies (Theroux and Wigley, 1998; Poppe et al., 1989). Although no studies focused solely on the South of Tuckernuck Island Alternative Site, the studies did include the Site as part of larger evaluations designed to characterize sea floor sediments in the region. In general, as discussed in Section 3.4.3.2.2, the South of Tuckernuck Island Alternative Site is dominated by sand-sized particles (Theroux and Wigley, 1998; Poppe et al., 1989), which in marine environments typically support the highest density and

biomass of organisms per square meter, as compared to either larger or finer grained material (Theroux and Wigley, 1998).

The content of TOC in sediment at the Site is reported to be low, with a TOC content of less than 0.5% throughout the area (Theroux and Wigley, 1998).

Benthic Community Composition and Abundance

Based on literature reviewed, the South of Tuckernuck Island Alternative Site is generally reported as a moderately productive area for benthic invertebrates, with densities of benthic organisms typically ranging between 700 and 5,500 individuals/m^2 and benthic organism biomass typically ranging between 50 and 500 grams/m^2 (Wigley and McIntyre, 1964 and Theroux and Wigley, 1998).

This Site is reported to have a slightly higher benthic organism diversity than Nantucket Sound and a diversity similar to that found near the New Bedford/Horseshoe Shoal Site (Sanders, 1968; Theroux and Wigley, 1998). This may be a function of the generally deeper water depths and more stable substrate at this Site. The reduced magnitude and frequency of sand movement is believed to be correlated with more diverse benthic communities, since relatively few species have adapted to recover from burial (Pratt, 1973).

Literature reviewed indicates that the most abundant taxa at the South of Tuckernuck Island Site are crustaceans and mollusks, followed by polychaete worms (Theroux and Wigley, 1998). Among the crustaceans, the amphipods are reported to be by far the most abundant. This is similar to the community found in Nantucket Sound. However, several taxon are expected to occur at the South of Tuckernuck Island Site that would be much less common within Nantucket Sound. These include the Crustacean taxa: Amphipoda, Cumacea, and Isopoda, as well as the Nemeitea, Nematoda, and Sipuncula (peanut worms).

In general, the fauna of the South of Tuckernuck Island Site is reported to be only moderately diverse (Pratt, 1973), with several researchers reporting that less than five faunal groups typically comprise more than 75% of the organisms collected (Sanders, 1959; Sanders, 1968). Table 3-17 lists the dominant benthic taxonomic groups and the corresponding densities (number of individuals/m^2) occurring at the Site according to the report prepared by Theroux and Wigley (1998).

Shellfish Resources

NMFS spring and fall research trawl survey data was obtained from trawl locations within the boundaries of the South of Tuckernuck Island Site (Figure 3-23) to characterize shellfish resources in this area. These data indicate that shellfish species collected during these surveys included the American lobster, Atlantic rock crab, Jonah crab (*Cancer borealis*), and spider crab in both the spring and fall trawl surveys and the lady crab, sea scallop, and unclassified shrimp in the fall trawl surveys. Commercial shellfishing and lobstering are discussed in Section 3.4.3.2.5.

Given that the South of Tuckernuck Island Site is, on average, deeper than the other two offshore alternative sites, it is expected that the shellfish community would not contain as many of the suspension (filter) feeding mollusk species. The highest abundances and diversity of suspension-feeding mollusks tend to be associated with water depths of less than 60 feet in areas south of Cape Cod (Saila and Pratt, 1973). Suspension-feeding species are reported to be less common South of Tuckernuck Island than at the other offshore alternative sites. These species include: northern quahog, bay scallop, sea scallop, surf clam, and soft-shelled clam (Weiss, 1995; Saila and Pratt, 1973; Gosner 1978; Smith 1964). In contrast to the suspension feeders, the channeled whelk (conch) and knobbed whelk are more common in shallow waters (Weiss, 1995) and would therefore be expected to be less common in the deeper waters of the Site.

Two species of mussel are common to the region, blue mussel (*Mytilis edulis*) and horse mussel (*Modiolus modiolus*). The blue mussel is common in shallower waters near low tide attached to rocks and shells (Weiss, 1995). Rocky habitat is not present at the South of Tuckernuck Island Site, but is present in New Bedford Harbor, and to a lesser extent in Nantucket Sound, particularly in areas associated with the various shoals and shallows where cobble and gravel are present. Therefore, it is expected that fewer blue mussels would be found at the South of Tuckernuck Island Site. The horse mussel is far less common in the region, particularly in areas south of Cape Cod, but typically lives in deeper waters to depths of 240 feet (73.2 m) (Weiss, 1995) and is

therefore expected to be more common at the South of Tuckernuck Island Site than at either of the other two offshore alternative sites.

Similarly, ocean quahogs are more common in deeper waters with finer sand to mud substrates (Weiss, 1995). Saila and Pratt (1973) report that the ocean quahog was found to occur at depths between 60 and 90 feet (18.3 and 27.5 m); therefore, this species is likely to be more common at the South of Tuckernuck Island Site than at the other two offshore alternative sites.

New Bedford / Horseshoe Shoal

This section describes benthic habitat, benthic community composition and abundance, and shellfish resources for the New Bedford/Horseshoe Shoal Alternative Site. For information on the Horseshoe Shoal portion of this alternative, please see the Nantucket Sound section, above.

Benthic Habitat

The New Bedford/Horseshoe Shoal Alternative Site includes a relatively small area south of New Bedford Harbor as well as a substantial portion of Horseshoe Shoal located within Nantucket Sound. For this analysis, the focus is on the benthic habitat and the benthic community associated with the New Bedford Harbor portion of the Site. Depths in this area range between 15 feet (4.6 m) and 48 feet (14.6 m) at MLLW, with an average depth of approximately 25 feet (7.6 m) (NOAA, 2001b). The magnitude of the annual temperature range in New Bedford Harbor averages 69.8°F (21°C) in nearshore waters, and slightly less in offshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C) (Theroux and Wigley, 1998).

Due to relatively shallow water depths, the benthic community of the New Bedford/Horseshoe Shoal Alternative Site is exposed to warmer water temperatures, on average, and a greater annual range in the temperature of bottom waters than the other two offshore alternative sites (Theroux and Wigley, 1998). Therefore, it is likely that there are fewer deposit-feeding species and more suspension-feeding species in this area, particularly in samples collected from the shallowest waters. In addition, the shallower areas of this Site (those with depths less than 20 feet (6.1 m)) are likely to be characterized by organisms that are prevalent in shifting substrates, since frequent disturbances would occur in these areas as a result of wave energy reaching the bottom. Consequently, the benthic community in this Site would be expected to have a higher abundance of amphipods and/or other taxa that would be adapted to shifting sands and frequent burial than the other two offshore alternative sites.

Although not occurring in locations where the WTGs will be sited, nor where inter-array cables would be installed, for this Alternative Site, the New Bedford Site is the only location evaluated where the nautical chart indicates the presence of rock, consisting of large boulders and bedrock ledge. This rocky substrate habitat is not present at the other alternative offshore sites.

Sediment Quality

The composition of the bottom sediments at the New Bedford/Horseshoe Shoal Alternative Site is well known and has been documented in several studies (Howes and Goehringer, 1996; CR Environmental, 2002; Theroux and Wigley, 1998; Poppe et al., 1989). Although no studies were found that focused solely on the New Bedford/Horseshoe Shoal Alternative Site, several studies did include this Site as part of larger evaluations designed to characterize seafloor sediments in the region. In general, as discussed in Section 3.4.3.2.2, the New Bedford/Horseshoe Shoal Alternative Site is reported to be dominated by fine sands, silts, and clays (Howes and Goehringer, 1996; Theroux and Wigley, 1998), with coarse sand-sized particles prevalent in the vicinity of rocky submarine exposures (Howes and Goehringer, 1996). Strong currents are reported to sweep away finer sands and silt in the vicinity of the rocky exposures (Howes and Goehringer, 1996). Fine sand and coarse sand are reported to support moderately high densities and biomass of organisms per square meter. The highest densities and biomass are reported to occur in substrate that would be characterized as simply sand, rather than fine sand or coarse sand.

The content of TOC in sediment at the New Bedford/Horseshoe Shoal Alternative Site is reported to be moderately high, with a TOC content of between 1 and 1.99% throughout the area (Theroux and Wigley, 1998).

Within and immediately adjacent to the New Bedford site boundary are named rocky substrate features such as Phinney Rock, Negro Ledge, Churon Rock, Decatur Rock, Russell Rock, and North Ledge. Several small unnamed areas of rock occur in the southern portion of the site, to the east of Great Ledge. It is assumed that these areas consist of granitic boulder and ledge and that their occurrence precludes the placement of WTGs or the inner-array cable in or across these areas.

Benthic Community Composition and Abundance

Based on literature reviewed, the New Bedford/Horseshoe Shoal Alternative Site and, to some extent, the surrounding Buzzards Bay area, is reported as a moderate to highly productive area for benthic invertebrates, with densities of benthic organisms typically ranging between 1,000 and 5,000 individuals/m^2 and benthic organism biomass typically ranging between 1 and 500 grams/m^2 (Theroux and Wigley, 1998). The wide range of biomass production as compared to the other two offshore alternative sites is likely due to the greater habitat diversity within the New Bedford/Horseshoe Shoal Alternative Site than the other two offshore alternative sites (e.g., a wider range of depths, sediment types, TOC content, and temperature).

The nearshore areas within New Bedford Harbor may be organically enriched as a result of sewage discharges in this area (Howes and Goehringer, 1996) and, presumably, stormwater runoff. These enriched areas are dominated by the polychaete, *Mediomastus ambisetsa*, an opportunistic colonizer of polluted sediments and sediments subject to disturbances that would typically limit recruitment of most other organisms (Howes and Goehringer, 1996). However, areas offshore of New Bedford Harbor still possess a benthic community that would be categorized as relatively “pristine” (Howes and Goehringer, 1996).

The relatively high productivity in some areas of the Site is most likely attributable to shallower water depths and sandier substrate in those areas. Higher sediment TOC content and organic enrichment of the water column from human activities on land may also contribute to the higher rate of productivity at the Site. This Site is reported to have slightly higher benthic organism diversity than Nantucket Sound and a diversity similar to that found near the South of Tuckernuck Island Site (Sanders, 1968; Theroux and Wigley, 1998). This is likely due to the presence of more stable bottom substrate, such as rock and gravel, within the very shallow portions of Buzzards Bay. Stable substrate is highly correlated with more diverse benthic communities, since relatively few species are adapted to recover from burial that is typically associated with less stable substrates (Pratt, 1973). The higher diversity may also be attributable to a wider range of habitat variables in the New Bedford Harbor area. Howes and Goehringer (1996) report that there are significant seafloor currents that scour portions of New Bedford Harbor and Buzzards Bay. These high current environments most likely support different benthic organisms than would be found at low current habitats. Similarly, the variation in water depths across the Site may also affect the composition of the benthic community due to differences in light penetration and wave disturbance.

Literature reviewed indicates that the most abundant taxa at the New Bedford/Horseshoe Shoal Alternative Site are crustaceans and annelids, followed by mollusks (Theroux and Wigley, 1998). Among the crustaceans, the amphipods are reported to be by far the most abundant. Among the mollusks, *Nassarius trivittatus* and *Yolidia limatula* are reported to comprise nearly 90% of all mollusks in offshore waters. In more shallow and protected waters, the mollusks are dominated by a diverse group comprised of *Crepidula fornicata*, *Nuncula proxima*, *Crepidula plana*, *Bittium alternatum*, and *Laevicardium mortoni* (Howes and Goehringer, 1996). In general, the community at this Site had a much lower density of Mollusks, Amphipoda, Echinoidea (sea urchins), and Cumacea than were reported in the vicinity of the other two offshore alternative sites (Theroux and Wigley, 1998).

The fauna of Buzzards Bay, including the New Bedford/Horseshoe Shoal Alternative Site, is reported to be only moderately diverse (Pratt, 1973), with several researchers reporting that less than five faunal groups typically comprise more than 75% of the organisms collected (Sanders, 1959; Sanders, 1968, Theroux and Wigley, 1998). Table 3-18 lists the dominant benthic taxonomic groups and the corresponding densities (number of individuals/m^2) occurring at the New Bedford area of the Site according to the report prepared by Theroux and Wigley (1998).

Within the areas of hard substrate, the benthic community is dominated by organisms that attach to the rock surfaces, forage and seek refuge among the cracks and crevices, and rely on attached macroalgae. Typical

attached epifauna include taxonomic groups such as bryozoans, sponges, tunicates, hydroids, sea anemones, *Mytilus edulis*, barnacles, and tube building polychaetes such as serpulid worms (Howes and Goehringer, 1996). Mobile hard substrate organisms include gastropods such as *Littorina* sp. *Crepidula* sp., chitons, amphipods such as *Ampelisca* sp., crabs such as *Cancer irroratus* and *Carcinus maenas*, seastars in the genus *Asterias*, green sea urchins, and a variety of polychaete worms. In addition, macroalgae such as *Laminaria* sp. *Chondrus crispus*, *Ptilota serrata*, *Ceramium* sp., and *Ulva* sp. This three-dimensional habitat provides forage and refuge for a diverse assemblage of species, including finfish such as tautog and cod.

Shellfish Resources

Buzzards Bay has many protected harbors and embayments that provide suitable habitats for Northern quahogs (hard-shelled clams), soft-shelled clams, eastern oysters (*Crassostrea virginica*), and scallops (Howes and Goehringer, 1996). Quahogs are the most prevalent of these species, and oysters are the least prevalent. Quahogs, soft-shelled clams, and bay scallops all have the potential to occur within the boundaries of the New Bedford portion of this alternative. Oysters, however, are not likely to be present within this Site, as they most frequently occur in the tributaries and inner harbors of the Bay. Other shellfish resources that are found in Buzzards Bay, but provide little in the way of commercial or recreational harvest, include black clams (*Arctica islandica*), duck clams (*Pitar morrhuanus*), and razor clams (*Ensis directus*).

MDMF bi-annual spring and fall research trawl survey data was obtained by Carey and Haley (2002) from trawl locations in Buzzards Bay. This information was reviewed to help characterize shellfish resources in the New Bedford/Buzzards Bay portion of this Site. Shellfish species collected in this area during the MDMF trawl surveys included the American lobster, Atlantic rock crab, bay scallop, blue crab, channeled whelk, horseshoe crab, Jonah crab, knobbed whelk, lady crab, Northern quahog, ocean quahog, and spider crab in both the spring and fall trawl surveys, and the sea scallop in the spring trawl surveys. Commercial shellfishing and lobstering are discussed in Section 3.4.3.2.5.

Comparative Summary of Existing Resources

This section describes benthic habitat, benthic community composition and abundance, and shellfish resources in the three offshore alternative sites. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

The South of Tuckernuck Island Site was found to be generally deeper and cooler than the other two offshore alternative sites. The Nantucket Sound Alternative Site is generally shallower and warmer than the South of Tuckernuck Island Site and generally deeper and cooler than the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Site. In terms of benthic organism abundance and density based on available literature values, the Nantucket Sound Alternative Site supports a benthic community that is similarly abundant to that of the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoal Site and somewhat less abundant than that of the South of Tuckernuck Alternative Site (Sanders, 1968; Mauer and Wigley, 1984; Theroux and Wigley, 1998). The South of Tuckernuck Alternative Site area was found to have organism densities higher than the other two offshore alternative sites in some areas and lower densities in others.

With regard to benthic species diversity, both the South of Tuckernuck Island Alternative Site and the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative Site are slightly more diverse than the Nantucket Sound Site (Pratt, 1973; Sanders, 1968; Theroux and Wigley, 1998).

With regard to commercial shellfish and lobster harvest, as discussed in detail in Section 3.4.3.2.5, the South of Tuckernuck Island Alternative Site and the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative Site were utilized more than the Nantucket Sound Site.

3.4.3.2.7 Upland Environmental Resources

This section describes upland environmental resources and protected species that occur within the MMR Alternative Site. No upland environmental resources or terrestrial features occur at the three offshore Alternative Sites (Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal). The data and level of detail used for this section was determined through consultation with other resource agencies.

A qualitative review of available studies has been conducted with regard to upland environmental resources. A summary of the key habitat, vegetation cover types, and species documented to occur at the MMR Alternative Site is provided below. Ecological information was obtained from habitat studies conducted by the Commonwealth of Massachusetts Military Division and natural resource management plans developed by the Massachusetts Army National Guard (MAARNG). Other resources at the MMR Alternative Site are discussed in greater detail in other sections of the alternatives analysis, including soils and geology (Section 3.4.3.2.2), water resources (Section 3.4.3.2.15), and avian use of the site (Section 3.4.3.2.1).

Massachusetts Military Reservation

The MMR includes one of the largest undeveloped, contiguous wildlife habitat areas in southeastern Massachusetts. A variety of vegetation community types provides habitat for a diversity of mammals, birds, amphibians, reptiles, and invertebrates. Furthermore, the Shawme-Crowell State Forest and Crane Wildlife Management Area abut the property to the north and the south, respectively, increasing the importance of the MMR for regional wildlife populations. The MMR provides a valuable wildlife corridor between these two areas (Commonwealth of Massachusetts Military Division, 1996).

Vegetative Communities

The MMR Alternative Site within the Camp Edwards section of MMR consists primarily of a mosaic of forested community types. The two predominant vegetation cover types within the Alternative Site consist of mixed woods forest and pitch pine scrub oak forest (MAARNG, 2001). Hardwood forest, scrub oak barrens, and grasslands are other vegetation cover types that also occur within the Alternative Site area, but to a much lesser extent. Vegetation community cover types are shown on Figure 3-51 in Section 3.4.3.4.7.

Mixed Woods Forest

This community ranges from exhibiting a low tree canopy with a dense shrub layer to a taller tree canopy with a sparser shrub layer. The mixed woods forest within Camp Edwards is in mid-successional state, where trees and shrubs are increasing in number and forbs and grasses are becoming less abundant. In general, this is a relatively young forest community, not older than 100 years (MAARNG, 2001). Typical tree species associated with this forest cover type include scarlet oak (*Quercus coccinea*), black oak (*Quercus velutina*), white oak (*Quercus alba*), white pine (*Pinus strobus*), pitch pine (*Pinus rigida*), and quaking aspen (*Populus tremuloides*). Black huckleberry (*Gaylussacia baccata*), blueberry (*Vaccinium spp.*), scrub oak (*Quercus ilicifolia*), American hazelnut (*Corylus americana*), sheep laurel (*Kalmia angustifolia*), and wintergreen (*Gaultheria procumbens*) typically comprise the majority of the shrub layer. Bracken fern (*Pteridium aquilinum*) is common in the herbaceous layer of a mixed woods forest (MAARNG, 2001).

Pitch Pine Scrub Oak Forest

Pitch pine scrub oak forest is a fire maintained and fire dependent community (Swaine and Kearsely, 2001). The pitch pine scrub oak forest is the second most predominant vegetation community type located within the Alternative Site area. This community consists almost exclusively of pitch pine with an understory of scrub oak. The structure of the pitch pine scrub oak forest within Camp Edwards varies greatly with age (MAARNG, 2001). The younger stands typically consist of short, dense thickets of immature pitch pine. As the pitch pines mature and fill in the tree canopy, scrub oak tends to thin out due to the decreasing availability of sunlight. Other plant species that may be present but not common in this community type include white oak and scarlet oak in the tree layer, with a shrub layer of black huckleberry, blueberry, wintergreen, Pennsylvania sedge (*Carex pensylvanica*), little bluestem (*Schizachyrium scoparium*), and sheep laurel interspersed among the scrub oak (MAARNG, 2001, Swaine and Kearsely, 2001).

Hardwood Forest

Pitch pine is the dominant tree species on Camp Edwards; however, some small isolated stands of hardwood trees exist in the northeastern corner of the Alternative Site area (MAARNG, 2001). Oaks dominate the tree canopy in these areas and typical shrub species include black huckleberry, blueberry, wintergreen, scrub oak, and sheep laurel (MAARNG, 2001).

Scrub Oak Barrens

Scrub oak barrens occur within pitch pine scrub oak communities, particularly in frost bottoms and frost pockets, and on ridge tops near ridge top pitch pine scrub oak communities (Swaine and Kearsely, 2001). On the Camp Edwards property, the scrub oak barren community type is located mostly within the area east of the WTG array area (MAARNG, 2001). However, as with the hardwood forest community, some small pockets of scrub oak barrens are located within the northern portion of the Alternative Site area. Scrub oak barrens represent one of the earliest states of vegetative succession in the Alternative Site area, consisting primarily of scrub oak interspersed with occasional pitch pine. Other common plant species associated with this vegetation community type include black huckleberry, blueberry, Pennsylvania sedge, little bluestem, cat brier (*Smilax glauca*), and wintergreen (MAARNG, 2001, Swaine and Kearsely, 2001).

Grasslands

Grassland habitats are present on MMR. Most of the grassland communities on the Camp Edwards property are located in the cantonment areas that were historically cleared for use as parade ground (MAARNG, 2001). These large grassland areas are located outside of the Alternative Site area. However, one small patch of grassland associated with the wastewater treatment facility in the northwestern corner of the Alternative Site does exist (MAARNG, 2001). The grassland areas are one of the least diverse plant communities on the MMR property. Typical species include filiform fescue (*Festuca tenuifolia*), little bluestem, switchgrass (*Panicum virgatum*), hairgrass (*Deschampsia flexuosa*), redtop (*Agrostis gigantea*), poverty grass (*Danthonia spiccata*), and Pennsylvania sedge. The abundance of grassland communities on MMR is gradually decreasing with the establishment and increase of trees and shrubs (MAARNG, 2001).

No large rivers, lakes, or streams occur on the MMR property, only small palustrine wetlands and ponds. Within the Alternative Site area, very few wetlands exist, and those that do consist primarily of isolated emergent marshes, kettle hole ponds, kettle hole wet meadows, and vernal pools (MAARNG, 2001). Palustrine wetlands are discussed in greater detail in Section 3.4.3.2.15 (Water Resources).

Rare, Threatened, and Endangered Plant Species

The Army National Guard reported no known federally-endangered or threatened plant species on the MMR property. However, the Massachusetts Natural Heritage and Endangered Species Program (Commonwealth of Massachusetts Military Division, 1996) has identified state-listed plants that could be present. Cunha (2004) states that the Commonwealth deems the MMR a priority location for rare habitat. These include three state-listed endangered species, horse gentian (*Triosteum perfoliatum*), ovate spikerush (*Eleochris ovata*), and Torrey's beak rush (*Rhynchospora torreyana*); and one state-listed threatened species, adders tongue fern (*Ophioglossum pesillum*). One state-listed Special Concern species, star grass (*Hypoxis hirsuta*); and three state "watch list" species, hyssop hedge nettle (*Stachys hyssopifolia*), nuttals milkwort (*Polygala nuttallii*), and umbrella grass (*Fuirena pumila*) are also found at this Alternative Site (Commonwealth of Mass Military Division, 1996).

Horse gentian, also referred to as broad tinker's-weed, is a coarse herbaceous plant typically found in dry open wooded areas (MNHESP, 1993). Ovate spikerush and Torrey's beak rush typically inhabit the edges of ponds and wetland areas (Rook, 2002). Torrey's beak rush does not grow well with shrubs and other coarse vegetation (MNHESP, 1988d). Star grass typically inhabits woods and open thickets (University of Wisconsin, 2004). Adders tongue fern typically inhabits marshes, bogs, and moist woods when clearings are present (MNHESP, 1990c).

Hyssop hedge nettle is a flowering herbaceous plant typically found in sandy, gravelly or peaty shores and bogs (Fernald, 1993). Its wetland indicator status is "FACW+," suggesting that it may have been observed in or around one of the ponds at the MMR property. Its range in Massachusetts is limited to Cape Cod and the islands (USDA NRCS, 2004).

Nuttals milkwort is a member of the milkwort family, and its preferred habitat type includes open pinelands with coarse sandy soils (Fernald, 1993). Its wetland indicator status is "FAC," suggesting that it can mostly likely be found in uplands, but may also be found on the fringe of wetland areas.

Umbrella grass is found in bogs and wet peaty or sandy shores (Fernald, 1993). Its wetland indicator status is "OBL," indicating that it was mostly likely observed in any one of the ponds at the MMR property. Its range in Massachusetts includes Barnstable, Plymouth, Middlesex and Hampden County (USDA NRCS, 2004).

Information regarding the observation location and population densities of these species is unavailable. If this site were selected for the Project, surveys would be conducted to identify whether these species occur in any of the anticipated impact areas. For the purposes of this Alternative Sites evaluation, the potential presence of these species is noted.

Wildlife

The MMR property provides habitat that is used by a variety of mammal, amphibian, reptile, and invertebrate species. Wildlife species documented to occur in the MMR property are discussed in the sections below. (Note that avian use of the MMR Alternative Site is discussed in Section 3.4.3.2.1.)

Mammals

Populations of small mammals have been monitored annually since 1994 at the MMR property (MAARNG, 2003). This survey confirms the presence of the white-footed mouse (*Peromyscus leucopus*), red-backed vole (*Clethrionomys gapperi*), meadow vole (*Microtus pennsylvanicus*), masked shrew (*Sorex cinereus*), long-tailed weasel (*Mustela frenata*), northern short tailed shrew (*Mustela ermine*), eastern chipmunk (*Tamias striatus*), and red squirrel (*Tamiasciurus hudsonicus*). The survey found that the mixed-woods forest communities exhibited the greatest species richness, and that the fewest number of species was observed within the disturbed, wetland and bivouac (developed) areas. The most abundant of the small mammals observed during these studies were the white-footed mouse and the southern red-backed vole. The meadow vole was commonly found in grasslands (MAARNG, 2003).

Other common mammal species observed within MMR include the white tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), eastern cottontail (*Sylvilagus floridanus*), gray squirrel (*Sciurus carolinensis*), mink *(Mustela vision*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitus*), and the woodchuck (*Marmota monax*) (MAARNG, 1999). Annual white-tailed deer hunts have taken place at MMR since the 1950s. The number of deer harvested by hunters does not provide a definitive estimation of the abundance of this species, but the consistent success rate suggests that the population has not fluctuated greatly (MAARNG, 2003). Between 1992 and 2002, an average of 101 deer were harvested each year.

A survey of bat species on Camp Edwards was conducted during 1999 and 2000. Four species were documented during the preliminary survey, including the big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), northern myotis (*Myotis septentrionalis*), and the eastern pipistrelle (*Pipistrellus subflavus*) (MAARNG, 2001). However, none of these bats are federally or state protected species.

The big brown bat inhabits cities, towns, and rural areas, but is least commonly found in heavily forested regions (Mulheisen, 2000). Besides human dwellings, it has been found to take up residence in barns, silos, and churches. Also, this bat has been found roosting in storm sewers, expansion joint spaces in concrete athletic stadiums, and mines. The big brown bat is a resident bat throughout New England, with breeding habitats in southeast Massachusetts.

Red bats are fast flying bats that live throughout the Americas (Myers, 2000). They tend to choose habitats that are sparsely to moderately populated by humans and are rare in heavily urbanized areas. Red bats are migratory, arriving in the northern climates in mid-April and leaving in late October. They typically hibernate in hollow trees and choose roosting sites in dense foliage. The red bat is a non-resident migratory bat found throughout the region but breeds locally.

The northern myotis bat is largely associated with boreal forests (Ollendorff, 2002). In areas of North America and Canada it roosts in buildings, under exfoliating bark, and in the cavities of trees. Caves and underground mines are this bat's choice sites for hibernating. Little is known about its food habits, although it has been observed foraging along forest edges, over forest clearings, at tree-top level, and occasionally over ponds. The northern myotis is a resident bat in northern New England which is common during the spring and summer in southeast Massachusetts.

The Eastern pipistrelle bat forages over streams and ponds and at the forest-field edge (Myers, 1999). Summer roosts are usually caves or mines, except in colder northern areas, where pipistrelles may be found in houses or hollow trees during summer months. The eastern pipistrelle performs short annual migrations between winter hibernation and summer nursery sites. Such travel is not known to exceed 50 miles and averages 31 miles or less (Texas Parks and Wildlife, undated). The Eastern pipistrelle is a summer resident with a breeding distribution unknown and that winters in central New Hampshire.

Amphibians and Reptiles

The abundance and diversity of amphibians and some reptiles are limited at the MMR property due to the relatively low availability of aquatic systems and wetland resources typically required for breeding and foraging. Despite the relative paucity of aquatic habitats, over 20 species of reptiles and amphibians have been observed at the MMR property (MAARNG, 1999). Typical amphibians found at MMR include spring peeper (*Pseudacris crucifer*), bullfrog (*Pana catesbeiana*), Fowlers toad (*Bufo woodhousii fowleri*), American toad (*Bufo americanus*), red-back salamander (*Plethodon cinereus*) and spotted salamander (*Ambystoma maculatum*). Typical reptiles observed at MMR include snapping turtle (*Chelydra serpentine*), eastern painted turtle (*Chrysemys picta picta*), eastern box turtle (*Terrapene carolina*), black racer (*Coluber constrictor constrictor*), garter snake (*Thamnophis sirtalis sirtalis*), and ringneck snake (*Diadophis punctatus edwardsii*). Table 3-19 provides a list of all amphibian and reptile species documented at MMR, and provides a summary of habitat requirements.

Rare, Threatened, or Endangered Amphibians or Reptiles

The four-toed salamander (*Hemidactylium scutatum)*, has been observed on the MMR property (location unknown) and is a state-listed species of Special Concern. The eastern box turtle and the spotted turtle have also been documented to occur on the MMR property. Both species are also state-listed species as Special Concern (MAARNG, 1999) (See Table 3-6 for a listing of protected species).

The four-toed salamander requires undisturbed, moist, deciduous, evergreen, or mixed forests in close proximity to shaded pools and seeps, swamps, and bogs (MNHESP, 1994a). Breeding habitat is limited to wetlands containing dense hummocks of grasses, sedges, and mosses that are adjacent to slow moving streams or pools. This habitat requirement limits their range throughout the region. The four-toed salamander breeds from late summer to early fall (August-October). The adults lay eggs after hibernation. Preferred nesting sites are generally located in sphagnum moss or other hummock areas on the margins of breeding pools. The eggs are laid in early spring and usually hatch in summer. Four-toed salamanders inhabit forested areas, but during spring, females migrate to forest breeding pools. The greatest threat to the four-toed salamander is habitat destruction resulting from road construction, development, and timber harvesting in and around wetlands that support salamander populations (MNHESP, 1994a).

The spotted turtle typically inhabits marshy meadows, bogs, small ponds, brooks, ditches, and other unpolluted bodies of water (MNHESP, 1994b). They spend a considerable amount of time basking on logs, rocks, tussocks, or adjacent upland areas. Breeding occurs in spring (March to May) followed by nest-building and egg-laying by females in early summer. Nesting sites are usually located in well-drained soil in open meadows, fields, or along roadsides. Hatchlings emerge in late summer and typically feed on worms, insects, and snails before returning to the nest for hibernation. On the MMR property, spotted turtles have been documented primarily within large swamp areas (Monument Swamp and Raccoon Swamp) (MAARNG, 2001). The greatest threats to the spotted turtle include the pet trade/collection, development and habitat fragmentation, residential development, and destruction of upland habitat. Nest predation by skunks, raccoons, and foxes is also a threat to spotted turtle populations (MNHESP, 1994b).

The eastern box turtle is primarily a terrestrial woodland species but is also found in marshes, bogs, and stream banks. In Cape Cod, its optimal habitat includes pine barrens and oak thickets. The box turtle hibernates from late October or November until it emerges in April, when it starts breeding. Female box turtles may build their nests in hayfields, roadsides, gardens, lawns, beach dunes, or woodlands. Hatchlings emerge usually in September. On the MMR property, box turtles have been observed in every vegetation community type, and sightings have occurred throughout the entire military installation (MAARNG, 2001). Personnel from the Camp Edwards Natural Resource Management Program and Range Control have recorded 50 box turtle individuals at the MMR Site. Forty-three individuals have been marked as part of a habitat range study (MAARNG, 2003). Most

individuals have defined home ranges averaging 100-750 feet (31 to 230 m) in diameter. Some individuals are transient and do not establish home ranges (MNHESP, n.d.(e)). Threats to the Eastern box turtle include the pet trade/collection, development and habitat fragmentation, residential development, and destruction of upland habitat. Nest predation by skunks raccoons, coyotes, and foxes is also a threat to eastern box turtle populations.

Invertebrates

The MNHESP has identified rare, threatened, or endangered invertebrates, including moths and dragonflies at the MMR property. The majority of the state-listed rare moth species on Camp Edwards are dependent upon the scrub oak barrens ecosystem for part or all of their life cycle, while the dragon and damselfly species are more dependent on aquatic systems (MAARNG, 2001). Table 3-20 lists the 17 state-listed moth and dragonfly species documented at the MMR property and adjacent properties and summarizes habitat requirements (MAARNG, 2003).

Insects are other flying creatures that may be present in the vicinity of the alternative sites. Per the USFWS endangered species listings for Massachusetts[40] and confirmed in 50 CFR 17.11, the only Federally Listed Insects are limited to 3 species of beetles, as follows: Puritan tiger Beetle (*Cicindela puritana*) (Threatened), Northeastern beach Beetle (*Cicindela dorsalis dorsalis*) (Threatened), and the Endangered American burying beetle (*Nicrophorus americanus*).

Although the MMR is an upland site, these beetles are also not likely to be found there. The puritan tiger beetle has a very limited range and has been found exclusively in the Connecticut River Valley of New Hampshire, Massachusetts, Connecticut and the Chesapeake Bay area of Maryland (MNHESP, 1990d). The few remaining populations of puritan tiger beetles have been found in sandy beaches along the Connecticut River. There have been no known documented occurrences in SE MA.

The Northeastern Beach Beetle's range in Massachusetts is restricted to a single beach, exact location unknown (MNHESP, 1991). Its habitat is limited to large, pristine, highly exposed beaches with fine sand, and low human disturbance. The beach beetle formerly inhabited beaches on the outer cape and off shore islands but has not been found in several years. Due to the beach beetle's specified habitat requirements, in addition to the fact that it may not exist, it is highly unlikely that activities at the alternative sites will impact this species.

The American burying beetle can only be found in the wild in Arkansas, Kansas, Nebraska, Oklahoma, South Dakota and Block Island, Rhode Island. Successful reintroduction has returned the beetle to two Massachusetts islands (Penikese and Nantucket) (ODNR, 2003). There are no known populations on the mainland.

The elderberry long horned beetle was documented in 22 Massachusetts towns prior to 1978. However, since then it has only been documented in 4 towns, none of which are in southeastern MA (MNHESP, 1992). The specific towns are not listed, but a map showing the documented occurrences clearly indicates that none were observed in the vicinity of the Cape and Islands.

Nantucket Sound, South of Tuckernuck Island and New Bedford/Horseshoe Shoal Alternative Sites

There are no upland resources or terrestrial features associated with these three offshore alternative sites, which are all located more than 3 miles (4.8 km) offshore except for the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Site.

3.4.3.2.8 Aviation

This section describes existing aviation use of the airspace in and around the alternative sites under consideration. The data and level of detail used for this section was determined primarily through consultation with the FAA, along with input from the other cooperating agencies.

Existing FAA publications have been reviewed and FAA Aeronautical Studies have been initiated on each offshore alternative site. In addition to input from the FAA, evaluation of the terrestrial alternative at MMR was largely

[40] http://northeast.fws.gov/Endangered/

based upon input from Air Force, Massachusetts Air National Guard, US Coast Guard (USCG) and other military personnel knowledgeable in the use of the MMR airspace at a consultation meeting at MMR on February 6, 2004 (see Appendix 3.0-L).

There are three commercial airports in the vicinity of the four alternative site areas under consideration. The Barnstable Municipal Airport, the Nantucket Memorial Airport, and the Martha's Vineyard Airport provide service connections from the mainland to the Islands of Nantucket and Martha's Vineyard. The MMR Alternative Site is located in the MMR, north of Otis Air Force Base and northwest of the USCG Air Station Cape Cod. Other airports in the area of the alternative sites include Provincetown Municipal Airport on the Outer Cape, New Bedford Regional Airport, Logan International Airport in Boston, T.F. Green Airport in Providence, Rhode Island, and Block Island Airport. These airport facilities also have connecting flights to the Barnstable, Nantucket, and Martha's Vineyard airports.

Massachusetts Military Reservation

The proposed MMR Alternative Site is located in the MMR, approximately 12.75 miles (20.5 km) west of Barnstable Municipal Airport, approximately 38 miles (61.2 km) northwest of Nantucket Memorial Airport, and 20 miles (32.2 km) north of Martha's Vineyard Airport. Otis Air Force Base is located on the southern portion of the MMR, adjacent to the proposed WTG array for this alternative location. The USCG Air Station Cape Cod is also located on the southeastern edge of the MMR, adjacent to the proposed WTG array. The Air Force runways are oriented northwest to southeast (see Figure 3-21).

The primary use of the airspace over the MMR is by military helicopters and fixed wing aircraft for training, by USCG aircraft for Search and Rescue (SAR), and by the Air National Guard for homeland security missions. During the USACE's public meeting (10/29/03) a representative from the Massachusetts National Guard reported that essentially the entire MMR property is used for low-level (tree-top) helicopter flight training exercises. According to military sources, helicopter training at the MMR is conducted on a regular basis throughout the year, with much of the activity taking place during the night time or under limited visibility conditions. Operational missions (SAR and homeland security) are conducted on an as-needed basis regardless of time or weather conditions. In addition to the training and operational missions conducted on a routine basis by the military, Otis Air Force Base is a designated alternate emergency landing site for the NASA Space Shuttle. The airspace surrounding that specifically above the MMR is used by commuter airplane traffic and by commuter helicopters.

The airspace above the MMR is classified by the FAA and the military as Special Use Airspace. The proposed turbine array at the MMR Site would not be located in the pathway of any low altitude Instrument Flight Rule (IFR) routes (U.S. Government Flight Information Publication – IFR Enroute Low Altitude-US). These routes are used by planes flying at night, or on instrumentation for guidance in low visibility conditions. There are three established IFR routes for crossing Cape Cod, but they are not in the vicinity of the MMR Alternative Site. IFR Route V167, connecting the T.F. Green and Provincetown airports, passes approximately 7 miles (11.3 km) south of the MMR alternative site at a minimum altitude of 1,600 feet (488 m). IFR Route V141 from Logan to Nantucket airports passes approximately 9.5 miles (15.3 km) east of the MMR alternative site at a minimum altitude of 1,700 feet (518 m). IFR Route V151 from T.F. Green airport passes approximately 5.75 miles (9.3 km) north of the MMR alternative at a minimum altitude of 2,000 feet (610 km). Please refer to Figure 3-29.

MMR staff has indicated that several existing aviation activities occur within MMR boundaries. Specifically, Otis Air Base is designated as an emergency landing strip for the Space Shuttle. F-15 instrument training for departure and landings occurs at MMR. Many of the low-level helicopter training exercises at MMR are conducted with night vision goggles. Lastly, the major runway orientation puts the flight path at the northwest end of the airfield directly over the southern portion of the Wind Park. Since the airspace over the MMR is designated as Special Use Airspace, commercial and/or recreational aviation activity is limited. While the FAA could view the WTG array at this site as having no adverse impact to navigation for commercial operations, since none are taking place, the Project could have significant impacts on military navigation. After discussions with the FAA, it was determined that an FAA study for the MMR Alternative Site was unnecessary in light of the significant military concerns (see Appendix 3.0-L).

Nantucket Sound

The proposed Horseshoe Shoal WTG array is located approximately 9 miles (14.5 km) south of Barnstable Municipal Airport, approximately 17 miles (27.4 km) northwest of Nantucket Memorial Airport, and 13 miles (21 km) northeast of Martha's Vineyard Airport. The proposed Monomoy-Handkerchief Shoal WTG array is located approximately 8 miles (12.9 km) southeast of Barnstable Municipal Airport, approximately 17 miles (27.4 km) northeast of Nantucket Memorial Airport, and 24 miles (38.6 km) northeast of Martha's Vineyard Airport. The proposed Tuckernuck Shoal WTG array is located approximately 13 miles (21 km) south of Barnstable Municipal Airport, approximately 10 miles (16.1 km) northwest of Nantucket Memorial Airport, and 13 miles (21 km) east of Martha's Vineyard Airport.

In addition to commuter airplane traffic, the airspace over Nantucket Sound is used by military aircraft for training, by USCG aircraft for SAR and other operations, by commercial fish spotter planes, and by commuter helicopters. Low flying aircraft operating under Visual Flight Rules (VFR), over open water may not be any closer than 500 feet from any vessel or structure (14 CFR part 91.119). In the absence of any vessel or structure, there is no minimum altitude restriction when flying over open water.

The three proposed turbine arrays in Nantucket Sound are not located in the flight paths of any low altitude IFR routes (US Government Flight Information Publication – IFR Enroute Low Altitude-US). The three IFR routes established for Nantucket Sound are not in the vicinity of the Nantucket Sound alternatives under consideration. IFR Route V167, connecting T.F. Green and Provincetown airports, makes a turn approximately 2 miles (3.2 km) northwest of the nearest alternative site area at a minimum altitude of 1,600 feet (488 m). IFR Route V141 from Logan Airport to Nantucket passes approximately 3 miles (4.8 km) northeast of the nearest alternative site area at a minimum altitude of 1,700 feet (518 m). IFR Route V146 connects Martha's Vineyard with Nantucket at a minimum altitude of 2,000 feet (610 m), approximately 2 miles (3.2 km) south of the nearest alternative site area. Please refer to Figure 3-29.

South of Tuckernuck Island

The proposed South of Tuckernuck Island Alternative Site is located approximately 26.75 miles (43.1 km) south of Barnstable Municipal Airport, approximately 8.0 miles (12.8 km) west of Nantucket Memorial Airport, 13.2 miles (21.1 km) southeast of Martha's Vineyard Airport, and 64 miles (102.4 km) east of Block Island Airport. These airports provide service connections from the mainland to the Islands of Nantucket and Martha's Vineyard.

In addition to commuter airplane traffic, the airspace in the vicinity of the South of Tuckernuck Island Alternative Site and the general surrounding area is used by military aircraft for training, by USCG aircraft for SAR and other operations, by commercial fish spotter planes, and by commuter helicopters.

The South of Tuckernuck Island WTG array is located within the flight path of two of the three established low altitude IFR routes (US Government Flight Information Publication – IFR Enroute Low Altitude-US) that service Martha's Vineyard and Nantucket Island. IFR Route V146 connects Martha's Vineyard with Nantucket at a minimum altitude of 2,000 feet (610 m), approximately 2 miles (3.2 km) north of the alternative site area. IFR Route V34-58 from Block Island to Nantucket passes over the alternative site area at a minimum altitude of 2,000 feet (610 m). IFR Route V46 from Long Island to Nantucket passes over the alternative site area at a minimum altitude of 2,000 feet (610 m). Please refer to Figure 3-29.

New Bedford / Horseshoe Shoal

For information on the Horseshoe Shoal portion of this combined alternative please see the discussion on Nantucket Sound above.

The proposed New Bedford portion of the combination alternative is located approximately 6.75 miles (10.8 km) south of New Bedford Regional Airport, approximately 27 miles (43.2 km) southeast of T.F. Green Airport in Providence, Rhode Island, 31.25 miles (50 km) southwest of Barnstable Municipal Airport, and 21.5 miles (34.4 km) northwest of Martha's Vineyard Airport.

In addition to commuter airplane traffic, the airspace over New Bedford and Buzzards Bay is used by military aircraft for training, by USCG aircraft for SAR and other operations, by commercial fish spotter planes, and by commuter helicopters.

The New Bedford portion of the combination alternative is not located in the flight path of the two established low altitude IFR routes (U.S. Government Flight Information Publication – IFR Enroute Low Altitude-US) that cross Buzzards Bay. IFR Route V167, connecting T.F. Green and Provincetown airports, passes approximately 4 miles (6.4 km) to the northeast of the New Bedford alternative site area at a minimum altitude of 1,600 feet (488 m). IFR Route V146 from T.F. Green to Martha's Vineyard passes approximately 4 miles (6.4 km) southwest to the New Bedford alternative site area at a minimum altitude of 2,000 feet (610 m). Please refer to Figure 3-29.

Comparative Summary of Existing Resources

All four of the alternative sites are located in areas that have some level of existing aviation use of airspace. The MMR Alternative Site has the most intensive use of airspace, since the MMR supports substantial military flight training and USCG search and rescue flights, as well as being a designated alternate emergency landing site for the NASA space shuttle. The proposed South of Tuckernuck Island Alternative Site is located within the pathway of two low altitude IFR routes (US Government Flight Information Publication – IFR Enroute Low Altitude-US). None of the other alternative sites, including the Nantucket Sound and New Bedford/ Horseshoe Shoals Alternative Sites, are located within the flight paths of any low altitude IFR routes.

3.4.3.2.9 Telecommunications

This section describes the telecommunications systems that exist at each of the four Alternative Sites under consideration. This evaluation is based on a review of existing and proposed FCC-licensed telecommunications towers, in addition to consultations with MMR military staff.
Telecommunication towers or antennae operate at different frequency ranges, depending on the service they provide. AM Radio transmits at 540-1,605 kHz, and FM Radio at 88-108 MHz. VHF television transmits at 30-300 MHz, and UHF television transmits at 300-3,000 MHz. Analog mobile phone signals are approximately 900 MHz, while PCS mobile phone signals fall between 1,800-2000 MHz[41].

Massachusetts Military Reservation

The MMR Alternative Site includes military radio communications, the PAVE/ PAWS radar installation on 100 acres (0.4 km^2) in the northeastern portion of the site, and the nearby U.S. Coast Guard Communication Center.

The PAVE/PAWS radar installation is a U.S. Air Force Phased Array Warning System that is employed to detect and track sea launched (SLBM) and intercontinental ballistic missiles (ICBM). The system is additionally employed to detect and track Earth-orbiting satellites. "PAVE" is an electronic systems program name, while "PAWS" stands for Phased Array Warning System. The unit is one of three Solid State Phased Array Radar Systems (SSPARS) in the United States operated by the 21st Space Wing of the Air Force Space Command.[42] The PAVE/PAWS system emits low-level radio frequency radiation (RFR). The unique aspect of this radar system is its phase array antenna technology, which differs from a mechanical radar that needs to be physically aimed at an object. The phase array antenna is fixed as a part of an exterior building wall and is aimed by electronically controlling the timing of the incoming and outgoing signals.

The US Coast Guard (1st District Boston) also operates a communication center on MMR that involves several antennae towers located in the eastern portion of the MMR property. The center transmits high frequency radio signals primarily to the east, serving the northeastern Atlantic Ocean.

According to consultation with MMR staff on February 6, 2004, much of the military training that takes place throughout the northern section of MMR utilizes mobile radio communications technology, including older line-of-sight technology, along with newer GPS satellite based technology.

[41] Cell Tower Operating Frequency http://www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html#8
[42] www.pavepaws.org

Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal

Recreational boating activity occurs in Nantucket Sound and Buzzards Bay, and is most prevalent from May through September. Commercial fishing and marine cargo ships traverse Nantucket Sound, as well as New Bedford Harbor and Buzzards Bay. Recreational vessels, commercial fishing and marine cargo ships also traverse Nantucket Sound via the nearby Muskeget Channel. All of these vessels use marine radios, which operate at a range of 156.05-157.425 MHz. Shore radios operate at approximately 156.85-162.025 MHz. The NOAA weather service operates at frequencies between 162.4-162.55 MHz[43].

Comparative Summary of Existing Resources

All of the Alternative Sites under consideration have existing telecommunications systems in sufficient proximity to allow telecommunications signals from cellular phone towers, local emergency response communication towers, radio towers, and television towers to be transmitted and received within the Alternative Site areas. The offshore Alternative Sites also allow for mobile sources of radio transmissions, such as marine VHF radios. The MMR Alternative Site also includes military radio communications, the PAVE/PAWS radar installation on the northern portion of the site, and the nearby U.S. Coast Guard Communication Center.

3.4.3.2.10 Navigation

This section describes existing navigation resources, including channels and fairways, vessel usage and U.S. Coast Guard (USCG) Search and Rescue (SAR) operations, for the four alternative sites under consideration. The data and level of detail used for this section was determined through consultation with other resource agencies.

Vessel type characteristics are described in a Navigational Risk Assessment (dated August 18, 2003, Appendix 5.12-B) for the alternative sub-site on Horseshoe Shoal (one of three sub-sites included in the Nantucket Sound Alternative Site). The USCG reviewed this document and determined the Navigational Risk Assessment appeared to have sufficiently addressed the issues they had raised regarding navigation. In a November 13, 2003 e-mail, the USCG Marine Safety Office in Providence stated that the Horseshoe Shoal Navigational Risk Assessment is applicable and valid for all of the offshore alternative site locations, provided the construction specifications and WTG Array spacing remain the same as those set forth for the Horseshoe Shoal Alternative. The USCG further stated that SAR response standards could be met for all offshore alternative locations.

Massachusetts Military Reservation

The MMR Alternative Site is located in an onshore, upland environment within the MMR. Only a portion of the MMR is in the vicinity of the Cape Cod Canal, between the Bourne and Sagamore Bridges. Nevertheless, there would be no direct interaction between the proposed WTG array at the MMR Alternative Site and the canal. Therefore, a review of marine navigation resources is not applicable for this Alternative Site. However, military land navigation training for infantry troops is performed at the MMR Alternative (see Appendix 3-L).

Nantucket Sound

Nantucket Sound is bordered on the north by the south coast of Cape Cod and on the south by Nantucket Island and part of Martha's Vineyard. Vineyard Sound lies to the west and the Atlantic Ocean to the east. Nantucket Sound is approximately 23 miles (36.8 km) in length in an east-west direction and 6 to 22 miles (9.6 to 35.2 km) wide in a north-south direction. It contains numerous shoals at the eastern and southern entrances. Navigation through these waters is via marked channels between the shoals.

Nantucket Sound has two shipping lanes, the Main and North Channels, which are used by larger vessels. Each is marked by the USCG with aids-to-navigation (buoys, lights, etc.) and are described below:

[43] Marine Radio Operating Frequency http://www.naval.com/marvhf.htm; http://www.m1cvc.uklinux.net/radio_frqlst_mrn.html

- The Main Channel lies in the central portion of Nantucket Sound, between the Horseshoe and Tuckernuck WTG Alternatives, and connects Vineyard Sound to the west and the Atlantic Ocean to the east. This channel is used by the majority of vessels transiting through Nantucket Sound, and provides an inside passage for vessels of medium draft to avoid Nantucket shoals. The Main Channel has a controlling depth of about 30 feet (9.2 m).

- The North Channel lies along the north side of Nantucket Sound, and extends west from Bishop and Clerks shoals in the north central part of Nantucket Sound, north of Horseshoe Shoal and the Horseshoe WTG Alternative, between Wreck and Eldridge shoals, north of L'Hommedieu Shoal, and into Vineyard Sound through one of the openings in the shoals west of L'Hommedieu Shoal. This channel is used mostly by vessels bound for the south shore of Cape Cod, and by vessels transiting the Sound during northerly winds. The shallowest depth in the channel is approximately 16 feet (4.9 m) at MLLW.

In addition to these shipping channels, privately and federally maintained channels are located at the approaches to Cotuit Bay, Centerville Harbor, and Hyannis Harbor.

The area between the Main Channel and the Cape Cod shoreline, including the Horseshoe Shoal and Monomoy-Handkerchief Shoal WTG Alternatives, is a designated anchorage ground, known as "Anchorage I." The area between the Main Channel and the west side of Nantucket shoreline, including the Tuckernuck Shoal WTG Alternative, is also a designated anchorage ground, known as "Anchorage G." Floats or buoys for marking anchors or moorings in place are allowed in both areas. Fixed mooring piles or stakes are prohibited in both areas.

Vessel Usage

Vessel traffic in Nantucket Sound includes small-to-large draft recreational, fishing, and commercial vessels. There is an increase in vessel traffic in and around Nantucket Sound during the warmer months (typically April through October). Increased recreational, ferry, charter fishing, touring, and cruise vessel traffic is common during these months.

Because shallow shifting shoals exist throughout Nantucket Sound, most medium-to-large draft vessel traffic is restricted to the marked channels described above. According to USACE data for 1998-2001, an annual average of 1,361 trips of vessels engaged in waterborne commerce were reported as passing Cross Rip Shoal in the Main Channel in Nantucket Sound (USACE, 1998-2001). Waterborne commerce statistics are self-reported and it is impossible to ascertain the actual total numbers. Cross Rip Shoal is centrally located in Nantucket Sound on the southern edge of the Main Channel, south of the Horseshoe and Monomoy-Handkerchief Shoal WTG Alternatives and north of the Tuckernuck Shoal WTG Alternative.

South of Tuckernuck Island

The South of Tuckernuck Island Alternative Site is located in the Atlantic Ocean southwest of Tuckernuck Island in open waters. There are no designated anchorages in the vicinity of this Alternative Site, and the northwestern portion of this Site lies on shallow shoals. The Muskeget Channel lies to the north with charted depths as shallow as 7 feet (2.1 m). Although the Muskeget Channel is partly buoyed, tidal currents with velocities of 2 to 5 knots (3.7 to 9.3 km/hr) make navigation dangerous (NOAA, 1994).

Vessel Usage

Annual vessel usage is not recorded for this area since it receives less traffic than other locations and is not proximate to federal navigation channels. This Alternative Site is removed from the more heavily navigated waters, as most large vessels travel either south of Nantucket Shoals in the Atlantic Ocean, or north of Nantucket Shoals through the Main Channel in Nantucket Sound.

As is characteristic of the area, there is an increase in vessel traffic in and around Nantucket Sound during the warmer months (typically April through October). Increased recreational, ferry, charter fishing, touring, and cruise vessel traffic is common during these months. However, larger vessels generally avoid the Muskeget Channel area due to the shallow depths and swift currents.

New Bedford / Horseshoe Shoal

This New Bedford WTG array of this Alternative Site is located in Buzzards Bay just south of Clarks Cove and New Bedford Harbor. The area is full of rocks and ledges, some of which are one foot or less below the surface. The majority of these are marked with buoys; however, some are not, making navigation somewhat dangerous for deeper draft vessels. The main entrance channel to New Bedford Harbor lies just to the east of this site and has a water depth of 30 feet (9.2 m) (NOAA, 1994). This Alternative Site does not lie within a designated anchorage area.

For information on the Horseshoe Shoal WTG array portion of this Alternative Site, please see the discussion above.

Vessel Usage

New Bedford Harbor is heavily used by commercial and recreational vessels. Vessel traffic in the vicinity of the New Bedford WTG Alternative includes commercial cargo ships, commercial and recreational fishing vessels, and recreational vessels. According to USACE data for the 1998-2001, an annual average of 4,811 trips of vessels engaged in waterborne commerce in New Bedford Harbor were reported. Waterborne commerce statistics are self-reported and it is impossible to ascertain the actual total numbers.

Recreational vessels navigate in the vicinity of this Alternative Site with seasonal variation. Increased recreational, ferry, charter fishing, touring, and cruise vessel traffic is common in Buzzards Bay during the warmer months, typically from April through October.

Comparative Summary of Existing Resources

Navigational uses vary between the four Alternative Sites under consideration. The MMR Alternative Site is located onshore in an upland location and has no marine navigational uses associated with it, however, military land navigation training for infantry troops is performed. The Nantucket Sound Alternative Site contains general anchorage areas that are outside of the adjacent shipping lanes known as the Main Channel and North Channel. Navigational use of the area South of Tuckernuck Island is generally limited to smaller craft, as most commercial shipping in the area use the Main and North Channels of the Nantucket Sound or the waters south of Nantucket Shoals. Although New Bedford Harbor is a busy commercial port, the location of the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site would be in shallow water outside of the local anchorage area and the harbor entrance channel. However, the New Bedford Harbor/ Horseshoe Shoal Alternative would have the largest impact on waterways users as it is a combination of the New Bedford Harbor and Nantucket Sound sites. Recreational vessels use the waters around all the offshore Alternative Sites.

3.4.3.2.11 Cultural / Historical Properties

Section 106 of the National Historic Preservation Act (NHPA) requires the USACE, as lead federal agency, to consider the effects of its undertakings (including issuance of permits) on any properties that are listed in, or eligible for listing in, the National Register of Historic Places (NRHP) and to afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. Although only the selected alternative will undergo this review, this section presents cultural resource information in order to compare each of the four identified alternatives.

In order to gather appropriate cultural and historical information, a literature review was conducted, research of both marine and terrestrial archaeological resources was undertaken, and the Massachusetts Historical Commission (MHC) was consulted. Documented screening studies were performed for each of the Alternative Sites under consideration, the results of which are described in the following sections. This review was limited to those sites/structures/districts currently listed or determined eligible for listing on the NRHP located within each Alternative Site's Area of Potential Effect (APE).

An APE for a project is defined as that geographic area or areas within which construction, operation or maintenance of a project may directly or indirectly cause alterations in the character or use of historic properties (per Section 106 regulations, 36 CFR Part 800 Section 16(d)). There are a variety of potential effects a project may have on historic properties, including physical effects (such as ground disturbance or destruction), noise

effects or visual effects of aboveground structures on the setting of historic properties. Specific APEs were determined for each Alternative Site under consideration.

Identification of Architectural Historic Properties

Inventory lists and maps were compiled showing existing historic architectural properties within each APE for the alternative sites from information available in GIS files, Massachusetts State Register of Historic Places (SRHP), National Register Information System (NRIS), Massachusetts Cultural Resource Information System (MACRIS), and files contained in the MHC's *Inventory of the Historic and Archaeological Assets of the Commonwealth* (MHC Inventory). This information was analyzed in order to identify architectural historic properties that may be visually affected by proposed WTGs at each Alternative Site. The visual APEs for the marine alternatives were defined as 300 feet (91.5 m) from the shorelines within view of each alternative, presuming that more distant views would be likely to be screened by vegetation or other intervening structures. The terrestrial alternative includes properties within 300 feet (91.5 m) of the proposed MMR Alternative Site boundary, as well as those in more elevated areas to the north and east, as shown in Figure 3-30. Areas to the west, south and southeast of the MMR alternative site were not included in the viewshed, due to foreground screening effects caused by mature vegetation, topography and intervening structures, although intermittent visibility from these areas could be available.

Properties included in the study are those within the APE that are listed in the National Register of Historic Places (NRHP), formally determined eligible for the NRHP, properties in the Inventory of Historic and Archaeological Resources for which MHC has concurred with eligibility recommendations in a statement of findings, and properties on the State Register of Historic Places (SRHP), including local historic districts, that MHC has found are eligible for the NRHP.

An initial search was conducted using Geographic Information Systems (GIS) data layers that provide locational information for properties listed in the SRHP. The SRHP is the state's list of properties that are listed in or formally determined eligible for listing in the NRHP, as well as Massachusetts landmarks, local landmarks, and local historic districts. The available SRHP data layers are relatively complete for properties designated before 1997. The data was crosschecked for accuracy using the NRIS and MACRIS databases. Properties designated between 1997 and the present were identified through research in the MACRIS database and MHC Inventory files. The MACRIS and MHC Inventory files were researched to identify properties that have been evaluated as eligible for the NRHP by the MHC, but which have not yet been listed in or formally determined eligible by the Keeper of the National Register.

The SRHP GIS data was incorporated into a base map prepared using the ArcView GIS program. Other data layers showing municipal boundaries, water resources, and streets were added to provide reference information about the location of the properties. The APEs for the proposed alternatives were digitized on the map and historic properties within them were identified using the selection tools available in ArcView. The base map was then transferred to AutoCad 2000 format and the location of properties identified during the review of the MACRIS and MHC Inventory research were added. This map was used to produce Figures 3-30, 3-32, 3-33, and 3-34. A database containing fields for location, property name, and designation information was created in Microsoft Access and was used to produce Tables 3-21 to 3-24.

Marine Archival Research

A review of available datasets for offshore archaeological sites was conducted, including information regarding shipwrecks and submerged prehistoric Native American sites. These datasets included:

- The National and State Registers of Historic Places;
- Cultural resource management (CRM) reports and site files at the MHC and Massachusetts Board of Underwater Archaeological Resources (MBUAR);
- Northern Maritime Research's Northern Shipwrecks Database (Version 2002);
- Available archaeological reports by vocational and professional archaeologists; and
- Environmental studies regarding the geomorphologic history of the region and the effects of the post-glacial Holocene marine transgression.

The National Oceanic and Atmospheric Administration's (NOAA) Automated Wreck and Obstruction Information System (AWOIS) was also accessed for this study. However, software problems were encountered with the database. Until these problems are resolved, the AWOIS information cannot be relied upon for this screening study (see Appendix 3-I).

Terrestrial Archival Research

To identify known archaeological sites, a review of the following sources was conducted:

- CRM reports, Inventory and site files at MHC;
- MACRIS and NRHP database listings;
- Available archaeological reports; and
- Environmental studies.

Archaeological Sensitivity Assessment

Using existing datasets and background research as described above, alternative-specific terrestrial or marine (as appropriate) archaeological sensitivity assessments were developed. Predictive models were then formulated to preliminarily assess the potential for the presence of previously unidentified Native American and Euro American archaeological resources within each alternative's APE for physical effects. The APE, identified historic and archaeological resources, and sensitivity assessment for each Alternative Site are presented below.

Massachusetts Military Reservation

Area of Potential Effect

The APE for the MMR alternative site is the geographic area within which the Project may cause potential physical, noise and visual effects on historic properties. For the purposes of this evaluation, the APE for visual effects is considered to be areas within 300 feet (91.5 m) of the perimeter of MMR, and more distant areas along topographic highs in the vicinity such as the bridges over the Cape Cod Canal, along the Sandwich moraine, the Cape Cod Canal area itself and bluffs to its north. The APE for physical and noise effects coincide with the polygon encompassing the WTGs and associated work areas.

Architectural Historic Properties

Aboveground historic properties within the viewshed of the MMR Alternate Site are shown on Figure 3-30 and listed on Table 3-21. The Bourne Bridge and Sagamore Bridge and the U.S. Coast Guard Station Cape Cod Canal are within the viewshed and have been evaluated as eligible for the National Register. The Cape Cod Canal, designated as a National Historic Civil Engineering Landmark in 1985, is also within the viewshed. The Camp Edwards Range Control and Ammunition Supply Point are two historic properties that have recently been evaluated as eligible for the National Register. These are both within the MMR Alternative Site, and will have expected visibility of Project structures.

Archaeological Sensitivity Assessment

Results of the archaeological sensitivity assessment of the MMR Alternative Site are shown on Figure 3-31 and presented in Appendix 3-I. A summary is presented below.

There are currently 23 known prehistoric archaeological sites located within and/or immediately adjacent to the proposed MMR Alternative Site. These sites are clustered in various sections of the proposed project area, and were identified during intensive archaeological surveys of location-specific project areas within MMR. None of these sites has been determined to represent significant archaeological resources. The sites are all comprised of low-density cultural deposits and/or solitary artifact finds that are unlikely to provide additional information about prehistoric period land use patterns. Many of the sites are located in areas that have since been re-classified as either low sensitivity or disturbed (Davin and Gallagher 1987; Fragola 1996a, 1996b; Fragola and Garman 1997; Herbster and Davin 1992; Macomber 1991).

No previously identified historic archaeological sites are located within the MMR Alternative Site, although two farms were located within the bounds of MMR during the nineteenth century to the early twentieth century.

The MMR Alternative Site includes areas of high, moderate and low archaeological sensitivity as well as areas of modern period disturbance. Systematic archaeological investigations within small portions of the proposed project area have identified prehistoric archaeological sites. Based on these studies, it is likely that additional prehistoric period archaeological deposits are located within the proposed project area. If present, these deposits would likely consist of the same spatially limited, low-density sites and artifact find spots that have been previously identified. The MMR Alternative Site exhibits low potential to contain historic period resources.

In summary, archaeological investigations in the form of an intensive (locational) survey would be recommended for any project impact areas located in moderate or high sensitivity areas as depicted on Figure 3-30. The goal of an intensive survey would be to locate and identify any prehistoric archaeological resources within project impact areas.

Nantucket Sound

Area of Potential Effect

The APE for physical and noise effects coincide with the polygon encompassing the WTGs and associated work areas. The APE for visual effects for alternative sites in Nantucket Sound includes offshore areas oriented to experience open unobstructed views of the proposed WTGs, extending onshore to areas 300 feet (91.5 m) landward of the shoreline.

Architectural Historic Properties

Locations of aboveground historic properties within the viewshed of one or more of the Nantucket Sound alternatives are shown on Figure 3-32 and listed on Table 3-22. A total of 19 historic properties and districts are listed in the towns of Falmouth (1 individual listing); Barnstable (3 districts and 3 individual listings, including one National Historic Landmark); Chatham (one district); Tisbury (one individual listing); Oak Bluffs (5 individually listings, including one National Historic Landmark and one district); Edgartown (two individual listings and one district), and Nantucket, the whole of which is a National Historic Landmark and listed on the NRHP.

The following NRHP-listed/eligible locations facing Nantucket Sound have been selected to serve as representative examples which are also tied to the visual analyses discussed in section 3.4.3.2.12:

- Wianno on Cape Cod, to simulate views of the Horseshoe Shoal full and reduced arrays (approximately 5.67 miles (9.1 km) to nearest WTG);
- Monomoy Lighthouse, to simulate views of Monomoy and Handkerchief Shoal alternative (approximately 6.4 miles (10.3 km) to nearest WTG); and
- Cape Poge near the lighthouse on Martha's Vineyard, to simulate views of Tuckernuck Shoal alternative (approximately 3.9 miles (6.28 km) to nearest WTG).

Wianno Historic District

The Wianno Historic District in the Village of Osterville on Cape Cod is comprised of 28 main buildings and 13 outbuildings on approximately 40 acres (.16 km^2) along Sea View Avenue and Wianno Avenue. The lands were originally assembled in the late 19th century by a consortium of businessmen, and developed as a summer colony. The large well-kept lots on either side of Sea View Avenue along Nantucket Sound contain grand Shingle Style and Colonial Revival style summerhouses, most of which were constructed between the late 19th century and World War I.

The focal point of the Wianno Historic District is the Wianno Club on Sea View Avenue, a massive three-story shingled main building and two-story rear ell, both with mansard roofs. The Club overlooks Nantucket Sound on almost 1,000 feet (305 m) of beach frontage. The building is described as extremely significant architecturally, as much of its original exterior and interior detailing survives. The structure was individually listed in the National Register in 1979, and is also included in the Barnstable Multiple Resource Area, listed in 1987.

Monomoy Point Lighthouse

The Monomoy Point Lighthouse is located at the southern end of Monomoy Island, a coastal barrier beach island extending approximately 10 miles (16 km) south of the Cape's elbow at Chatham. The island is an uninhabited coastal dune and marsh complex, and comprises most of the Monomoy National Wildlife Refuge managed by the

U.S. Fish and Wildlife Service. The island is accessible only by boat, and little human disturbance or development is evident, except footpaths and the historic lighthouse and its associated buildings. Landform in this area is characterized by rolling dunes and bluffs, with beach grass and sparse, scattered woody vegetation. Marshes and open water dominate views near the shoreline.

Wildlife such as gulls, terns and seals are abundant, and add to the remote and undeveloped character of the island. The island is a National Wilderness Area, although the parcel that contains the lighthouse is not included in the designation. The Massachusetts Audubon Society has owned the parcel since 1977. A lighthouse has occupied the site since 1823. The present lighthouse was constructed around 1871. The lighthouse complex is unmanned, and includes a brick light tower and a two-story keeper's house, both of which have deteriorated. The complex was determined significant in the areas of engineering, exploration and settlement, and transportation.

Cape Poge

Cape Poge, Martha's Vineyard is a largely natural area on the north side of Chappaquiddick Island and is protected by the Massachusetts Trustees of Reservations. The area contains dunes and low coastal vegetation, bordered in places by a steep 20 to 30 foot (6.1 to 9.2 m) high sandy bluff at the ocean shoreline. The area is undeveloped, with the exception of approximately 5 to 10 large homes and several unimproved sand roads. Cape Poge offers expansive views at and near the shoreline. Once away from the shoreline, including at the base of the lighthouse discussed below, the dunes and dune vegetation effectively screen most views toward the water.

The Cape Poge Lighthouse is one of the five lighthouses on Martha's Vineyard listed on the National Register. Built in 1922 on the northeastern tip of Chappaquiddick, the present wood-shingled lighthouse replaced several earlier decaying towers, the earliest of which was constructed in 1802. Encircling the top of the tower is a simple cast iron balustrade; the windows and doorway are pedimented.

Marine Archaeological Sensitivity Assessment

The marine archaeological sensitivity assessment of each of the Nantucket Sound sub-alternative sites are presented in Appendix 3-I. A summary is presented below.

Horseshoe Shoal

No submerged historic properties or archaeological sites are recorded in the area in the National or State Registers, or the MBUAR or MHC site files. No wrecks or obstructions are currently charted in the Horseshoe Shoal alternative site, although 18 vessel casualties ranging in date from 1819 to 1963 are reported in the area in the Northern Shipwreck Database. A review of the MHC's records indicates that no marine archaeological investigations have been conducted within the Alternative Site. However, previous marine geophysical (i.e., remote sensing) and geotechnical (vibratory coring and deep boring) surveys of Nantucket Sound, including in this area, encountered intermittent organic materials in the easternmost portions of the Alternative Site, which may represent former exposed land surfaces.

The archaeological sensitivity of the Horseshoe Shoal Alternative is anticipated to be "high" for Euro-American submerged cultural resources, because of the general area of Nantucket Sound's documented vessel losses, navigational hazards (i.e., submerged shoals), and proximity to modern and historic-period shipping routes between some of the region's most active and oldest ports. The archaeological sensitivity for ancient Native American submerged cultural resources is anticipated to be "high" due to the potential presence of archaeologically sensitive intact buried paleosols within the Alternative Site, the area's variable bathymetry, and its somewhat protected location from the open waters of the Atlantic Ocean.

Monomoy and Handkerchief Shoals

No submerged historic properties or archaeological sites are recorded in the alternative site in the National or State Registers, or the MBUAR or MHC site files. There are no wrecks currently charted within the search area, although five wrecks in the vicinity ranging in date from 1853 to 1899 are listed in the Northern Shipwreck Database. The MHC's records indicate that only one previous marine archaeological investigation, and marine archaeological reconnaissance survey of a planned dredging area in Hyannis Harbor, has been conducted in the vicinity to date. No submerged historic properties were identified during the survey.

Because of the general area of Nantucket Sound's documented vessel losses, and proximity to the shipping route between Hyannis and Nantucket Harbors, the archaeological sensitivity of the Monomoy and Handkerchief Shoals Alternative is anticipated to be "moderate" for Euro-American submerged cultural resources. The archaeological sensitivity for ancient Native American submerged cultural resources is also anticipated to be "moderate" because of the alternative's proximity to previously identified potentially archaeologically sensitive areas within the nearby Horseshoe Shoal alternative, areas of variable bathymetry, and protected location from the open waters of the Atlantic Ocean.

Tuckernuck Shoals

No submerged historic properties or archaeological sites are recorded in the area in the National or State Registers, or the MBUAR or MHC site files. There are two unidentified wrecks currently charted within the search area. The Northern Shipwreck Database reports 102 vessel casualties ranging in date from 1799 to 1937 for the search area, of which only 17 were reported to have been refloated and/or removed. A review of the MHC's records indicates that no previous marine archaeological investigations have been conducted in this Alternative Site area.

The archaeological sensitivity of the Tuckernuck Shoal Alternative is anticipated to be "high" for Euro-American submerged cultural resources, because of the area's navigation hazards (i.e., the shoals listed above), proximity to the Main Channel, charted shipwrecks (2), and large number of documented shipwrecks (85). The variable bathymetry, proximity to the Main and Muskeget channels (potential former river beds), and somewhat protected location from the open waters of the Atlantic Ocean create conditions such that the archaeological sensitivity for ancient Native American submerged cultural resources at this location is also anticipated to be "high."

South of Tuckernuck Island

Area of Potential Effect

The APE for physical and noise effects coincide with the polygon encompassing the WTGs and associated work areas. The APE for visual effects for South of Tuckernuck Island includes offshore areas oriented to experience open unobstructed views of the proposed WTGs, extending onshore to areas 300 feet (91.5 m) landward of the shoreline.

Architectural Historic Properties

Locations of aboveground historic properties within the viewshed of this alternative layout are shown on Figure 3-33 and listed on Table 3-23. Two properties were included: the entire island of Nantucket (a National Historic Landmark) and Cape Poge Light (individually listed on the NRHP). WTGs at this site are not expected to be visible from Cape Cod.

Marine Archaeological Sensitivity Assessment

The Tuckernuck Island Alternative is located in the open waters of the Atlantic Ocean southwest of Nantucket and Tuckernuck islands. No submerged historic properties or archaeological sites are recorded in the area in the National or State Registers, or the MBUAR or MHC site files. There are no wrecks currently charted within the search area. Four vessel casualties ranging in date from 1817 to 1969 are reported in the Northern Shipwreck Database, but only the most recently wrecked vessel was not re-floated. A review of the MHC's records indicates that no marine archaeological investigations have been conducted in the area.

The archaeological sensitivity of the South of Tuckernuck Island Alternative is anticipated to be "low" for Euro-American submerged cultural resources, because of its distance away from charted navigation channels, ports-of-call, and hazards to navigation, as well as the absence of charted shipwrecks and obstructions, and the relatively small number of documented shipwrecks (1) that are reported for the area. The archaeological sensitivity for ancient Native American submerged cultural resources is also anticipated to be "low." The area's homogenous bathymetry and largely unprotected location from the open waters of the Atlantic Ocean together suggest a low probability for the presence of contextually intact, archaeologically sensitive, buried paleosols or undisturbed archaeological sites within the alternative.

New Bedford / Horseshoe Shoal

Area of Potential Effect

The APE for physical and noise effects coincide with the polygon encompassing the turbines and associated work areas. The APE for visual effects for New Bedford/Horseshoe Shoals includes offshore areas oriented to experience open unobstructed views of the proposed WTGs, extending onshore to areas 300 feet landward of the shoreline.

Architectural Historic Properties

Locations of aboveground historic properties within the viewshed of the New Bedford layout are shown on Figure 3-34 and listed on Table 3-24. For Horseshoe Shoal, see the discussion regarding Nantucket Sound, above.

A total of 13 historic properties were identified with expected visibility of the WTGs at this Alternative Site. The properties are located in Dartmouth (the Padanaram Village Historic District is the closest to the site), New Bedford, Fairhaven, and at greater distances in Mattapoisett, Marion, Bourne and Falmouth. Since the Padanaram Village is the closest historic property to the New Bedford Alternative Site, it suitably represents the other historical properties in the area.

Marine Archaeological Sensitivity Assessment

One wreck and one identified obstruction are currently charted within the search area. Ten vessel casualties ranging in date from 1908 to 1963 are listed in the Northern Shipwreck Database within the search area. As many as nine of the ten were total losses, although several vessels have undocumented identities, dates, and dispositions. MHC and MBUAR site files document the presence of two shipwrecks and a "grounding site" within the alternative search area. The two wreck sites consist of the 62-ton fishing vessel, *Margaret Kehoe*, that sank near Church Rock in 1963, and the U.S.S. *Yankee* (ex-*El Norte* [1892]), a 6,225-ton, 391-foot, naval steam-cruiser that ran aground and sank near Great Ledge on September 23, 1908, three miles (4.8 km) east of Round Hill Point. Archaeological investigation to delimit either wreck site and evaluate their potential National Register-eligibility has not yet been undertaken.

The H.M.S. *Nimrod* Grounding Site (DAR-HA-2) is located in 20 feet (6.1 m) of water on Great Ledge at the southwest corner of the Alternative Site. The archaeological site consists of a deposit of 19th century artifacts (i.e., weapons) that were jettisoned from the *Nimrod* on June 14, 1814, to lighten and refloat the vessel after it ran aground on the ledge. The effort was apparently successful; no shipwreck is present at the site. The extent and potential National Register eligibility of the site have not yet been defined and evaluated; however, several cannon were recovered from the site under MBUAR permit by the Kendall Whaling Museum, with additional cannon and other cultural materials presumed to still be present (Trubey, 2004). A review of the MHC's and MBUAR files indicates that four marine archaeological investigations have been conducted in the vicinity of the area, with no potentially significant submerged historic properties identified other than those described above. No other submerged historic properties or archaeological sites are recorded in the area in the National or State Registers, or the MBUAR or MHC site files.

The archaeological sensitivity of the relatively small New Bedford/Buzzards Bay portion of the combination alternative is anticipated to be "high" for Euro-American submerged cultural resources due to the area's documented vessel losses, documented shipwrecks and archaeological site, navigational hazards (i.e., submerged ledges and rocks), and proximity to the Entrance Channel into New Bedford Harbor, one of New England's most active and historic ports. However, the archaeological sensitivity for ancient Native American submerged cultural resources is anticipated to be "moderate," due to the area's proximity to the archaeologically sensitive Acushnet River area, and somewhat variable bathymetry and protected location from the open waters of the Atlantic Ocean, both of which enhance the potential for preservation of intact paleosols offshore.

Comparative Summary of Existing Resources

Based on a thorough sensitivity assessment of each alternative, three of the alternative sites (MMR, Nantucket Sound and New Bedford/Horseshoe Shoal) were determined to contain moderate to high potential for containing previously unrecorded, potentially significant archaeological resources.

The Nantucket Sound Alternative Site, with its three sub-alternatives, contained the greatest number of National Register-listed or eligible historic properties within its viewshed. The South of Tuckernuck Island and the New Bedford Alternative Sites had fewer properties within their respective viewsheds. However, the properties associated with the New Bedford Alternative would be combined with some or all of the properties listed for the Nantucket Sound viewshed when considering the New Bedford/Horseshoe Shoal Alternative.

3.4.3.2.12 Aesthetic/Landscape/Visual

This section describes the aesthetic and landscape character and the viewshed in the vicinity of each Alternative Site under consideration. The representative locations (viewpoints) for each Alternative Site have been limited to the onshore historic property closest to and with an open view of the site (that is, having limited obstructions). For each Alternative Site, existing views during both daytime and nighttime have been described.

Because all the selected viewpoints for the offshore alternative sites are shoreline historic properties, a generic seascape view (shown in Figure 3-35) was determined to be suitable for the offshore photo renderings. Photographs of the existing viewscape toward MMR as seen from the Sagamore Bridge were taken (shown in Figure 3-36), for use in simulating proposed views from that historic property. The following sections characterize the existing visual setting for each Alternative Site location. For more information on viewpoint selection and simulation methodology, please refer to Appendix 3.0-K.

Massachusetts Military Reservation

The landscape character in the vicinity of the MMR Alternative Site is mixed, and includes areas of mature forests and undulating topography, communities such as Sandwich and Bourne, outlying mixed suburban development, busy transportation corridors including secondary roads and rotaries, and open marine views in the vicinity of the Cape Cod Canal. Public access to the MMR itself is restricted.

The onshore viewshed is considered for this screening analysis to include the area within 300 feet (91.5 m) of the perimeter of the MMR property boundary, and along topographic highs in the vicinity such as the bridges over the Cape Cod Canal, along the Sandwich moraine, and along both sides of the Canal, to the bluffs north of the Canal, as well as northwestern Sandwich (see Figure 3-30). Due to the screening typically provided in the area by mature vegetation, intervening structures and topography, this area was determined to adequately represent the viewshed for the MMR Alternative Site. Historic properties and recreational resources within these areas were identified, as described in Sections 3.4.3.2.11 and 3.4.3.2.13, respectively.

The view from the Sagamore Bridge was selected for photo renderings to represent the change in views associated with the project if it were located at the MMR Alternative Site. The bridge represents both a higher elevation vantage point towards the site as well as a historic resource. Both the Sagamore Bridge and the Bourne Bridge have been evaluated eligible for listing on the National Register of Historic Places (NRHP). To document the existing view, and for use in developing renderings of the project at the MMR Alternative Site, daytime color photographs toward the MMR Site were taken in January 2004 (leaf-off conditions). The photographs were taken from three viewpoint locations on the sidewalk along the east side of the Sagamore Bridge. The distance from the Sagamore Bridge viewpoint to the closest WTG location for the MMR Alternative Site is approximately 0.8 mile (1.3 km).

At each of these viewpoints, a camera and tripod were set up and the exact location of the camera determined using GPS survey equipment. Bearings of each sequential photograph of the viewscape south of the Canal were measured using a compass. Locations of other known features in the view were also determined using in-field GPS and aerial photographs. Color photographs were taken with an Olympus OM-10 SLR camera using a 50 mm setting, to simulate normal human eyesight relative to scale. Field conditions were clear, cold and sunny.

The southernmost viewpoint location was determined to be most representative of existing views of the MMR Alternative Site as experienced by travelers coming onto the Cape (see Figure 3-36). Views of the MMR Alternative Site from the two other viewpoints photographed (one at the crest of the Bridge and one midway between that point and the selected viewpoint were partially obstructed due to the presence of densely gridded safety fencing along the outer sides of the bridge. The selected viewpoint, while lower in elevation than the

other two, offered the most open, unobstructed available views toward the MMR Alternative Site. Night time photographs were not taken of the existing view from the bridge, as it was determined that the high levels of existing floodlighting, as well as vibrations from passing cars, would interfere with the long timed exposures needed and prevent an accurate portrayal of background landscape at night.

The selected view from the Sagamore Bridge (Figure 3-36) includes a number of existing features in the landscape, including the blades of an artificial windmill at the Christmas Tree Shop at the base of the Bridge (see lower left of figure), the busy Route 6 on and off ramps, adjacent commercial buildings, and the tall lights that illuminate the Sagamore Bridge and the nearby Cape Cod Outlet Mall. In the panorama outside the photograph are other built features such as electric transmission lines, cell towers, other busy transportation corridors, and a power plant stack.

There is a relatively high level of ambient night time lighting in the vicinity of the selected viewpoint toward the MMR Alternative Site. Sources include the floodlighting on both bridges and along both sides of the Canal, lighting along the transportation corridors, and illumination of nearby commercial buildings and parking lots, as well as headlights from traveling vehicles.

Nantucket Sound

For purposes of this screening analysis for all offshore alternatives, the onshore viewshed is considered to be the shoreline area oriented to experience open unobstructed views of the proposed WTG locations, extending onshore to areas 300 feet (91.5 m) landward of the shoreline. Views further onshore were considered to be potentially screened by mature vegetation, intervening structures and topography.

The existing seascape in Nantucket Sound is comprised of a large expanse of open water, rimmed by the low-lying landforms of the Cape and the Islands. The character of the viewscape is consistent with a natural unified nearshore southern New England seascape. Activity visible from the shoreline is limited to recreational and fishing boats, ferries, navigational aids, and aircraft flying overhead. Tankers, freighters and other large commercial ships typically avoid the shallow drafts and shoals of the Sound. Historic properties and recreational resources related largely to seaside activities line the shorefronts, and are described in Sections 3.4.3.3.2.11 and 3.4.3.3.2.13, respectively.

The following NRHP-listed/eligible locations facing Nantucket Sound were selected for use in developing daytime and nighttime photo renderings of the Nantucket Sound Alternative:

- Wianno Historic District on Cape Cod, to represent views of the Horseshoe Shoal full and reduced arrays;
- Monomoy Point Lighthouse, to represent views of the Monomoy and Handkerchief Shoal sites; and
- Near the lighthouse at Cape Poge on Martha's Vineyard, to represent views of the Tuckernuck Shoal site.

The generic seascape view shown in Figure 3-35 is considered representative of the existing unobstructed shoreline from these viewpoints, and will be used to develop the photo renderings of the Nantucket Sound Alternative. The existing landscape character of each of these historic properties is described below.

The focal point of the Wianno Historic District, located in the Village of Osterville on Cape Cod, is the Wianno Club on Sea View Avenue. The Club overlooks Nantucket Sound on almost 1,000 feet (305 m) of beach frontage. The structure was individually listed in the National Register in 1979, and is also included in the Barnstable Multiple Resource Area, listed in 1987. The Wianno Historic District is approximately 5.7 miles (9.1 km) from the closest WTG proposed in the full Horseshoe Shoal array and approximately 6.2 miles (9.9 km) to the closest WTG in the proposed reduced array.

The Monomoy Point Lighthouse is located at the southern end of Monomoy Island, a coastal barrier beach island extending approximately 10 miles (16 km) south of the Cape's elbow at Chatham. The island is an uninhabited coastal dune and marsh complex, and comprises most of the Monomoy National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. The landform is characterized by rolling dunes and bluffs, with beach grass and sparse, scattered woody vegetation. Marshes and open water dominate views near the shoreline. Monomoy Light is approximately 6.4 miles (10.2 km) from the closest WTG proposed at Monomoy/Handkerchief Shoals.

Cape Poge, Martha's Vineyard is a largely natural area on the north side of Chappaquiddick Island that is protected by the Massachusetts Trustees of Reservations. Cape Poge Light is one of the five lighthouses on Martha's Vineyard that is listed on the NRHP. The area contains dunes and low coastal vegetation, bordered in places by a steep 20- to 30-foot (6 to 9 m) high sandy bluff at the ocean shoreline. The area is undeveloped, with the exception of approximately 5 to 10 large homes and several unimproved sand roads. Cape Poge offers expansive views at and near the shoreline. Once away from the shoreline, including at the base of the lighthouse, the dunes and dune vegetation effectively screen most views toward the water. Cape Poge is approximately 3.9 miles (6.2 km) from the closest WTG proposed at Tuckernuck Shoal.

South of Tuckernuck Island

Panoramic open views of the Atlantic Ocean are available from the continuous sandy beaches of south Nantucket and Tuckernuck Islands. The shorefront is characterized by crashing surf, rolling sand dunes, and low beach grass, and has a remote and wild setting, especially between the several public beaches on Nantucket. The adjacent land area is sparsely developed with homes.

The existing seascape toward the South of Tuckernuck Island Alternative Site is comprised of open ocean. The character of the viewscape is not fragmented, and is consistent with a natural unified southern New England ocean view. Offshore activity is limited to recreational and fishing boats, navigational aids, and aircraft flying overhead. Tankers, freighters and other large commercial ships transit the area to the south of the islands. Historic properties and recreational resources related largely to seaside activities line the shorefronts, and are described in Sections 3.4.3.3.2.11 and 3.4.3.3.2.13, respectively.

The entire island of Nantucket is a National Historic Landmark. Madaket Beach, located 3.8 miles (6.1 km) from the closest WTG proposed for the South of Tuckernuck Island Alternative, has been selected for use in developing daytime and nighttime photo renderings to represent proposed views of this Alternative Site from the closest onshore historic property. The generic seascape view shown in Figure 3-35 is considered representative of the existing unobstructed shoreline from this viewpoint.

New Bedford / Horseshoe Shoal

The existing viewscape in the vicinity of the New Bedford Alternative Site includes developed shoreline and headlands, overlooking the outer New Bedford Harbor, a busy fishing and industrial port. Smaller harbors in the area are popular with recreational boaters. The seascape in Buzzards Bay also reflects commerce and maritime use of the area, with large vessels transiting Buzzards Bay and the Cape Cod Canal year-round, with fishing boats and numerous recreational boats in the warmer months.

The view towards the Buzzards Bay portion of the New Bedford/Horseshoe Shoal Alternative Site from the vicinity of Padanaram Village Historic District, which extends to the eastern shoreline of Dartmouth, was selected to simulate views of the Buzzards Bay portion of this alternative. Daytime and nighttime photo renderings, developed from the generic seascape shown in Figure 3-35, are used to represent the anticipated views from Padanaram Historic District. This historic district is located approximately 0.9 mile (1.4 km) from the closest WTG proposed for the New Bedford Alternative Site. This village is characteristic of New England colonial seaside villages, with stately former ship captains' homes, well-kept yards, and picket fences.

Comparative Summary of Existing Resources

This section describes the aesthetic and landscape character and the viewshed in the vicinity of each Alternative Site under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

The existing landscape character in the vicinity of the Alternative Sites under consideration range from unobstructed shoreline views of open water for the Nantucket Sound and South of Tuckernuck Island Alternatives to partially obstructed views of a busy commercial and industrial seaport in New Bedford. The MMR Alternative Site contains views of both forested land as well as busy transportation corridors. It is presumed that viewers

toward each Alternative Site would include both residents and tourists, although viewers of the MMR Alternative Site could be more transitory in nature, as they would view that Alternative Site while traveling along the Sagamore and Bourne bridges.

3.4.3.2.13 Recreation

This section describes the on and offshore recreational resources located in the vicinity of the each Alternative Site under consideration. Documentation of existing recreational conditions at the four Alternative Sites was based on a review of the Massachusetts GIS' 2003 database of Protected and Recreational Open Space ("MassGIS database"). In addition, the *Universal Atlas of Cape Cod & Southeastern Massachusetts* was also consulted for Nantucket Sound since some popular area beaches in the visual APE are not included in the GIS database.

The MassGIS database review was conducted to identify and locate onshore recreational resources within approximately 300 feet (91.4 m) of shoreline areas (for offshore Alternative Sites) and within approximately 0.25 mile (0.4 km) of the perimeter of the mapped property boundary (for the onshore Alternative Site at MMR). Due to the number of informational parameters provided for each recreational resource listed in the GIS database, one recreational resource may be listed many times, both in the below-referenced tables and corresponding figures. Therefore, the total number of recreational resources may not accurately reflect the true number of facilities in a particular area. This information, however, is considered an accurate reflection of the general recreational character of each Alternative Site location.

Massachusetts Military Reservation

Onshore recreational resources within the viewshed of the MMR onshore alternative site were identified generally within 0.25 mile (0.4 km) of that portion of the perimeter of MMR that is adjacent to the western and northern portions of the Alternative site boundary, as well as those immediately along both sides of the Cape Cod Canal. Onshore recreational resources identified in this area by MassGIS are listed on Table 3-25; locations are shown on Figure 3-37. Although several listings appear within the MMR property, these are not open to the public, as public access is completely restricted for the MMR property. Therefore, no public recreational resources were identified within the MMR property itself; and the identified resources are located some distance from the Alternative Site location. The most proximate recreational resources are described below.

Portions of the Shawme Crowell State Forest immediately north of Route 6 are the closest recreational resource to the MMR Alternative Site, located between approximately 0.3 mile (.5 km) and 0.7 mile (1.1 km) to the north and northeast. Current recreational activities at the Shawme Crowell State Forest include camping, hiking, biking, fishing and bird watching. This area is generally well vegetated with mature forest. It should be noted that approximately 15,000 acres (60.7 km^2) of the northern portion of MMR (the Camp Edwards area) have been given to the state for wildlife management purposes by the Massachusetts Division of Fisheries and Wildlife. Approximately half of this area was formerly part of the Shawme Crowell State Forest. However, this area is still being leased by MMR, and will continue to be restricted to the public, despite state wildlife management activity. If military operations were closed at MMR, public use of this 15,000-acre (60.7 km^2) area could then be allowed.

Bicycle paths are located on both sides of the Cape Cod Canal. The bike paths south and north of the Canal are approximately 1,500 feet (457 m) and 2,300 feet (701 m), respectively, at their closest points to the WTG at the MMR Alternative Site. The Sagamore and Bourne Bridges, while not recreational resources themselves, are transportation conduits for numerous tourists accessing the Cape Cod area for recreational purposes. The Sagamore Bridge is approximately 0.8 (1.3 km) and the Bourne Bridge is approximately 1 mile (1.6 km) to the closest proposed WTG at the MMR Alternative Site.

Approximately 1,100 acres (4.5 km^2) on both sides of the Cape Cod Canal are operated by USACE as a linear public recreational area. Recreational resources north of the Canal within this area are, from east to west, the bike path along the Canal (a paved service road); the Scusset Beach State Park and saltwater fishing pier, the Herring Run Visitors Center, and the Bourne Scenic Park (a campground operated by the Town of Bourne). On the south side of the Canal are the bike path, the Cape Cod Canal Visitors Center, the Midway Recreational Area and the Bourne Recreation Area. These resources are located between 1,500 feet (457 m) (the south side bike

path) and 2 miles (3.2 km) (the Cape Cod Visitors Center) from the MMR Alternate Site. Saltwater fishing is also allowed from the riprap along both sides of the Canal.

In addition to these onshore recreational uses, recreational boaters and fishermen are located in the vicinity of the MMR Alternative Site, transiting the Canal, and in Buzzards and Cape Cod Bays.

Nantucket Sound

Onshore recreational resources were identified within 300 feet (91.4 m) of shoreline areas oriented toward the Nantucket Sound Alternative Site. Onshore recreational resources identified in this area by MassGIS are listed on Tables 3-26 to 3-28, with locations shown on Figure 3-38.

The sandy shorelines of the south side of Cape Cod, western Martha's Vineyard and northern Nantucket contain numerous recreational resources, including beaches, bike paths, conservation land and wildlife refuges, scenic lighthouses, marinas and yacht clubs, and boat ramps. Recreational activities such as windsurfing, jet skiing, swimming, sunbathing, fishing, hiking and picnicking are common at these onshore areas. The recreational areas closest to each of the three components of the Nantucket Sound Alternative Site under consideration are identified below.

Onshore Recreational Resources within Viewshed of Horseshoe Shoal

Beaches and recreational areas closest to this site along the south side of the Cape are those from South Cape Beach State Park (6.9 miles (11.1 km) to nearest proposed WTG) and Popponesset Beach (5.4 miles (8.7 km)) in Mashpee east of the mouth of Bass River at the Yarmouth-Dennis town line. Open views of the Horseshoe Shoal site will be available from other south-facing beaches including beaches in the GIS database and shown in the Universal Atlas in Cotuit (5.7 miles (9.2 km)), Wianno (5.7 miles (9.2 km)), Centerville (6.5 miles (10.5 km)), Craigville (6.5 miles (10.5 km)), Hyannis Port (6.5 miles (10.5 km)), Hyannis (6.5 miles (10.5 km)) and South Yarmouth (7.6 miles (12.2 km)). Please refer to Table 3-26

Other onshore recreational areas in the vicinity of this Alternative Site include the New Seabury Golf Club's Ocean Course and the Hyannis Port Golf Club, both approximately 6.5 miles (10.5 km) from the nearest WTG proposed for this Alternative Site, and shorefront conservation areas identified on the *Universal Atlas of Cape Cod and Southeastern Massachusetts*: Waquoit Bay National Estuarine Research Reserve (ACEC), Falmouth (7.6 miles (12.2 km)) Sampson's Island, Barnstable (Mass. Audubon Society Sanctuary) (5.5 miles (8.9 km)), and the Long Beach Conservation Area, Centerville (6.6 miles (10.6 km)).

On Martha's Vineyard, the closest onshore recreational areas to the Horseshoe Shoal Alternative Site are along the northeastern portion of Cape Poge, including the lighthouse (5.5 miles (8.9 km)) and beach areas (5.5 to 7.2 miles (8.9 to 11.6 km)). Lighthouse Beach and Joseph Sylvia Beach in Edgartown are approximately 9 to 10 miles (14.5 to 16.1 km) from this area, respectively. East-facing shorefront beaches and recreational areas in Oak Bluffs are approximately 9.5 miles (15.3 km) from the nearest portion of this Alternative Site.

North and northwesterly facing areas of Nantucket will also have potential exposure to the project at this Alternative Site. Conservation lands on Tuckernuck Island are approximately 11 miles (17.7 km) from the nearest proposed WTG at this Alternative Site; Eel Point at Nantucket is approximately 12 miles (19.3 km) from this Site.

Onshore Recreational Resources Within Viewshed of Monomoy-Handkerchief Shoal

The closest onshore recreational resources to this Alternative Site are the south-facing public beaches in South Yarmouth (4 to 6 miles (6.4 to 9.7 km)), Dennis (4 to 5 miles (6.4 to 8.1 km)) and Harwich (4.5 to 6 miles (7.2 to 9.7 km)). Private conservation lands on Point Gammon and Great Island in Yarmouth are approximately 4.5 miles (7.2 km) away. The southernmost, remote tip of Monomoy Island is a National Wildlife Refuge, approximately 6 miles (9.7 km) from this Alternative Site. More populated beaches of Chatham are located from 7 to 8.5 miles (11.3 to 13.7 km) away from this Alternative Site. Distances from other onshore recreational resources listed on the MassGIS database to this Alternative Site are listed in Table 3-27.

This alternative is the most distant of the three Nantucket Sound alternative sub-sites under consideration from popular recreational areas on areas on Nantucket and Martha's Vineyard. The closest point on Nantucket is

remote Great Point, which is 9.5 to 11.5 miles (15.3 to 18.5 km) from this Alternative Site. The closest area on Martha's Vineyard is Cape Poge lighthouse at 15.5 miles (25 km) from the Site.

Onshore Recreational Resources Within Viewshed of Tuckernuck Shoal

The westernmost portion of this Alternative Site is the closest to onshore recreational resources of all the Nantucket Sound alternative sub-sites under consideration. The closest WTGs proposed for Tuckernuck Shoal would be approximately 3.9 miles (6.3 km) from the Cape Poge lighthouse and nearby beaches on Martha's Vineyard, and approximately 7 miles (11.3 km) from Lighthouse Beach in Edgartown. On Nantucket, the northwestern portions of the island, including Tuckernuck Island and Eel Point, will be the closest areas to this site, each approximately 5 miles (8.1 km) away. Distances from other onshore recreational resources listed on the MassGIS database are included in Table 3-28.

This Alternative Site is the most distant from south-facing beaches on Cape Cod. The closest onshore Cape Cod recreational resource to this Alternative Site is Mashpee's South Cape Beach State Park and Popponesset Beach, at approximately 10 miles (16 km) distant.

Offshore Recreational Resources

The Nantucket Sound Alternative Site is centrally located within the popular recreational resource of Nantucket Sound. Nantucket Sound is used for a variety of water-related recreational activities. Peak recreational activity is during the warmer months of the year (typically April through October). Recreational users such as windsurfers, swimmers, water skiers and jet skiers are active along the nearshore and shoreline areas facing Nantucket Sound. Scuba diving is limited in the area because the soft sediment habitat is generally uninteresting.

The charted shallow water depths, particularly across Horseshoe Shoal and Tuckernuck Shoal, physically limit the sizes of recreational boats that can transit those areas. Because shallow, shifting shoals exist throughout the Sound, most medium to large draft vessel traffic is restricted to marked channels, as described in Section 3.4.3.3.2.10. Changes in water depths over short distances and strong tidal currents (with peak currents often exceeding two knots) tend to create steep waves that break on the shoals, causing many boaters to avoid the shoals. In addition, the long distance from shore and the wave and tidal action also limit use by very small recreational vessels, such as open runabouts.

The Figawi Race from Hyannis to Nantucket and back is one organized recreational activity held every year over Memorial Day weekend, and includes approximately 200 sailboats (in 2004) with overall lengths of 20 feet (6.1 m) or more (Figawi, 2004). The course varies every year, but typically starts to the north of Horseshoe Shoal and proceeds around or over portions of the shoal. Special marine events such as the Figawi must be registered in advance with the USCG local office. A review of partial records of marine events at the USCG Marine Safety Office in Providence indicates most of the events in the Nantucket Sound area have been located nearer to shore than the Nantucket Sound Alternative sub-sites, with the exception of the Figawi Race.

Recreational fishing in Nantucket Sound is described in Section 3.4.3.2.5.

<u>South of Tuckernuck Island</u>

Onshore recreational resources in the vicinity of the South of Tuckernuck Island Alternative Site, identified as those within 300 feet (91.4 m) of shoreline areas oriented toward the Alternative Site, are listed on Table 3-29. Locations of these recreational resources are shown on Figure 3-39.

Onshore Recreational Resources Within Viewshed

The southwesterly-facing beaches on the west half of Nantucket and south-facing beaches on Tuckernuck Island, as well as the southeastern portion of Martha's Vineyard are most proximate to the Alternative Site location. This site will be closest to Madaket Beach on Nantucket, which would be approximately 3.7 miles (6 km) from the nearest WTG proposed for this Alternative Site. The Head of the Plains conservation area and Cisco Beach will also be about 4 miles (6.4 km) away. On Martha's Vineyard, Wasque Reservation on the southeast side of Chappaquiddick Island, managed by the Trustees of Reservations, will be the closest recreational area, at approximately 6 miles (9.7 km) from the nearest WTG.

Recreational activities such as windsurfing, jet skiing, swimming, fishing, sunbathing, hiking and picnicking are common at these onshore areas, and are therefore more likely to experience only visual affects.

The South of Tuckernuck Island Alternative Site will not be visible from Cape Cod.

Offshore Recreational Resources

As with the recreational activities associated with the waters surrounding the other offshore alternatives, offshore recreational activities near the South of Tuckernuck Island Alternative Site are limited primarily to the summer months. However, because the area south of Tuckernuck Island is an open ocean area, recreational boating in small boats is more limited than in the protected waters of Nantucket Sound and Buzzards Bay. Larger recreational vessels transit Muskeget Channel between Martha's Vineyard and Nantucket, and sail south of Nantucket. Similarly, fishing activity in the area tends towards a more open ocean experience from larger vessels often operated as a commercial enterprise. Due to the open ocean conditions, recreational users such as windsurfers, swimmers, water skiers and jet skiers are not expected in the waters south of Nantucket Island. However, boaters utilizing Madaket Harbor on Nantucket could be in visual range for this Alternative Site, depending on location, weather and sea conditions.

New Bedford / Horseshoe Shoal

For information on the Horseshoe Shoal component of this combined Alternative Site please see the Nantucket Sound section, above.

Onshore Recreational Resources Within Viewshed

Onshore recreational resources identified in this area by MassGIS are listed on Table 3-30; locations are shown on Figure 3-40.

Fort Rodman Park in New Bedford is the closest recreational resource to this Alternative Site, approximately 1 mile (1.6 km) away. Other nearby New Bedford recreational resources include No Name Beach, West Beach, Hazelwood Park and East Beach, all less than 2 miles (3.2 km) from the Alternative Site. Easterly facing shorefront in Dartmouth, including Salter's Point, Round Hill, Nonquitt, Knowles and Anthony's Beaches are all located less than 3 miles (4.8 km) away.

Southwesterly facing beaches in Fairhaven are located less than 3.5 miles (5.6 km) from this Alternative Site. The closest recreational resource in the Elizabeth Islands is the Penikese Island Sanctuary, at 5.8 miles (9.3 km) away. Recreational resources along southwest facing shoreline in Falmouth are located more than 9 miles (14.5 km) away.

Recreational activities such as windsurfing, jet skiing, swimming, fishing, sunbathing, hiking and picnicking are common at these onshore areas.

Offshore Recreational Resources Within Viewshed

Recreational users such as windsurfers, swimmers, water skiers and jet skiers, fishermen, as well as sailors and motor boaters, are active along the nearshore and shoreline areas in Buzzards Bay, especially on clear warm days from April through October. Buzzards Bay is a popular boating area, offering steady winds to sailors but protection from the open ocean for smaller boats.

Comparative Summary of Existing Resources

This section describes the on and offshore recreational resources located in the vicinity of the each Alternative Site under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

Of the four Alternative Sites under consideration, the MMR Alternative Site has the fewest proximate recreational uses. As an onshore location within a publicly restricted military reservation, significant buffering (both from distance and with vegetation) exists between the MMR Alternative Site and nearby recreational resources. The remaining three Alternative Sites are located within a setting that offers many recreational resources and

amenities throughout the region. Their coastal location provides opportunities for recreational boating, fishing, swimming and other water-related activities.

Because of the further distance offshore, boating, fishing and other recreational activities are probably least at the South of Tuckernuck Island Alternative Site compared to the other offshore sites. Comparison between the other two offshore alternatives would suggest that the Nantucket Sound Alternative is intermediate in recreational activity and the Ned Bedford/Horseshoe Shoal Alternative involves the greatest amount of recreation since it involves recreation and recreational users in both the New Bedford Harbor area and Nantucket Sound.

3.4.3.2.14 Noise

This section describes the existing sound levels in the vicinity of the four Alternative Sites under consideration as well as sound levels associated with potential noise receptors. Figure 3-41 shows locations of noise monitoring and potential receptors considered in this analysis. Existing sound measurement data have been reviewed for receptors associated with the Nantucket Sound Alternative Sites. The measurements taken in late 2002 (see Appendix 5.11-A) are considered to be representative of quiet onshore, coastal locations that may be affected by sound from the proposed WTGs at the Nantucket Sound Alternative Sites. Existing sound levels have been determined to be reasonably qualified at potential receptors for the other two offshore Alternative Sites through the use of the Nantucket Sound data. Higher existing sound levels are expected in the vicinity of the MMR Alternative Site because of its level of physical development and round-the-clock use as a base of military operations.

Massachusetts Military Reservation

For the MMR Alternative Site, existing background sound levels at nearby receptors are expected to be higher than at the onshore receptors for other Alternative Sites. Military training operations taking place on MMR property, especially low-level F-15 flights out of Otis Air National Guard Base (34 daily operations)[44], traffic on local roads (especially Routes 6 and 28), and the operation of the Canal Electric Generating Station all contribute to higher background sounds near the MMR Alternative Site. Even within the Shawme-Crowell State Forest, sounds from these nearby activities are expected to elevate the background sound levels.

Nantucket Sound

Background sound measurements have been taken at the following three receptor locations intended to be representative of the three Nantucket Sound sub-alternatives:

- Horseshoe Shoal Receptor: Point Gammon
- Tuckernuck Shoal Receptor: Cape Poge
- Monomoy-Handkerchief Shoal Receptor: Point Gammon

To ensure conservative (i.e., low) measured sound levels of baseline conditions representative of the entire coast, secluded beaches were sought out. Measurements were taken in November and December 2002, the time of year with the fewest beach-goers and least amount of boat or motor vehicle traffic. The three monitoring sites were located on the coast at Point Gammon in Yarmouth (4.7 miles (7.5 km) from the closest proposed WTG at the northeast corner of the Horseshoe Shoal area); at Oregon Beach, Cotuit in Barnstable (5.5 miles (8.8 km) from the closest proposed WTG at the northwest corner of the Horseshoe Shoal area); and at the Cape Poge Wildlife Refuge, at the tip of Cape Poge on Martha's Vineyard (5.4 miles (8.6 km) from the closest proposed WTG at the southwest corner of the Horseshoe Shoal area). The baseline measurements covered a full range of meteorological conditions, with wind speeds ranging from 0 to 28 mph (0 to 100.8 km/hr), blowing both on-shore and offshore. (For additional information on the 2002 noise studies please refer to Appendix 5.11-A.)

Point Gammon is on a private peninsula (Great Island) in Yarmouth that sticks out into Nantucket Sound. The monitoring location was on the south tip of Great Island on a south-facing beach. The equipment was positioned

[44] Massachusetts Air National Guard, Final Air Installation Compatible Use Zone Resource Book for Otis Air National Guard Base, May 2002, pp. 3-4, 3-5.

100 feet (30.5 m) from the high water mark on a flagpole where the grade is 20 feet (6.1 m) above the beach. The microphone (with wind screen) was mounted 7 feet (2.1 m) above grade, and all equipment was chained to the pole in a waterproof case. The principal sounds at this site were the ocean waves and wind, periodic overflying aircraft, and an occasional passing ferryboat. The measurement program had a 7-day duration (November 15 to 22, 2002), during which time there was no vehicle or pedestrian access to this private beach.

Oregon Beach is a public beach located off Main Street and Oregon Way, south of Cotuit Center in Barnstable. At this point, the coast generally faces southeast. The equipment was located 80 feet (24.4 m) from the high water mark on a tree. The microphone (with wind screen) was mounted 7 feet (2.1 m) above grade, and all equipment was chained to the tree in a waterproof case. The principal sounds at this site were the ocean waves and wind, sea birds, periodic over-flying aircraft, and occasional motor vehicles and pedestrians accessing the beach area. Monitoring was conducted over a 4-day period (November 14 to 18, 2002).

Cape Poge Wildlife Refuge on Chappaquiddick Island, Martha's Vineyard is a wildlife refuge and recreational area with facilities for swimming and shore fishing. Access to this isolated location requires a four-wheel drive vehicle. The monitoring location was established a short distance from the lighthouse where the coast faces east towards the ocean. The equipment was located 40 feet (12.2 m) from the high water mark on a sand dune where the grade is 20 feet (6.1 m) above the ocean. The microphone (with wind screen) was tripod-mounted 8 feet (2.4 m) above grade, with the heavy-duty tripod lashed to a low split-rail fence, and all equipment protected in a waterproof case. The principal sounds at this site were the ocean waves and winds, and sea birds. Measurements were taken for seven days (November 25 through December 2, 2002).

At all three sites, baseline sound levels are directly correlated to surface wind speed, and on-shore winds produce higher baseline levels than offshore winds, which is expected because offshore winds both suppress wave action at the shoreline and shield the coast from the sound of ocean waves by the wind shadow effect. The existing sound level results from these three representative coastal sites are provided in Table 3-31.

South of Tuckernuck Island

A representative onshore receptor for the South of Tuckernuck Alternative Site is Madaket Beach on Nantucket. This area does not contain any nearby major roadways or urban centers. Accordingly, the existing sound levels for the Madaket Beach area are expected to be comparable to the measured existing sound levels and sources at Cape Poge (see Nantucket Sound discussion above and Table 3-31) as these settings are comparable.

New Bedford / Horseshoe Shoal

The New Bedford Combination Alternative Site has receptors in two separate areas: those associated with the Horseshoe Shoal portion of this combination alternative (represented by the measurements at Cape Poge, as discussed above), and receptors closer to New Bedford. Because of industrial and commercial activity in the harbor area, the proximity of major roadways (e.g., I-195) and vehicular traffic in the city itself, the New Bedford waterfront is expected to have higher existing sound levels than the coastal beaches and may be more similar to the MMR site than to other offshore sites. However, in the vicinity of the New Bedford Alternative Site there are isolated waterfront areas such as Clark's Point that can be expected to have existing sound levels comparable to those measured at Cape Poge and Point Gammon (shown in Table 3-31 and discussed above).

Comparative Summary of Existing Resources

This section describes the existing sound levels in the vicinity of the four Alternative Sites under consideration as well as sound levels associated with potential noise receptor sites. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and the Horseshoe Shoal component of the Nantucket Sound Site.

Given its location near major Cape Cod transportation corridors, its proximity to a large electric generating station and its 24-hour per day military operations, the MMR Alternative Site and its nearby noise receptors would have the highest existing sound environment of all four Alternative Sites under consideration. The New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site would also be expected to have higher ambient

levels than the remaining Alternative Sites. Of the remaining Alternative Sites, all offshore, the more remote receptors associated with the Nantucket Sound and South of Tuckernuck Island Alternatives Sites are expected to have the lowest, and similar, ambient noise levels.

3.4.3.2.15 Water Quality and Water Resources

This section describes water resources in the four Alternative Sites under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. The data and level of detail used for this section was determined through consultation with other resource agencies.

A qualitative review of water resources has been conducted consisting of a summary of the key resources documented to occur at each of the Alternative Sites. Massachusetts Water Quality Standards and water quality assessment reports (MADEP, 1996), available water quality studies (e.g., Howes and Goehringer, 1996; Theroux and Wigley, 1998; Massachusetts Estuaries Project, 2003; Paul et al., 1999; USEPA, 2001), and natural resource management plans (e.g.,MAARNG, 2001) were used for this characterization, where applicable.

Massachusetts Military Reservation

This section describes wetlands, waterbodies, groundwater, and water quality resources within the MMR Alternative Site.

Wetlands and Waterbodies

There are no large streams, floodplains, or lakes at the MMR Alternative Site. Surface waterbodies are limited to several small ponds along the western boundary of the Alternative Site and to small isolated wetlands. Review of USGS topographic maps for the area indicates there are no mapped intermittent or perennial streams located at the Alternative Site. Given the sandy, well-drained nature of the soils, surface water is limited. The following waterbodies have been identified within the MMR Alternative Site (Commonwealth of Mass Military Division, 1996):

Spruce Swamp	Cranberry Bog
Raccoon Swamp	Deep Bottom Pond
Grassy Pond	Bailey's Pond
Ox Pond	Little Halfway Pond
Gibbs Pond	Tank Trail Pond
Round Swamp	Donnely Pond
Monument Swamp	Fish and Game Ponds

Wetlands

A total of 31 wetlands occur on the Camp Edwards portion of MMR and comprise 51 acres (0.35%) of 14,433 total acres (58.4 km^2) of land. Using the National Wetlands Inventory (NWI) classification system, the dominant wetland types within the Site include palustrine scrub shrub (PSS) and palustrine emergent marsh (PEM). Wetlands types (using NWI classifications) and acreages are summarized in Table 3-32. Wetland identification was based on 1993 aerial photographs and was confirmed in the field by Camp Edwards and MADEP personnel in 1995. Wetlands at the Camp Edwards portion of MMR tend to be small isolated freshwater marshes and kettle hole ponds (MAARNG, 2001).

The Massachusetts Natural Heritage Atlas (2003 edition) indicates that there are no certified vernal pools at the MMR property. However, vernal pool indicator species (i.e., spotted salamander and/or wood frogs) were found in Gibbs Pond, Raccoon Pond, and Grassy Pond during a survey conducted in 1995 (Commonwealth of Mass Military Division, 1996). If this Alternative Site were selected, field studies should be undertaken to determine the potential presence of vernal pools in the area.

Groundwater

The surficial geology of MMR is comprised of unconsolidated glacial outwash sediments and glacial moraines, and the MMR is located entirely within the Cape Cod Aquifer. Stratified sands and gravels provide an important water supply source for Cape Cod. The Cape Cod Aquifer underlies western Cape Cod and has been designated a

sole-source aquifer by the USEPA (Commonwealth of Massachusetts Military Division, 1996). The primary source of recharge for the aquifer is precipitation. Groundwater under upland areas of MMR tends to be greater than 10 feet (3.1 m) below the ground surface and along the western side of MMR flows towards the Cape Cod Canal.

The MMR is a Superfund site, and plumes of groundwater contamination have been identified beneath the MMR property, primarily to the south and east of the Alternative Site. However, an explosives residue plume above USEPA health advisory levels is mapped as occurring under the Alternative Site (Air Force Center for Environmental Excellence, 2004).

Water Quality

The aforementioned waterbodies within the MMR Alternative Site are categorized as Class B waters pursuant to 314 CMR 4.06(2)(b). According to Massachusetts Water Quality Standards, Class B waters are designated as "habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment". None of the waterbodies on the MMR Site are listed on the Massachusetts Year 2000 Integrated List of Waters (formerly known as the Section 303(d) List of Impaired Waters) (MADEP, 2002).

Nantucket Sound

This section describes wetlands and water quality within the Nantucket Sound Alternative Site.

Wetlands

Under Section 404 of the federal Clean Water Act, "Waters of the U.S." include navigable waters that are subject to the ebb and flow of the tide and the territorial seas (33 C.F.R. Part 328). Territorial seas are defined as the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three nautical miles. Waters outside of the three mile limit are classified as "navigable waters" that are subject to USACE jurisdiction under Section 10 of the Rivers and Harbors Act of 1899 only. Therefore, the Nantucket Sound Alternative is not subject to USACE review under Section 404, but is subject to review under Section 10. For more information on regulatory jurisdiction, please see Section 7.0.

Massachusetts Geographic Information System (MassGIS) data for eelgrass was reviewed for the presence of eelgrass beds within the Nantucket Sound Alternative Site. MassGIS data is limited to within the 3-nautical mile state limit and therefore no eelgrass information is readily available for the Nantucket Sound Alternative Site.

Water Quality

The estimated average depth within the Nantucket Sound is approximately 45 feet (13.7 m); however the water depth ranges between 6 feet and 74 feet (1.8 to 22.6 m) below MLLW (NOAA, 2001a). The relatively shallow and clear waters of the Sound allow light penetration sufficient for photosynthesis to occur throughout the water column. The magnitude of the annual temperature range in Nantucket Sound averages 64.4°F (18°C) in offshore waters and 71.6°F (22°C) in nearshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C), which is relatively warmer than the South of Tuckernuck Island Site and relatively cooler than the New Bedford/Horseshoe Shoal Site (Theroux and Wigley, 1998).

The Massachusetts Surface Water Quality Standards (314 CMR 4.06(3)) categorize Lewis Bay and surface waters adjacent to Nantucket Island as Class SA coastal and marine waterbodies. There is no classification for offshore waters in Nantucket Sound. According to the MADEP standards, Class SA waters are designated as "an excellent source of habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation". It is expected that water quality in the Nantucket Sound Alternative Site would meet this designation, since there is no known major source of pollutant input or other degrading factors. In approved areas, Class SA waters are "suitable for shellfish harvesting without depuration (Open Shellfish Areas)."

Dissolved oxygen is a fundamental requirement for the maintenance of balanced indigenous populations of fish, shellfish, and other aquatic biota. A concentration of 5 ppm is used by Massachusetts to set water quality standards (MADEP, 1996), while a concentration of 2 ppm is used as a threshold for oxygen concentrations

thought to be extremely stressful to most biota. Nantucket Sound has been designated by USEPA as within the Virginian Province, which includes coastal waters from Virginia to the Town of Chatham on Cape Cod (Paul et al., 1999). Based on a four-year assessment of this region, USEPA reports that dissolved oxygen levels (perhaps the most critical water quality parameter for aquatic life) are considered good in Nantucket Sound, although several constricted harbors exhibited moderate hypoxia (Paul et al., 1999).

Algal blooms are another major water quality concern in the coastal waters, although they are typically short-lived and localized in Massachusetts's waters (MADEP, 1996). Algal blooms are typically brief and occur in response to episodic nutrient loading incidents, such as rainstorms, and are generally confined to the bays and estuaries surrounding Nantucket Sound rather than impacting the Sound itself. Chlorophyll, a pigment that occurs in algae, is often used to indicate the intensity of an algal bloom (or algal biomass). Chlorophyll levels measured in Nantucket Sound were found to be on the order of 10 ppb (USEPA, 2001), a level that would indicate only moderate productivity and a moderate likelihood of algal bloom occurrence.

Nitrogen is often the limiting nutrient that controls biological productivity. Background concentrations of nitrogen are reported to be 0.29 mg/L in Nantucket Sound (Massachusetts Estuaries Project, 2003), which can be considered moderate, depending on other site conditions such as flushing rates and salinity.

South of Tuckernuck Island

This section describes wetlands and water quality within the South of Tuckernuck Island Alternative Site.

Wetlands

Under Section 404 of the federal Clean Water Act, "Waters of the U.S." include navigable waters that are subject to the ebb and flow of the tide and the territorial seas. Territorial seas are defined as the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three nautical miles. Waters outside of the three mile limit are classified as "navigable waters" that are subject to USACE jurisdiction under Section 10 of the Rivers and Harbors Act of 1899 only. Therefore, the South of Tuckernuck Island Alternative Site is not subject to review under Section 404, but is subject to USACE review under Section 10.

MassGIS data for eelgrass was reviewed for the presence of eelgrass beds within the South of Tuckernuck Island Alternative Site. MassGIS data is limited to within the 3-nautical mile state limit and therefore no eelgrass information is readily available for the South of Tuckernuck Alternative Site. .

Water Quality

Water depth within South of Tuckernuck Island Alternative Site ranges between 15 feet and 95 feet (4.6 and 29 m) below MLLW, with an estimated average depth of approximately 70 feet (21.4 m) (NOAA, 2001a). The magnitude of the annual temperature range at the South of Tuckernuck Island Site averages 62.6°F (17°C). The minimum temperature at this Alternative Site is reported to be 35.6°F (2°C) and the maximum is reported to be 64.4°F (18°C), which is slightly cooler than either the Nantucket Sound Site or the New Bedford/Horseshoe Shoal Site (Theroux and Wigley, 1998).

Because the Alternative Site is outside of state waters, it is not officially classified by MADEP. However, waters in the South of Tuckernuck Island Alternative Site are assumed to be Class SA or equivalent, and to represent fully marine conditions of salinity, nutrients, and minerals.

South of Tuckernuck Island, the area is not in any way confined by landforms and, therefore, the water quality of this area is dictated by the quality of water in the surrounding open ocean. This could explain why the USEPA did not report any instances of low dissolved oxygen (<5 ppm) occurring in the area South of Tuckernuck Island (Paul et al., 1999).

Algal blooms are another major concern in some marine waters, although they are not common in unconfined, open ocean situations such as the South of Tuckernuck Island Alternative Site. Chlorophyll, a pigment that occurs in algae, was measured in the waters at the South of Tuckernuck Island Site and found to be on the order

of 1 ppb (USEPA, 2001), a level that would indicate low productivity and a low likelihood of algal bloom occurrence.

Even though no specific information on background concentration of nitrogen in the area South of Tuckernuck Island was available, given that algal biomass in this region is reported to be lower than that of Nantucket Sound, it is likely that the background concentrations of nitrogen in this area would be lower than levels reported for Nantucket Sound of 0.29 mg/L.

New Bedford / Horseshoe Shoal

This section describes wetlands and water quality within the New Bedford Harbor/Buzzards Bay portion of the New Bedford/Horseshoe Shoal Alternative Site. Information on the Horseshoe Shoal portion of this Alternative Site is presented above in the Nantucket Sound Alternative Site section.

Wetlands

The New Bedford/Horseshoe Shoal Alternative Site includes both “navigable waters” and “Waters of the U.S.,” as defined under the federal Clean Water Act and summarized above in the Nantucket Sound section. Therefore, the New Bedford/Horseshoe Shoal Alternative Site is subject to USACE review under both Section 404 and Section 10. State-regulated “Land Under the Ocean” is also found within the New Bedford Harbor/Buzzards Bay portion of the Alternative Site.

MassGIS data for eelgrass was reviewed for the presence of eelgrass beds within the New Bedford/Horseshoe Shoal Alternative Site. No eelgrass beds occur within the Alternative Site area (MassGIS, 1999).

Water Quality

Depths at this Alternative Site range between 7 feet and 48 feet (2.1 and 14.6 m) below MLLW, with an average depth of approximately 25 feet (7.6 m) (NOAA, 2001b). The annual magnitude of the temperature range in New Bedford Harbor averages 69.8°F (2°C) in nearshore waters, and just slightly less in offshore waters. The minimum temperature at this site is reported to be 32°F (0°C) and the maximum is reported to be 71.6°F (22°C) (Theroux and Wigley, 1998).

Outer New Bedford Harbor and Buzzards Bay are the primary waterbodies within the New Bedford Harbor/Buzzards Bay portion of this Alternative Site. These waterbodies are categorized as Class SA by MADEP pursuant to 314 CMR 4.06(3). Outer New Bedford Harbor is listed on the Massachusetts Year 2000 Integrated List of Waters (formerly knows as the Section 303(d) List of Impaired Waters) as a Category 5 Water requiring a pollutant loading assessment (i.e., TMDL) for priority organics, nonpriority organics, metals, organic enrichment/low dissolved oxygen, and pathogens (MADEP, 2002). This list is reported to USEPA every two years as required under the federal Clean Water Act.

USEPA reports that dissolved oxygen levels (perhaps the most critical water quality parameter) are considered good in most areas of Buzzards Bay, but moderate hypoxia (dissolved oxygen below 5 ppm) occurs in the waters of New Bedford Harbor (Paul et al., 1999). This condition has also been documented for the New Bedford Outer Harbor area by MADEP (MADEP, 1996), although the occurrence is reported to be associated with rain events and the associated stormwater runoff. Dissolved oxygen levels ranged between 3.0 ppm and 13.8 ppm with an average of 9.3 ppm at a sampling station located in the vicinity of the New Bedford Harbor Alternative Site (MADEP, 1996).

Due to the limited flushing of the Harbor and the nutrient loading attributed to stormwater runoff and point-source pollution discharges, algal blooms are a major concern in New Bedford Harbor (MADEP, 1996). The algal blooms of *Ulva* and *Codium* are reported to occur in Buzzards Bay every summer (MADEP, 1996). The blooms negatively impact aesthetics (visual and odor) at public and private beaches. In addition, *Psuedo-nitzschia*, a genus of diatom that is known to produce toxic algal blooms, was encountered in the vicinity of this Alternative Site (MADEP, 1996). Reports of the red tide organisms *Alexandrium fundyense* and *Alexandrium tamarense*, which can produce paralytic shellfish poisoning toxins, were also reported in the vicinity of the New Bedford Harbor Alternative Site (MADEP, 1996). Chlorophyll, a pigment that occurs in algae, was found in New Bedford Harbor at levels ranging between 1 ppb and 28 ppb (USEPA, 2001; MADEP, 1996), and would indicate moderate

to high productivity. This level of productivity is higher than levels reported for either Nantucket Sound or South of Tuckernuck Island.

The background concentration of nitrogen in New Bedford Harbor is higher than the levels occurring at the Nantucket Sound Site or expected to occur at the South of Tuckernuck Island Site. The levels reported for the area vary widely and are believed to be a function of rain events, tidal flushing, and point-source discharges (Howes and Goehringer, 1996; MADEP, 1996). Average background nitrogen levels above 0.3 mg/L would be expected, and levels over 8.0 mg/L have been reported (MADEP, 1996), which can be considered high, depending on other site conditions such as flushing rates and salinity.

Salinity and pH data from Buzzards Bay indicate that water quality in the bay fluctuates seasonally due to variability in freshwater inputs to the system from the surrounding land (Driscoll, 1975). This variability is more pronounced in New Bedford Harbor and Buzzards Bay than in Nantucket Sound or South of Tuckernuck Island. Salinity was reported to range between 28% and 33% in Buzzards Bay, while pH was reported to range between 8.1 and 7.5, with the lowest values for each parameter typically occurring during June (Driscoll, 1975). Based on these factors, the waters of Outer New Bedford Harbor area of Buzzards Bay can be characterized as marine, with periodic estuarine influences.

Comparative Summary of Existing Resources

This section describes water resources in the four Alternative Sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

In general, the South of Tuckernuck Island Alternative Site was found to be deeper and cooler than the other two offshore alternative sites. The South of Tuckernuck Island Alternative Site also exhibited lower nitrogen concentrations and fewer algal bloom occurrences than either of the other offshore alternative sites. The Nantucket Sound Alternative Site is generally shallower and warmer than the South of Tuckernuck Island Site and generally deeper and cooler than the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site. Nantucket Sound was found to have occasional algal bloom occurrences and localized areas of low dissolved oxygen; however, these occurrences were reportedly associated with enclosed estuaries and harbors draining to the Sound and not with the open water areas of the Sound itself. The New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site exhibits poorer water quality conditions than the other two offshore alternative sites. Conditions at the New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site were reported to include periodic occurrences of hypoxia (low dissolved oxygen), algal blooms including toxin-producing algal species, and elevated nitrogen levels.

The MMR Alternative Site was the only inland/terrestrial site evaluated. Wetlands at the MMR Site were dominated by palustrine marshes. Wetlands at the offshore alternative sites include federally-regulated “navigable waters” and “Waters of the U.S.” The Nantucket Sound and South of Tuckernuck Island Sites are not subject to USACE review under Section 404 but are subject to review under Section 10. The New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site is subject to USACE review under both Section 404 and Section 10, and includes state-regulated “Land Under the Ocean.”

3.4.3.2.16 Electrical and Magnetic Fields

This section describes the potential presence of electric and magnetic fields (EMF) at the four Alternative Sites under consideration. The Massachusetts National Guard, Cape Cod Draft Master Plan/Area-Wide Environmental Impact Report (August, 1999) and other available information were reviewed with respect to existing sources of EMF for the upland MMR Alternative Site. In general, the undeveloped offshore Alternative Sites under consideration are not expected to have measurable existing power frequency EMF. For a more detailed discussion and background information on electric and magnetic fields please refer to Section 5.13 and Appendix 5.13-A.

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The MMR Alternative Site is expected to have measurable EMF levels that would be comparable to other developed areas containing electric transmission substations and both high voltage electric transmission and lower voltage electric distribution lines. Commonwealth Electric Company has several high voltage transmission lines and two high voltage substations located in the vicinity of the MMR Alternative Site. The 115 kilovolt (kV) Bourne Switching Station is located at the northernmost point of this Alternative Site. Also, at the north end of the MMR site, two 345 kV and two 115 kV transmission lines run from the east into the Bourne Switching Station. Three overhead 115 kV transmission lines associated with this Station are in the proximity of the Alternative Site. One of the 115 kV lines runs south from the station in a right-of-way along the western edge of the site to the Otis 115 kV Substation, located toward the westerly end of Monument Beach Road. The transmission line continues south, generally paralleling Route 28 into Falmouth. The other two 115 kV lines run generally southeast in a common right-of-way out of the Bourne Switching Station, proximate to the MMR Alternative Site.

The electric requirements of all the MMR are served by Commonwealth Electric Company via two overhead 25 kV distribution lines. The Main Substation, located on MMR's west side, steps transmission voltage down to 4,160 volts and provides switching and voltage regulation. This Substation serves the non-airfield Cantonment area including the Coast Guard housing areas, industrial areas, schools, barracks, Massachusetts Air National Guard support areas, and firing ranges. The East Substation, which is fed by a 25 kV transmission line from the West/Main Substation, currently serves the U.S. Air Force and the Otis Air Base. The Coast Guard Air Station is separately served by two Commonwealth Electric Company distribution lines. Additional EMF is likely at the MMR Alternative Site due to the presence of substantial military communications and tracking operations that utilize electric power to operate.

Nantucket Sound, South of Tuckernuck Island and New Bedford/Horseshoe Shoal

The undeveloped offshore alternative sites under consideration are not expected to have measurable existing power frequency EMF because of the absence of existing sources of power frequency fields in these areas.

Comparative Summary of Existing Resources

Electric and magnetic fields currently exist at the MMR Alternative Site because it is an upland site that includes existing high voltage electric transmission, electric power distribution, and military communications and tracking operations that require electric power to operate. The MMR Alternative Site is the only one of the four alternative sites under consideration to have existing EMF in its vicinity.

3.4.3.2.17 Air and Climate

This section describes the existing air quality and the climate for the four alternative sites under consideration. A general discussion of climate and existing air quality is followed by a specific discussion of each Alternative Site and a comparative summary.

Climate

The Massachusetts climate is characterized by frequent and rapid changes in weather, large daily and annual temperature ranges, large variations from year to year, and geographic diversity. The National Climatic Data Center (part of the National Oceanic and Atmospheric Administration) defines distinct climatological divisions to represent areas that are, as nearly as possible, climatically homogeneous. Locations within the same climatic division are considered to share the same overall climatic features and influences. The Alternative Sites under consideration are all located within the Massachusetts coastal division. Therefore, no major climatic differences among the four Alternative Sites are expected.

Data from the National Climatic Data Center for the coastal climatological division show an average annual temperature of 49.9^{o}F (9.9^{o}C), an average winter (December – February) temperature of 31.0^{o}F (-.6°C), an average summer (June – August) temperature of 68.6^{o}F (20.3^{o}C), an average daily maximum temperature of about 57°F (13.9^{o}C), and an average daily minimum temperature of about 43°F (6.1^{o}C). Temperatures at individual stations that could be considered representative of the alternative project sites are summarized in Table

3-33, along with the climatological division average where available. Although data for some stations reflect different periods of record, they show the lack of any major temperature differences over the area encompassing the alternative sites.

Data from the National Climatic Data Center show an annual average precipitation of 43.4 inches (110.2 cm) over the coastal climatological division. An examination of precipitation data from individual stations that could be considered representative of the alternative project sites shows values that are not significantly different from the division average: Nantucket (44.0 inches (111.8 cm)); Martha's Vineyard (49.1 inches (124.7 cm)); Provincetown (39.5 inches (100.3 cm)); Falmouth-Otis (43.8 inches (111.3 cm)); New Bedford (41.1 inches (104.4 cm)); and Hatchville (46.2 inches (117.3 cm)). Although they may reflect different periods of record, these average annual precipitation totals again show the lack of major climatic differences over the area encompassing the alternative project sites.

Although snowfall can vary significantly over small distances, the annual average snowfall for stations in coastal, southeastern Massachusetts is generally in the range of 30 to 40 inches (76 to 102 cm). Representative stations for the alternative project sites include: Fall River (36.1 inches (91.7 cm)); New Bedford (33.3 inches (84.6 cm)); Nantucket (34.3 inches (87.1 cm)); and East Wareham (35.6 inches (90.4 cm)). These averages demonstrate the lack of any major climatic variation over the area encompassing the alternative project sites.

Fog is a fairly common occurrence over the area including the Alternative Sites. Fog is especially frequent and persistent at times in areas south of Cape Cod resulting in significant restricted visibility. On average, Nantucket experiences fog on approximately one day out of four.

General information concerning the frequency of freezing precipitation is available in "A Climatography of Freezing Rain, Freezing Drizzle, and Ice Pellets Across North America" (Cortinas et. al., 2000). Isopleths presented in this paper indicate that freezing rain occurs from 0 to 10 hours per year on average over the area encompassing the four Alternative Sites, with somewhat higher frequencies of occurrence at inland areas and at coastal and near coastal areas located north and south of the Alternative Sites. The distribution of ice pellets indicates an average frequency of 10 to 20 hours per year on average for the proposed Alternative Sites, with a lower frequency of occurrence on the eastern portion of Cape Cod and along the southern Rhode Island coast. The distribution of freezing drizzle indicates an average frequency of 0 to 10 hours per year on average over the area encompassing the Alternative Sites, with a higher frequency of occurrence at inland areas and at coastal and near coastal areas located north and south of the offshore Alternative Sites. The frequency of freezing precipitation in Massachusetts is generally higher in inland areas as compared to coastal areas, and it is not expected that there would be significant variations among the four Alternative Sites.

Wind speed data were gathered from MTC/True Winds maps (see Figures 3-1 and 3-2) and wind roses for each site are included on Figures 3-44, 3-46, 3-47 and 3-48 as discussed later in Section 3.4.3.2.17.

Existing Air Quality

One measure of air quality within a region is whether ambient air concentrations are in attainment with National Ambient Air Quality Standards (NAAQS). NAAQS were developed by the USEPA for criteria pollutants to protect human health and welfare. The attainment status of an area is determined through an evaluation of available air quality data. The Massachusetts Department of Environmental Protection (MADEP) collects ambient air quality data from a network of monitors located throughout the state. The network is designed to provide data representative of pollutant concentrations over large areas and also to determine concentrations in areas where they are expected to be the highest. In 2002, the most recent year for which MADEP has published quality assured data, MADEP operated a public monitoring network encompassing 40 monitoring stations located in 25 communities. The network was consolidated in 2003 to 28 stations in 21 communities following a review of data needs and available resources.

The MADEP monitoring data show that Massachusetts is in attainment with NAAQS for all criteria pollutants except for ozone. Available monitoring data show that the 1-hour and 8-hour NAAQS for ozone have been exceeded at several monitors, and all of Massachusetts is classified as a serious non-attainment area with respect to the 1-hour NAAQS for ozone. On April 15, 2004, the US EPA announced their designation of the entire Commonwealth as being in moderate nonattainment with the 8-hour standard. This designation became

effective on June 15, 2004. Ground level ozone is created through chemical reactions involving precursor pollutants (NO_x and VOCs) in the presence of sunlight. Motor vehicles and fossil fuel fired power plants are among the major contributors to ozone precursor emissions.

The USEPA regulations, published as "General Conformity Rule" (58 FR 63214, November 30, 1993) to implement section 176(c) of the Clean Air Act for non-attainment areas and maintenance areas, require that Federal actions, unless exempt, conform with the Federally approved state implementation plan (SIP). The impacts on air quality associated with the regulated activity described in this EIS have been considered and would not exceed *de minimus* levels of direct emissions of a criteria pollutant or its precursor, and are exempted by 40 CFR Part 93.153. Therefore, a conformity determination is not required.

Local Air Quality

Although the entire Commonwealth of Massachusetts has been classified as being in attainment with NAAQS for all criteria pollutants, with the exception of ozone, some local variations in air quality may exist due to differences in meteorological conditions and emissions sources. Local air quality has been evaluated by examining data obtained from individual monitoring stations, as discussed below for each alternative project location. Qualitative assessments of influences on local air quality have also been made based on a consideration of air emissions generating activities and operations conducted in each local area.

Data from available MADEP monitoring stations in southeastern Massachusetts can be used to describe air quality in this part of the Commonwealth, including the alternative project locations, and to demonstrate that air quality does not vary significantly over the region. Monitoring data for 2002 are available for Fairhaven (ozone and NO_2), Truro (ozone and NO_2), New Bedford ($PM_{2.5}$), and Fall River ($PM_{2.5}$ and SO_2). Another source of $PM_{2.5}$ data for 2002 is the Truro monitor operated as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring program.

Available air quality monitors nearest to the area including the Alternative Sites have been located in different settings and for various purposes. Table 3-34 provides some summary information concerning the nearest monitors and their intended purpose.

Information in the *Commonwealth of Massachusetts 2002 Air Quality Report* was reviewed to obtain information on how air quality, as measured at MADEP air quality monitors, varied within southeastern Massachusetts. $PM_{2.5}$ monitoring data from the IMPROVE monitor in Truro was also obtained and reviewed to allow for a comparison of air quality variations over the region.

During 2002, the monitoring stations in Truro and Fairhaven each recorded exceedances of the ozone 8-hour NAAQS of 0.08 parts per million (ppm). The Truro monitoring station recorded 9 exceedances averaging 0.095 ppm with a maximum value of 0.112 ppm and a fourth highest value of 0.093 ppm. The Fairhaven monitoring station recorded 5 exceedances averaging 0.093 ppm with a maximum value of 0.105 ppm and a fourth highest value of 0.087 ppm. During 2002, the Truro monitor recorded a single exceedance (0.130 ppm) of the 1-hour ozone NAAQS of 0.120 ppm, while the Fairhaven monitor measured a maximum 1-hour ozone concentration of 0.115 ppm, slightly below the standard. The second-high 1-hour concentrations were 0.118 ppm at Truro and 0.113 ppm at Fairhaven. These data showing slightly higher concentrations and more exceedances at Truro compared to Fairhaven in 2002 are generally consistent with observations from previous years and show that there can be modest differences in air quality over the region.

Monitoring data for NO_2 were also available for 2002 from the Truro and Fairhaven monitors. Annual average concentrations at each monitor were well below the NAAQS of 0.053 ppm. Annual average values at Truro and Fairhaven were 0.0047 ppm and 0.0042 ppm, respectively. As was the case for ozone, the concentrations measured at Truro were somewhat higher than those at Fairhaven.

Monitoring data for $PM_{2.5}$ for 2002 are available from MADEP monitoring sites in New Bedford and Fall River and from the IMPROVE monitor in Truro. Data from the Truro monitor were collected and analyzed using a different protocol, so the $PM_{2.5}$ data from Truro may not be directly comparable to those from the MADEP sites in New Bedford and Fall River. Although MADEP has not collected enough $PM_{2.5}$ data to formally designate areas with respect to attainment, the data collected in 2002 show levels in southeastern Massachusetts are well below the

annual NAAQS of 15.0 micrograms per cubic meter ($\mu g/m^3$) and the 24-hour NAAQS of 65 $\mu g/m^3$. Annual average $PM_{2.5}$ concentrations were 11.1 $\mu g/m^3$ in Fall River, 10.3 $\mu g/m^3$ in New Bedford, and 7.2 $\mu g/m^3$ in Truro. The lower values in Truro may be due to its more rural location or to differences in monitoring methodology. The fourth-highest 24-hour concentrations in 2002 were 26.8 $\mu g/m^3$ in Fall River, 23.1 $\mu g/m^3$ in New Bedford, and 23.5 $\mu g/m^3$ in Truro. Once again, modest differences in air quality are reflected in the monitoring data available for southeastern Massachusetts. However, these differences are not considered to be significant.

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MMR is located in southeastern Massachusetts on Cape Cod in the towns of Bourne and Sandwich. Information in the Draft Environmental Impact Statement/Environmental Impact Report (EOEA No. 5834) for Massachusetts Military Reservation Facilities Upgrade indicates that air quality in the Cape Cod region is generally good (with the exception of ozone) and that there are not many local air pollution sources in the vicinity of MMR. However, various activities at MMR – including aircraft operations, military training activities, fossil fuel fired combustion sources, storage tanks, and prescribed burns – can reasonably be expected to affect the air quality in the local area. Emissions from residential furnaces and activities and mobile sources, such as vehicular traffic, also have a localized impact on the air quality in this Alternative Site area.

Given the location of MMR relative to available air quality monitors, air quality in the vicinity of MMR is probably best represented by data from the Fairhaven and Truro monitors for ozone, NO2, and PM2.5.

Mean wind speeds at a 230-foot (70-meter) elevation above ground surface within the MMR Alternative Site vary from a low range of 13.4-14.5 mph (21.6 - 23.3 km/hr) to a high range of 15.7 – 16.8 mph (25.3 – 27 km/hr). The majority of the Site has a mean wind speed of 14.5-15.7 mph (23.3 to 25.3 km/hr) (Figure 3-42).

Nantucket Sound

There are no air quality monitoring stations in Nantucket Sound. However, given the location of the area and the prevailing wind direction (most frequent winds from the SSW), it is reasonable to conclude that the air quality in this area is similar to the air quality as measured at the Truro and Fairhaven monitors. Air quality in this area may be affected to some extent by various mobile sources, including recreational and commercial shipping vessels and military and commercial aircraft. However, given the lower density of mobile sources and the absence of industrial activities in Nantucket Sound relative to the monitor locations, it is likely that the localized air quality in Nantucket is somewhat better than that measured at the onshore monitoring stations.

Mean wind speeds within the Nantucket Sound area at 230 feet (70 m) vary from a low range of 15.7 – 16.8 mph (25.3 – 27 km/hr) in the nearshore areas to a high range of 20.1 – 21.3 mph (32.3 – 34.3 km/hr) in the southern and eastern portions of the Sound that lack the sheltering effects from the islands (Figure 3-43). As shown in Table 3-35, the three areas within Nantucket Sound have essentially the same mean wind speed, with a very slight lower bound at the Horseshoe Shoal area.

South of Tuckernuck Island

The South of Tuckernuck Island Alternative Site would be expected to have essentially the same existing air quality as the Nantucket Sound Alternative for the same reasons discussed above. Monitoring data from the Fairhaven and Truro monitors for ozone, NO_2, and $PM_{2.5}$ would best represent air quality for the South of Tuckernuck Island Alternative Site.

Mean wind speeds for the South of Tuckernuck Island at 230 feet (70 m) vary from a low range of 19.0 – 20.1 mph (30.6 – 32.3 km/hr) in the near shore areas to a high range of 20.1 – 21.3 mph (32.3 – 34.3 km/hr) offshore of the island which lack the sheltering effects from the island (Figure 3-43).

New Bedford

Various industrial and commercial activities – including fossil fuel fired combustion units and other sources of air pollutant emissions – affect the air quality around New Bedford Harbor. Mobile sources, such as vehicular traffic,

also have an impact on the air quality of the local area. New Bedford Harbor is a heavily commercialized port, resulting in emissions from shipping and trucking activities that further affect the local air quality.

Air quality for ozone and NO_2 in New Bedford would best be represented by data collected at the Fairhaven monitor, since Fairhaven and New Bedford are neighboring communities. Air quality for $PM_{2.5}$ in New Bedford would best be represented by data from the New Bedford monitor.

Mean wind speeds within the New Bedford Outer Harbor area at 70 meters vary from a low range of 15.7 – 16.8 mph (25.3 – 27 km/hr) in the near shore areas to a high range of 16.8 – 17.9 mph (27 – 28.8 km/hr) in the southern portions of the Outer Harbor which lack the sheltering effects from the nearby land masses (Figure 3-43).

Comparative Summary of Existing Resources

This section describes the existing air quality and the climate for the four alternative sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

With the exception of wind resources, all four Alternative Sites are sufficiently close to one another that no significant climatic differences are known to exist or are expected. Mean wind speeds within each site were similar for the Nantucket Sound and South of Tuckernuck Island Alternative Sites (with a high of 21.3 mph (34.3 km/hr)). Mean wind speeds were somewhat lower in the New Bedford area of the New Bedford/ Horseshoe Shoals Alternative Site (with a high of 17.9 mph (28.8 km/hr)) and lowest at the MMR Alternative Site (with a high of 16.8 mph (27 km/hr)). Existing air quality conditions at the four alternative sites are similar, although the offshore alternatives are likely to have marginally better air quality given the distance of the Nantucket Sound and South of Tuckernuck Island Alternative Sites from industrial activities and vehicular traffic that may have localized adverse effects in the vicinity of the MMR Alternative Site and the New Bedford Harbor area of the New Bedford/ Horseshoe Shoals Alternative Site.

3.4.3.2.18 Safety

This section describes safety considerations for the four Alternative Sites under consideration. Existing conditions related to aviation and navigation are discussed in more detail in Sections 3.4.3.2.8 and 3.4.3.2.10, respectively. Section 3.4.3.2.16 discusses the existing conditions related to EMF. This section provides a discussion, for each of the Alternative Sites, of current uses and safety issues at each area, as a backdrop against which safety issues will be assessed in the alternatives impact evaluation.

Massachusetts Military Reservation

As an active military installation, a variety of operations are routinely conducted 24 hours per day at the MMR. Many of these operations pose health and safety risks to personnel present on site including military and USCG aircraft operations and support activities (e.g., engine testing, refueling, etc.), military training exercises (e.g., small arms fire, tactical ordnance testing, etc.), and operation of military and civilian vehicles.

In addition to the health and safety issues created by military activities conducted at the MMR, past activities on the Reservation have resulted in ongoing health and safety issues at the site. For example, the presence of unexploded ordnance and hazardous materials in the soil pose an additional safety and health concern to military staff and visitors/trespassers alike.

The military uses the MMR property under a long-term lease, with no immediate plans to cease military training operations. Public access is not allowed on MMR property, including the MMR Alternative Site location. Safety issues at this site are therefore limited to those associated with personnel utilizing the MMR facilities. Issues for consideration of a new use, such as the WTGs, at the site would include security and public protection, as well as potential safety concerns associations with ongoing activities at the MMR property.

Nantucket Sound and South of Tuckernuck Island

The location of the Nantucket Sound Alternative Sites is currently undeveloped open water. With no nearby land uses, the extent to which the area is utilized for commercial or recreational use will define the potential for safety concerns. Specific issues associated with aviation and navigational issues are addressed in Sections 3.4.3.4.8 and 3.4.3.4.10, respectively. Nantucket Sound is frequented by a number of commercial and recreational vessels year-round. In an effort to promote safe boating, navigational channels are identified, and submerged hazards are marked or identified in Notice to Mariners. Operation of vessels in Nantucket Sound is regulated by the USCG. Smaller vessels, however, are not necessarily confined to navigational channels, and frequently do not have the navigational tools that larger commercial vessels may utilize. In addition to safety issues created by the presence of surface vessels, aircraft operating in the area can present safety concerns. Commercial flights between the mainland and the islands, as well as military and USCG aircraft overflights (due to the proximity of MMR) occur regularly over the Nantucket Sound Alternative Site area.

Potential safety issues at the South of Tuckernuck Island Alternative Site are essentially the same as those of the Nantucket Sound Alternative Site area. However, there is less vessel activity because of the more offshore location and less overflight activity because the site is on the ocean side of Nantucket Island and would not be crossed by aircraft transiting between Cape Cod or other continental airports and the island. No marked navigation channel exists adjacent to the South of Tuckernuck Island Alternative Site compared to the other two offshore alternative sites.

New Bedford / Horseshoe Shoal

While the New Bedford Alternative Site shares the same navigational safety issues as the Nantucket Sound and South of Tuckernuck Island Alternative Sites, New Bedford Harbor is a heavily commercialized port, and the presence of an increased number of commercial vessels increases potential safety risks. Submerged rocky ledge is more prevalent at the New Bedford Site than the other offshore sites, and therefore represents a greater grounding concern for deep draft vessels. A regional airport is also located in New Bedford; the proximity of this local airport may pose aviation safety concerns as aircraft depart or approach the airport.

Comparative Summary of Existing Resources

This section describes safety considerations for the four Alternative Sites under consideration. The New Bedford/ Horseshoe Shoal Site includes the resources found at both the New Bedford Harbor and Nantucket Sound Sites.

The Nantucket Sound Alternative Site has slightly greater safety concerns than the South of Tuckernuck Island Alternative Site because of the greater vessel traffic and the presence of the marked Main Channel that passes through the Sound. No marked navigational channel exists adjacent to the South of Tuckernuck Island Alternative Site and therefore deeper draft commercial vessels are unlikely to transit the area. The New Bedford Harbor portion of the New Bedford/ Horseshoe Shoals Alternative Site is affected by the same safety issues as the Nantucket Sound and South of Tuckernuck Island Alternative Sites, but perhaps to a slightly greater extent than either, due to the increased presence of commercial shipping vessels entering and exiting the harbor area and the proximity of the marked channel to the WTG array. Since MMR is an active military installation, safety issues are significantly different and more complex that those present at the other Alternative Sites, and reflect the more active, military land uses that currently exist at that site.

3.4.3.2.19 Socio-Economic Conditions

This section describes the existing socio-economic conditions at each of the alternative sites under consideration. The predominant socioeconomic affects at the local level from the four alternative sites are expected to be located near the onshore facilities associated with each alternative. The onshore facilities for the Nantucket Sound and South of Tuckernuck Island Alternatives and the entire MMR Alternative are located in Barnstable County, while the Buzzards Bay portion of the New Bedford/Reduced Horseshoe Shoals Alternative is located in Bristol County. As discussed further in Sections 3.4.3.4.19 and 5.16, the anticipated socioeconomic affects at the state or broader level will be essentially the same, regardless of which alternative is built. State-wide or regional economic conditions are generally not presented here. This analysis will compare the existing economic

conditions in Barnstable County with the existing economic conditions in Bristol County. Supplementary pertinent information is presented for individual municipalities.

Existing Economic Conditions in Barnstable County

The onshore facilities associated with the MMR, Nantucket Sound and South of Tuckernuck Island sites are all located in Barnstable County and it is reasonable to assume that the socio-economic setting at these sites will be similar to one another. For purposes of this analysis, the Region of Impact (ROI) for these alternatives is therefore defined as Barnstable County, Massachusetts, which contains a total of 15 cities and towns: Barnstable, Brewster, Chatham, Dennis, Eastham, Harwich, Mashpee, Orleans, Sandwich, Yarmouth, Bourne, Falmouth, Provincetown, Truro, and Wellfleet. The following is a description of the existing conditions in Barnstable County.

As shown in Table 3-36, the Bureau of Economic Analysis (BEA) estimated Barnstable County's Personal Income at $11.0 billion in 2001. Per Capita Income was $36,100 in the same year. The average annual pay per worker in Barnstable County during 2001 was $36,700, up about 0.8% from the year before. According to the BEA, in 2001 total non-agricultural employment was 91,870 employees, with the non-manufacturing sector accounting for 88,400 employees. Retail Trade and Services had the largest shares of non-manufacturing employment, accounting for 29,900 and 30,850 workers, respectively.

The BEA estimates that there were 5,200 construction related workers employed in the Cape and Islands Workforce area in 2001. The manufacturing sector accounted for approximately 3,500 jobs. Table 3-36 provides a summary of the existing income and employment conditions in Barnstable County.

Property tax and housing data are compiled on a municipal basis. For Barnstable County, the primary towns potentially affected by the Project would be Barnstable and Yarmouth for the offshore alternatives and Bourne and Sandwich for the MMR Alternative. Table 3-37 lists the most recent available annual property tax revenues by town.

Tables 3-38 and 3-39 list housing occupancy in the towns of Barnstable and Yarmouth or Bourne and Sandwich, respectively, in 2000. It should be noted the vacant housing category includes seasonal, recreational or occasional dwellings. Roughly 89% of the vacant housing in Barnstable and Yarmouth and 84% of the vacant housing in Bourne and Sandwich would be in this category. Given the nature of Barnstable County as a vacation destination, these seasonal, recreational and occasional housing units are typically occupied during the summer months.

Existing Economic Conditions in Bristol County

The ROI for the Buzzards Bay portion of the New Bedford/Reduced Horseshoe Shoals Alternative is defined as Bristol County. Bristol County contains the following 20 cities and towns in Massachusetts: Acushnet, Attleboro, Berkley, Dartmouth, Dighton, Easton, Fairhaven, Fall River, Freetown, Mansfield, New Bedford, North Attleborough, Norton, Raynham, Rehoboth, Seekonk, Somerset, Swansea, Taunton, and Westport.

As shown in Table 3-40, the BEA estimated Bristol County's Personal Income at $15.7 billion in 2001. Per Capita Income reached an estimated $29,200 that same year. The average annual pay per worker in Bristol County during 2001 was $31,700, up approximately 1% over the previous year. According to the BEA, in 2001 total non-agricultural employment was 270,100 employees, with the non-manufacturing sector accounting for 226,700 employees. Retail Trade and Services had the largest shares of non-manufacturing employment, accounting for 52,700 and 92,000 workers, respectively.

The BEA estimates that there were 15,100 construction related workers employed in Bristol County in 2001. The manufacturing sector accounted for approximately 43,400 jobs. Table 3-40 provides a summary of the existing income and employment conditions in Bristol County.

For Bristol County, the primary area potentially affected by the Project (the New Bedford portion of the New Bedford/Reduced Horseshoe Shoal Alternative) is the City of New Bedford. Table 3-41 lists the most recent available property tax revenues for New Bedford.

Table 3-42 lists housing occupancy in the City of New Bedford in the year 2000. It should be noted the vacant housing category includes seasonal, recreational or occasional dwellings. Roughly 3% of the vacant housing in the city would be in this category.

Environmental Justice

This section examines the socioeconomic characteristics of the area surrounding the Alternative sites, as described above, for purposes of determining if any one population subgroup could potentially be disproportionately impacted by the proposed Project. Executive Order 12898 on Environmental Justice requires that each Federal agency address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The main consideration when addressing Environmental Justice is whether environmental burdens associated with the construction and operation of the proposed Wind Park could potentially adversely impact particular population subgroups given their location relative to the project area. Specifically, minority and low-income populations will be considered in this analysis. A meaningfully greater percentage of minority populations or persons below the poverty level associated with one of the four Alternative Sites relative to the others could raise a concern over Environmental Justice for that area. Minority and poverty level data provided in Table 3-43 were obtained from the 2000 Census.

As shown, Barnstable County and the City of New Bedford boast significantly larger populations than the other represented counties and towns potentially impacted by the proposed Project. This being the case, to assess the demographic profile fairly, percentages were compared for each population based on Census race and income numbers.

At 21.1 percent, the City of New Bedford has the largest percentage of minority races in its population, at least twice as high as the other towns in the study group. As a point of reference, there is a higher percentage of minorities in New Bedford than in Massachusetts as a whole, but a lower percentage of minorities as compared to the United States.

Additionally, New Bedford reports 20.2 percent of its residents live below the poverty level. This is twice the percentage of individuals living in poverty across the state of Massachusetts (9.3 percent) and significantly higher than the national average as well (12.4 percent).

On a countywide basis, both the percentage of minorities and percentage of persons below the poverty level in all four counties is consistently lower than national trends, and about equal or lower to the state's figures. As provided in the socioeconomic discussion early, the per capita income at the potential host cities and counties for the Alternative Sites is generally favorable, and it can be argued that none of these areas presently suffer from environmental justice issues.

Comparative Summary of Existing Conditions

Table 3-44 provides a comparison of existing income and employment conditions between Barnstable and Bristol counties in 2001.

In terms of population, Bristol County is more than twice the size of Barnstable County with a population of approximately 539,000 as opposed to Barnstable's population of approximately 226,000. Bristol County's higher population is reflected in its higher total personal income of $15.7 billion vs. Barnstable County's $11.0 billion. However, average annual wages are approximately 14% lower in Bristol County ($31,700) than for Barnstable County ($36,700). Similarly, Per Capita Income is approximately 19% lower in Bristol County than for Barnstable County ($29,200 vs. $36,100), the increase in the disparity is possibly due to higher non-wage income in Barnstable County.

With regard to employment, the two counties are similar in terms of where employment is concentrated. Both counties have high levels of employment in Trade, Services, and State and Local Government. These three sectors combined account for approximately 83% of overall, non-agricultural employment in Barnstable County and approximately 64% in Bristol County. The existing number of construction jobs is a relatively small portion (approximately 6%) of non-agricultural employment in both counties. One significant difference is that the

manufacturing sector accounts for approximately 16% of non-agricultural employment in Bristol County versus only 4% in Barnstable County. This reflects the higher occurrence of manufacturing jobs in the New Bedford area when compared with the Cape.

Of all the towns evaluated for Alternative siting, the City of New Bedford has considerably more minorities and a higher percentage of citizens living below the poverty level. The City of New Bedford is therefore the only area to consider with regard to Environmental Justice and the impacts to such communities due to Project development and operation.

3.4.3.3 Engineering and Economics

3.4.3.3.1 Engineering

Engineering issues which may affect the viability of an alternative site for wind power production will vary between terrestrial and offshore sites, and involve a number of variables including WTG size, spacing, siting considerations, geologic and soil conditions, foundation types, cabling lengths, construction access, and water depth.

Massachusetts Military Reservation

A conceptual terrestrial alternative wind park sited at the Massachusetts Military Reservation is shown in Figure 3-44. This alternative would involve the installation of 132 wind turbines (GE 1.5 MW units) capable of producing approximately 200 MW, the installation of approximately 56.7 miles of underground cable, construction of a new substation (or the expansion of the existing Bourne substation) and would encompass the use of approximately 6,120 acres of the northern portion of MMR which is presently undeveloped land.

Turbine Siting and Array Development

The conceptual array for the MMR alternative site as shown in Figure 3-44 maximizes the number of WTGs that can be sited on the northern portion of the base, given the known conflicting military facilities and topographical variations of the landscape. Siting considerations included the use of topographical high points, previously disturbed areas and adequate spacing between turbines (minimum of 5 rotor diameters or approximately 1260 feet (385 meters)) in order to maximize efficiency. Areas specifically avoided included wetlands and established military facilities such as artillery ranges, known unexploded ordnance areas, remediation clean up sites, PAVE PAWS radar site, and other active military and governmental uses.

Inner-array cabling was routed to maximize the use of previously disturbed areas (roads, trails, utility rights-of-way) and to minimize the amount of new access road clearing. Turbines would be connected in strings of up to 20 WTGs that would then interconnect with a new substation located adjacent to the existing Bourne substation in the northwestern corner of MMR, and ultimately deliver power to the established grid. It should be noted that even with the use of a considerable portion of MMR, the installed capacity is just under the 200 MW target set as a lower limit on reasonable alternatives to the proposed project.

Wind Turbine Generator (WTG)

The WTGs proposed for use at the MMR alternative are GE 1.5 MW units. The 1.5 MW unit is a state of the art upland design that has a positive track record over the installation of more than 2,000 units worldwide. The 1.5 units have a rotor diameter of 253 feet (77 meter) at a hub height of 279 feet (85 meters), for an overall tip height of approximately 405 feet (123.5 meters).

The MMR land based alternative utilizes the relatively smaller 1.5 MW machine, rather than the 3.6 MW machine proposed for all offshore alternatives, for several reasons. The 3.6 MW unit has been specifically designed for offshore use and due to the large size and weight of its components, the 3.6 MW unit causes transportation issues that are not easily overcome in an upland installation. Although each land-based turbine is a smaller generating unit (when compared to an offshore WTG), it is required to be placed on a taller tower in order to access the higher quality winds above the turbulences associated with topographical variations and land cover, resulting in overall tip heights approaching that of the offshore 3.6 MW unit (405 feet vs. 417 feet). When the topographical elevation above sea level for the land based WTG site is accounted for, the true overall height for

land based turbines (particularly as it affects navigable airspace and aviation) is significantly greater than those sited offshore.

Foundation Design

Based on available geotechnical data, and industry experience for established land based wind parks, a concrete spread footing was deemed most appropriate for this application. See Figure 3-45 for a typical design. The spread footing for each of the units will be approximately 1,830 square feet installed to a depth of approximately 9 feet below grade.

Construction Issues

The MMR site presents a number of construction challenges for the installation of a significant scale wind generating facility. As an EPA Superfund Site with a number of contaminated areas spread throughout the site, liability concerns will add significant cost to the construction methods. As an active military base, with heightened security requirements, coordination with the appropriate authorities for base access, road construction, necessary tree clearing and supply and delivery will become additional challenges.

The foundation construction for the 1.5 MW WTGs is relatively straightforward and utilizes common construction equipment and material. Each spread footing will require the removal and proper disposal of approximately 16,500 cubic feet of fill (total of 2,178,000 cubic feet). Due to the level of contamination identified throughout significant portions of MMR it can be assumed that the excavation of some of the WTG foundation sites will involve either contaminated soils or previously remediated sites. Excavation of WTG foundation sites at MMR is further complicated by the possible presence of unexploded ordnance, requiring that the sites, and access to them, first be swept and cleared of explosives.

In addition to the footprint of the WTG foundation, the area surrounding each WTG must be cleared of vegetation within a 400 foot diameter in order to reduce interference from wind shear.

Construction and maintenance access to each WTG will require a roadway cleared to a minimum of 20 feet in width. Access roadways will also serve as inner array cable corridors for burying the cables connecting WTGs. Cables will be buried to an approximate depth of 5 feet. Where practical, existing cleared roadways, trails and rights-of-way have been utilized in the design of the access / cabling, however it is estimated that approximately 14 miles of new access will need to be cleared. Approximately an acre of land will be required for the construction of a new or expanded substation to accommodate the necessary transformers and switching equipment.

Actual supply and erection of the land based WTGs will be considerably less difficult than the offshore alternatives simply because the site is on land verses offshore. While delivery systems required for the land based WTGs are simplified, by not requiring marine transport, they are also limited due to the logistics of delivering the larger sections, such as blades and towers, and the heavier sections, such as the nacelle, over public roads, and the crossing of the Cape Cod Canal by bridge.

Nantucket Sound

A conceptual offshore design for the three alternative wind park sites within Nantucket Sound are shown in Figures 3-46. This Horseshoe Shoal and Tuckernuck Island layout would involve the installation of 130 turbines and the Monomoy-Handkerchief Shoal layout would contain 92 wind turbines. The Nantucket Sound Alternative would involve the installation of between 46 and 81 miles of inner-array submarine cabling. All of the offshore wind park alternatives will utilize the GE 3.6 MW wind turbines.

Turbine Siting and Array Development

The Nantucket Sound Alternative Site has the potential for three different individual arrays as shown in Figure 3-46. All arrays were designed to efficiently utilize the available area within the identified alternative. Each array is designed to balance the required WTG spacing to effectively capture the wind resource, with economic and physical constraints on foundation depth. Siting considerations for these alternatives also include avoidance of navigational channels, ferry routes, and existing utility cable corridors.

As shown in Figure 3-46, the Horseshoe Shoal sub-alternative has an array of 130 WTGs. The Tuckernuck Shoal sub-alternative also has an available area that allowed for an array of similar size to that developed for Horseshoe Shoal (130 WTGs). The Monomoy-Handkerchief Shoal sub-alternative site however contains only 92 WTGs due to insufficient available watersheet area.

Each of the offshore alternatives has been designed with significant spacing between WTGs (a minimum of 0.34 nautical mile x 0.54 nautical mile grid) which ensures efficiency, and that the construction and operation of the proposed Project will minimally impact existing watersheet uses.

Inner-array submarine cables (33 kV) will be jet plowed six feet beneath the seafloor so as to minimize sediment disturbance. Turbines would be connected in strings of up to 10 turbines that would then be interconnected to an Electric Service Platform (ESP) centrally located within the WTG array.

Wind Turbine Generator (WTG)

As in all offshore alternatives, the GE 3.6 MW WTG is proposed. The 3.6 MW unit is a state-of-the-art wind turbine specifically designed for offshore applications. This unit has had more than a year of operating experience on the first prototype and is currently in serial production.[45] The 3.6 MW units have rotor diameters of 341 feet (104 meter) at a hub height of 246 feet (75 meters), for an overall tip height of approximately 417 feet (127 meters).

Foundation Design

All three of the sub-alternatives in Nantucket Sound will utilize the same foundation assumption of a single monopile per WTG. Sufficient geotechnical, geophysical and oceanographic data are available to suggest that this commonly used design is most appropriate from both environmental and economic viewpoints. The monopiles that will be located within the Nantucket Sound Alternative Site will utilize two different diameter foundation types depending upon water depth. Water depths between 0-40 feet will utilize a 16.75 feet (5.1 meter) diameter monopile, and water depths between 40-50 feet will utilize an 18.0 feet (5.5 meter) diameter monopile. See Figure 3-45 for a typical design. The monopiles within Nantucket Sound will be driven approximately 85 feet into the seabed to provide adequate structural support for the WTG support tower and the nacelle.

Construction Issues

Offshore construction would be staged and scheduled in order to have the 115 kV cable transmission system ready to accept power at approximately the same time that the first WTGs are ready to produce power. Therefore, the initial activities will focus on construction and commissioning of the Electric Service Platform (ESP) and the 115 kV submarine cable system from the ESP to the Barnstable Switching Station. The work to install the WTGs will start at such time to ensure that the first string of eight to ten WTGs is ready to commission as the ESP is completed. Additional strings of WTGs will be sequenced as quickly as delivery logistics and weather allow.

The sequence of construction for the individual WTGs comprises the installation of a monopile followed by the fitting and leveling of the transition piece, then the tower, nacelle and rotor. Each of those operations is expected to take about a day and will be performed as separate operations by different crews. Once some experience is gained, it is anticipated that one WTG per day will be completed.

Major construction activities will be supported by onshore facilities which are assumed likely to be located in Quonset, Rhode Island which has adequate size to marshal and store enough equipment and material to support an efficient construction effort. Material and equipment will be staged at the onshore facilities in Quonset, RI and then loaded onto various vessels for installation. Once loaded, the vessels will travel from Quonset through Narragansett Bay to Rhode Island Sound to Vineyard Sound, North of Martha's Vineyard to the Main Channel, a distance of about 50-60 nautical miles.

The foundation construction for the 3.6 MW WTGs will require standard heavy marine construction techniques. Each wind turbine foundation is expected to occupy approximately 220 square feet to 255 square feet depending

[45] The first seven GE 3.6 MW units are in service at the Arklow project in the Irish Sea and thirty additional units are planned for the Gunfleet Sands project off the coast of Great Britain. By the time installation begins for the Cape Wind Project, this design will have tens of thousands of hours of operating experience.

upon water depth and pile diameter. The Wind Parks will have approximately 46 miles to 81 miles of inner-array cabling that will be jet plowed approximately 6 feet below the seabed.

South of Tuckernuck Island

A conceptual offshore design for the South of Tuckernuck alternative wind park site is shown in Figure 3-47. This alternative would involve the installation of 130 wind turbines (GE 3.6 MW). The South of Tuckernuck Alternative Site would involve the installation of approximately 85.5 miles of inner-array submarine cabling.

Turbine Siting and Array Development

This alternative has been designed to accommodate 130 WTGs for comparison purposes with the sub-alternative at Horseshoe Shoal. Both alternatives utilize the same grid spacing of 0.34 nautical mile x 0.54 nautical mile.

Similar to the Nantucket Sound Alternative, the inner-array submarine cables (33 kV) will be jet plowed six feet beneath the seafloor so as to minimize sediment disturbance. Turbines would be connected in strings of up to 10 turbines that would then be interconnected to the ESP centrally located within the WTG array.

Wind Turbine Generator (WTG)

The WTG proposed for this site is the same as described under the Nantucket Sound Alternative.

Foundation Design

This alternative requires foundations to be placed in various water depths ranging from approximately 15 to 100 feet, but still benefits from some sheltering effects from open ocean waves due to Nantucket Island to the east. Unlike the other offshore alternatives presented here, and indeed, unlike any other currently constructed offshore wind park in the world, foundations reach depths of 100 feet (30 meters). The South of Tuckernuck Alternative will require the use of four (4) different foundation types corresponding to various water depths. Proposals for wind parks in various stages of development in Europe seem to indicate that the practical limit for a single monopile design is about 65 feet (20 meters). Beyond this depth, new (and as yet untried) solutions must be developed. This alternative will utilize three different sized monopiles and a quad-caisson foundation. Water depths between 0-30 feet will utilize a 16.75 feet (5.1 meter) monopile, water depths between 30-45 feet will utilize a 18.0 feet (5.5 meter) monopile, and water depths between 45-65 feet will utilize a 19.0 feet (5.8 meter) diameter monopile. The quad-caisson foundation, a fabricated steel structure, will be utilized for all WTGs installed at a depth greater than 65 feet (20 meters). This structure will consist of four tower foundations that support the tower interface. See Figure 3-45 for a typical example of a design. This structure will require more complex fabrication and installation due to its large size and the more challenging sea conditions off the southern coast of Nantucket Island.

Construction Issues

This alternative is located in the open ocean that presents a set of sea conditions considerably different from the other offshore alternatives. Greater precautions for personnel safety will add to the complexity of the construction. The sea conditions will also restrict access to the site for construction to a considerably greater degree than the other alternatives. Routing for delivery of material to the site from a marshalling area (assumed to be Quonset Rhode Island for purposes of this comparison) would be from south of Martha's Vineyard.

The construction sequencing of this alternative is similar to that described for the Nantucket Sound alternatives. However, rather than the mechanical driving of the structure into the seabed as described for the monopiles, the caissons of the deep water foundation are set on the seabed and then suctioned into place to the appropriate depth.

New Bedford / Horseshoe Shoal

A conceptual offshore design for the New Bedford / Horseshoe Shoal Combination alternative wind park site within New Bedford Outer Harbor and Nantucket Sound is shown in Figure 3-48. This combination layout would involve the installation of 25 turbines for the New Bedford portion and would contain 114 wind turbines on Horseshoe Shoal. The New Bedford portion would involve the installation of approximately 15 miles of inner-

array submarine cabling and the reduced Horseshoe Shoal portion would involve approximately 69 miles of inner-array cable.

Turbine Siting and Array Development

For comparative purposes, this array was developed to be comparable in terms of installed capacity, to the sub-alternative on Horseshoe Shoal. In this case, both for the New Bedford and Horseshoe Shoal portions, the same grid spacing was utilized (a minimum of 0.34 nautical mile x 0.54 nautical mile grid).

This combination alternative was designed to allow a comparison of a project similar in total net output to the sub-alternative at Horseshoe Shoal, but split into two locations. One component is located on Horseshoe Shoal but with a reduced number of turbines from the original Nantucket Sound sub-alternative at Horseshoe Shoal as described above. The other component is a separate location south of New Bedford. Together, the combined net output is similar to the sub-alternative located on Horseshoe Shoal. To arrive at this combination, the New Bedford site was populated with the maximum number of WTGs that could be reasonably sited in an area defined by Buzzards Bay Main Channel, New Bedford Harbor Channel, and the channel into Apponagansett Bay.

As with all of the offshore alternatives, the inner-array submarine cables (33 kV) will be jet plowed six feet beneath the seafloor so as to minimize sediment disturbance. Turbines for the Horseshoe Shoal component of the combination alternative would be connected in strings of up to 10 turbines that would then be interconnected to an ESP centrally located within the WTG array. Turbines for the New Bedford component would be connected in strings of up to 10 turbines that would be connected directly to shore. Due to the close proximity to land, an offshore ESP would not be required for the New Bedford component.

Wind Turbine Generator (WTG)

The WTG proposed for this alternative is the same as described under the Nantucket Sound Alternative.

Foundation Design

As previous stated under the Nantucket Sound Alternative, the Horseshoe Shoal component of the combination alternative will utilize the same foundation assumption of a single monopile per WTG based on the geotechnical and oceanographic data available. Sufficient data also exists to assume that a single monopile for each WTG is most appropriate for the New Bedford portion of this alternative. However, there are significant geotechnical construction challenges in New Bedford (discussed below). The monopiles that will be used for the combination site will utilize two different diameter foundation types depending on water depth. Water depths between 0-40 feet will utilize a 16.75 feet (5.1 meter) diameter monopile and water depths between 40-50 feet will utilize a 18.0 feet (5.5 meter) diameter monopile. See Figure 3-45 for a typical design. It is assumed, based upon available data, that the WTGs for the combination alternative will be driven approximately 85 feet into the seabed to provide adequate structural support for the WTG support tower and the nacelle.

Construction Issues

Because of the geographical separation of the components a split project by nature requires two separate construction areas (each with its own unique environmental issues), doubling the logistical issues and fixed costs associated with each area. This duplication of efforts on two different fronts negates any economies of scale that can be realized with one contiguous project site. Geotechnical conditions at New Bedford contrast this alternative with all the other offshore alternatives being considered. Bedrock and boulders located within the New Bedford component will likely require drilling, elimination or relocation, increasing construction costs. The sequencing and construction of the combination alternative will be similar to that discussed under the Nantucket Sound Alternative above.

Comparative Summary of Engineering

While the installation and operation of a land based wind park at MMR would present less complex engineering challenges than the offshore alternatives, the conflicts with MMR's active military training mission, the extensive soil contamination of the site, and the presence of unexploded ordnance present significant impediments to a large scale wind project that are not present with the offshore alternatives. The South of Tuckernuck Island alternative would involve work in deeper, open ocean conditions requiring the use of conceptual, un-proven foundation systems and longer construction times due to limited availability and longer transport distances. The

New Bedford / Horseshoe Shoal combination alternative would involve work in two geographically separate locations and foundation / cable installation in difficult geotechnical conditions including shallow bedrock and possible contaminated sediments. The Nantucket Sound alternative presents the fewest engineering challenges of the offshore alternatives evaluated due to relatively shallow water depths, relatively sheltered sea conditions and geological conditions which allow the use of the proven monopile foundation design.

3.4.3.3.2 Economic Analysis

The relative economic viability of an alternative site is driven by five primary variables:

- **Capital Cost** of constructing a wind facility on the site.
- **Installed Capacity** of the proposed facility.
- **Wind Regime** at the site.
- **Net Power Production,** which is gross power production minus losses due to terrain effects, wind wake effects, weather and/or geographic conditions, and electrical losses.
- **Operation and maintenance costs**.

Capital Cost

For the purpose of this analysis, a comparison of capital cost among the alternatives will be made based on published data for both onshore and offshore wind parks. See Table 3-45 for a summary of data sources used to determine base costs. Although certain economic adjustments would need to be made to reflect its operation as an active military training facility, the chosen onshore alternative (MMR) has no apparent characteristics that would distinguish it economically from a typical onshore site using state-of-the-art WTGs. It is assumed that the data in Table 3-45 is reasonably representative for the MMR site. All the sources of offshore data referenced in Table 3-45, represent sites similar in conditions to the Nantucket Sound shallow water alternative. Therefore, the capital costs for the other offshore alternatives can be derived from the Nantucket Sound Alternative base cost.

Installed Capacity

The installed capacity of a wind park facility equals the number of turbines installed at a proposed site multiplied by the nameplate rating of the turbine type. The installed capacity is a function of the geographic conditions at the site: the area available for turbines and restrictions on turbine type caused by geographic conditions such as access, foundation strata and wind regime.

Wind Regime

The wind regime of an alternative site is a function of local climate and geographic conditions. For comparative purposes, this analysis uses wind regime data provided by the New England Wind Map.[46] The New England Wind Map was produced by True Wind Solutions, LLC, a nationally recognized wind consultant. The source document for this data was sponsored in part by the Massachusetts Technology Collaborative.

Net Production

The actual output, or Net Production, of the turbine array is the gross production (a function of installed capacity and wind regime) minus production losses. These losses are largely made up of terrain effects, wind wake effects, weather and/or geographic conditions (as they affect availability), and electrical losses. Gross production for each of the alternatives can be estimated by:

- Obtaining site specific wind regime data[46]
- Determining the power curve for the particular wind turbine. This information is available from the turbine manufacturers, frequently on their websites.
- Entering this data into a standard wind turbine power calculator (such as the one found on the Danish Wind Industry Association's website www.windpower.org) yields the production for a single WTG. Gross production of the alternative is the product of this number and the total number of WTGs proposed for the site.

To determine the wind park net output, gross production must be adjusted for the following losses:

[46] New England Wind Map available at http://truewind.teamcamelot.com/ne/.

- **Terrain Effects –** This requires detailed statistical analysis in order to calculate losses. For offshore alternative sites, terrain effects are presumed to be insignificant due to the smooth ocean surface; however, terrain effects are relevant for terrestrial sites.
- **Wind Wake Effects -** Production losses due to wind wake effects within the turbine array are likewise difficult to estimate. Wind wake effect losses result from the turbine's conversion of kinetic energy in the wind to electrical energy (leaving less kinetic energy in the wind according to the first law of thermodynamics) and from additional turbulence in the downwind flow induced by the turbine. Wind wake effect losses vary by alternative site according to the wind regime, the spacing / orientation layout of the turbine array and the geographic conditions at the alternative site.
- **Weather and/or geographic conditions -** Production losses due to weather and/or geographic conditions differ for terrestrial and marine alternative sites. These factors affect wind turbine accessibility that in turn effects net power production. Accessibility is generally less a problem for terrestrial sites than for offshore sites, due to fewer weather conditions that would prevent technicians from accessing the turbine to perform unscheduled maintenance. However, accessibility is a more significant problem for offshore alternatives, where high winds, large waves and sea ice can make travel and access to offshore WTGs slow or dangerous thereby reducing the overall opportunity to perform unscheduled maintenance.

  Elsam, operators of the Horns Rev wind farm, indicate that access and standby time for maintenance of offshore WTGs is judged on the basis of a significant wave height (Hs) of 4.3 feet (1.3 meters).[47] Accessibility at this condition is expressed as the percentage of time in a given month where Hs is greater than 4.3 feet (1.3 meters) for a period of 12, 24 or 72 hours. To determine the approximate duration of accessibility at the Nantucket Sound and South of Tuckernuck alternative sites, Woods Hole Group, Inc. compared the percentage of time for each month that significant wave height was less than 4.3 feet (1.3 meters) for a 24-hour period at the Cape Wind SMDS in Nantucket Sound and the Martha's Vineyard Coastal Observatory. See Figures 3-49 and 3-50 for these results. (The 24-hour period was chosen to reflect the need for a 8-12 hour scheduling period before each 12-hour repair.) It is readily apparent that in comparison to Nantucket Sound, the South of Tuckernuck Alternative represents a considerable challenge to maintain year-round, especially during the winter months. The winter is when most production is likely to occur due to higher average wind speeds, exacerbating the impact of lost production for this alternative.
- **Electrical Losses –** Electrical losses are a function of the amount of cabling and other electrical infrastructure. Please refer to Appendix 3-C, Transmission Issues for Offshore Wind Farms for a discussion on comparative losses as cable length increases.

Operation and Maintenance Costs

Typical estimated operation and maintenance costs are readily available in published literature[48]. Comparative variations for offshore alternatives could be inferred from the combination of distance from the maintenance port and sea conditions as discussed above. Land based operations and maintenance costs are considerably less than offshore wind parks due to ease of accessibility.

An additional item that could impact operation and maintenance cost is the provision for decommissioning. Published references for decommissioning of onshore facilities generally indicate that the decommissioning cost is negligible when the salvage value of the material is considered[49,50]. Offshore costs for decommissioning a project similar to the Nantucket Sound (shallow water) alternative seem to indicate a cost of about $53 per installed kW (see Table 3-46).[51] A somewhat higher value would be necessary to account for more challenging conditions in the deep water alternative and somewhat lower values for the relatively small portion of the combination alternative located off New Bedford.

[47] Horns Rev Offshore Project Seminar at Esbjerg, Denmark, June 27-28, 2002.
[48] See State of the Art and Trends Regarding Offshore Wind Farm Economics and Financing - CA-OWEE / RISO (http://www.offshorewindenergy.org/ca-owee/indexpages/downloads/Brussels01_Economics.pdf) for example.
[49] http://www.retscreen.net/ang/pdf/WIND02-A.pdf
[50] http://www.amec.com/wind/where/where_2ndlevel.asp?pageid=8170#decomm
[51] Published sources do not contain estimates for the salvage value of offshore facilities.

Massachusetts Military Reservation

It is generally acknowledged that a minimum wind resource of class 4 or higher (15.7 – 16.8 mph or 7.0 – 7.5 m/s) is required to make an onshore project financially viable.[52,53,54,55] As previously discussed in Section 3.4.3.2.3, MMR has a wind resource of class 3 (14.5 – 15.7 mph or 6.4 – 7.0 m/s) and is therefore not likely to be financially viable. See Figure 3-42.

The installed capacity of the MMR alternative is 198 MW (132 of the 1.5 MW WTGs). Employing the methodology described above, this alternative yields a gross production of 700 GWHrs per year. Due to a less robust wind resource and the use of smaller (1.5 MW) WTGs, the net output delivered to the grid from the MMR Alternative is considerably less than any of the offshore alternatives identified for comparison. This alternative does have the potential for higher average availability than all the offshore alternatives due to considerably easier year-round access to perform planned and unplanned maintenance. Net production for the MMR alternative is estimated to be approximately 600 GWHrs per year.

As detailed in Table 3-47, and based upon published information on existing wind parks, the installed costs for the MMR alternative are estimated to be approximately $228,253,000, or $1,153 per installed kilowatt.

Nantucket Sound

The shallow water alternative contains the proposed project and is considered the base case for economic comparison. For the purposes of this analysis the Horseshoe Shoal sub-alternative will be used as representative of all three Nantucket Sound sub-alternative sites. Factors that impact the economics of the alternatives positively or negatively are useful only for relative comparisons and not necessarily to judge the overall viability of the alternative projects.

The Nantucket Sound alternative has a wind resource of class 6 (17.9 - 19.5 mph or 8.0 - 8.8 m/s), Figure 3-43. The installed capacity of the Nantucket Sound alternative is 468 MW (130 of the 3.6 MW WTGs). Employing the methodology described above, this alternative yields a gross production of approximately 2,000 GWHrs per year. Accounting for installed capacity, wind regime, electrical and other losses and availability, the proposed project on Horseshoe Shoal will yield a net production of approximately 1,500 GWhrs per year (See Section 4.1) of energy delivered to the Barnstable Switching Station. This is considered the "base" value of economic comparison for the purposes of this analysis. The 130 WTG sub-site north of Tuckernuck Island on Tuckernuck Shoal will yield slightly greater output due to a slightly better wind regime and the 92 WTG site on Monomoy-Handkerchief Shoal Site will (approximately) yield a proportionally lower net output. Availability is impacted by a number of factors that will vary from one alternative to another. These include environmental issues that relate to the WTG maintenance program, the ability to perform routine, scheduled maintenance and the ability to perform unscheduled maintenance. Availability at these three sites is considered to be similar and this again is considered the base for comparison of the other alternatives in this analysis.

As detailed in Table 3-47, and based upon published information on existing wind parks, the installed costs for the Nantucket Sound alternative are estimated to be approximately $895,277,000, or $1,913 per installed kilowatt.

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[52] Elliott, Schwartz, Bailey & Phillips, 1997: Availability of Renewable Resources: Wind Energy. **CRC Handbook of Energy Efficiency** (edited by F. Kreith and R. West), CRC Press, New York, pp 751-780. This article states "Areas designated as Class 5 or above are well suited to wind power generation. Class 4 regions, which are abundant throughout the nation's midsection, are just now becoming economical for power generation. "

[53] http://www.infinitepower.org/reswind.htm Texas Renewable Energy Resources. This article states "Technology currently being developed should make class 4 (yellow) wind regimes viable."

[54] http://www.palmsprings.com/services/wind1.html This article states "For utility applications, class 4 or higher energy classes are usually required"

[55] http://www.poweringthesouth.org/articles/static/1/1012843409_1012401156.html This article states "With today's wind technology, most utility-scale wind plants are being installed in class 4, 5, and 6 areas"

South of Tuckernuck Island

The wind regime in the South of Tuckernuck alternative area is better than that of the other alternatives evaluated. The South of Tuckernuck alternative has a wind regime of approximately 19.5 mph (8.7 m/s) that places it at the upper limits of a class 6, Figure 3-43.

The installed capacity of the South of Tuckernuck alternative is 468 MW (130 of the 3.6 MW WTGs). Employing the methodology described above, this alternative yields a gross production of approximately 2,000 GWHrs per year. Although the size of the South of Tuckernuck alternative is comparable to the base case Nantucket Sound alternative (130 WTGs) there are two significant differences between the two alternatives. The wind regime is measurably better at South of Tuckernuck, causing the potential net output to be greater than the base case. However, the sea conditions in this area will reduce the amount of time in any given year that would allow access for both planned and unplanned maintenance. These issues, along with greater electrical losses from the necessarily longer 115 kV interconnection system, combine to result in an approximate net production of power delivered to the Barnstable Switching Station of approximately 1,500 GWhrs per year.

As detailed in Table 3-47, and based upon published information on existing wind parks, the installed costs for the South of Tuckernuck alternative are estimated to be approximately $1,252,863,000, or $2,677 per installed kilowatt. The higher installed costs are primarily due to the greater foundation costs related to deeper water installations (see Table 3-48), and increased construction costs due to distance from shore and accessibility issues as discussed previously.

New Bedford / Horseshoe Shoal

The New Bedford portion of the combination alternative has a lower wind regime than the Horseshoe Shoal portion, resulting in an estimated average wind regime for the Combination Alternative of approximately 18.5 mph or 8.3 m/s (class 6) for the purposes of this economic analysis, Figure 3-43.

The installed capacity of the New Bedford / Horseshoe Shoal alternative is approximately 500 MW (139 of the 3.6 MW WTGs). Employing the methodology described above, this alternative yields a gross production of approximately 2,000 GWHrs per year. This alternative site was designed to approximate the output of the proposed site at Horseshoe Shoal. Due to the poorer wind resource in New Bedford, the total number of WTGs must be increased by 9 to 139 to produce the required net output. This number was arrived at accounting for the lower average wind speed (which reduces output), and the greater loses involved with two separate grid connections. As shown in Table 3-47 similar additional losses to those of the Nantucket Sound alternative are assumed. These issues combine to result in an approximate net production of power delivered to the grid, from two separate locations, of approximately 1,500 GWhrs per year.

As detailed in Table 3-47, and based upon published information on existing wind parks, the installed costs for the New Bedford / Horseshoe Shoal alternative are estimated to be approximately $962,629,000, or $1,924 per installed kilowatt. The higher installed costs are primarily due to additional foundation construction costs related to anticipated difficult geotechnical conditions in New Bedford, and increased construction costs related to two geographically separate construction sites. Operations and maintenance costs are expected to be greater as a result of operating and maintaining two geographically separate facilities simultaneously.

Comparative Summary of Economics

As summarized in Table 3-48, while the terrestrial alternative at MMR has the lowest capital costs per installed kW, it produces less than half of the net output of the three offshore alternatives. Of the three offshore alternative sites evaluated, each of which produces approximately the same net output, the Nantucket Sound alternative has the lowest capital cost per installed kW. The South of Tuckernuck alternative is the most expensive alternative primarily due to the increased deep-water foundation costs and considerably higher construction costs.

3.4.3.4 Environmental Consequences

3.4.3.4.1 Protected Avian Species and Avian Resources

This section describes potential impacts to avian resources and protected avian species at the four Alternatives under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal.

A review of existing information on avian resources consisting of a summary of the key species and resources documented to occur at each of the Alternatives (see Section 3.4.3.2.1) was conducted. Available studies of impacts to birds from wind generation facilities (e.g., Christensen et al., 2002; Pedersen and Poulsen, 1999; Appendix 5.7-A; Erickson et al., 2001; Kerlinger, 2000a & b; Leddy et al., 1999; Still and Lawrence, 1996) were reviewed as part of this evaluation as well as behavioral studies of migrants and protected bird species known to utilize the Alternatives (e.g., Massachusetts Army National Guard, 2001). Consultations with the Massachusetts Natural Heritage Endangered Species Program (NHESP) and ornithological experts from the University of Massachusetts, CUNY College of Staten Island, and the Massachusetts Audubon Society between 2001 and 2004 were also considered as part of this assessment. A summary of potential impacts to avian resources at the Alternatives under consideration is presented below.

In addition to true avian species, this section also addresses other flying creatures that may have the potential to be impacted by the construction and operation of the wind park at the alternative sites under consideration. As discussed in Section 3.4.3.2.1, most of the seven bat species that occur in southeastern Massachusetts are uncommon to rare in the southeastern Massachusetts portion of their ranges and are not known to spend substantial periods of time over large bodies of open water such as Nantucket Sound (DeGraaf and Yamasaki, 2001). Thus, bats are not likely to be present in great numbers at the offshore alternative sites, and impacts to bats are unlikely at the Nantucket Sound, South of Tuckernuck and New Bedford / Horseshoe Shoal offshore alternative sites. The potential impacts to bats at the upland site at the MMR alternative is discussed in Section 3.4.3.4.7.

As also discussed in Section 3.4.3.2.1, federally-listed insect species are not expected to be found at either the offshore alternative sites or the upland site at the MMR alternative. The potential impacts to other insects, including state-listed species at the MMR can be found in Section 3.4.3.4.7.

Massachusetts Military Reservation Alternative

The MMR Alternative is the only terrestrial Alternative under consideration and the only Alternative that includes a Massachusetts Audubon Society (MAS) Important Bird Area (IBA).[56] Potential impacts to birds at this Alternative from Project construction and decommissioning include habitat loss and fragmentation and disturbance/displacement from construction vehicle/equipment traffic. Potential impacts to birds during Project operation include disturbance/displacement by turbines, collisions with turbines (and associated lighting and perchability influences), disturbance from vehicle traffic, and effects on bird migration. These may include both indirect and cumulative impacts.

Construction and Decommissioning

Impacts to upland resources, including vegetation/habitat community types at the MMR Alternative are discussed in Section 3.4.3.4.7. As shown in Figure 3-51, there are six major habitats within the MMR Alternative (in order of dominance): 1) mixed woodlands; 2) pitch pine scrub oak forest; 3) hardwood forest; 4) scrub oak barrens; 5) grassland habitat; and 6) open water/wetlands of various types (Massachusetts Army National Guard, 2001). Table 3-50 summarizes anticipated impacts to these vegetative communities based on the proposed Wind Park layout.

As shown in Figure 3-51, the greatest impacts would occur to upland forested areas, including both mixed woods and pitch pine/scrub oak forest. Impacts to grasslands are somewhat less, however, because this habitat type is

[56] An IBA is an area critical to birds during some part of their life cycle (breeding, wintering, feeding and/or migrating). (from http://www.massaudubon.org/)

locally and regionally less common, its loss may significantly impact species that depend on grassland habitat (e.g., grasshopper sparrow, vesper sparrow, northern harrier and upland sandpiper). The Project layout is located in close proximity to several small wetland areas and may include wetland resource area and/or buffer zone. Birds which favor wetlands may be impacted by the presence of the Wind Park. Impacts to wetland areas are discussed in Section 3.4.3.4.15 (Water Quality and Water Resources).

Disturbance / Displacement

The avifauna that are characteristic of each of these habitat types could be affected by habitat loss and fragmentation from tree clearing and road construction as part of wind turbine and cable installation.[57] Also, increased traffic, noise, and human presence during construction and decommissioning activities could adversely impact breeding, nesting, foraging, and migration activities of certain species (see Appendix 5.7-A). Examples of potentially affected bird species include:

- Eastern Towhees, Chipping Sparrows, Sharp-shinned Hawk, Northern Parula (upland forest, dominated by pine and oak);
- Hermit Thrush, Gray Catbirds, Black and White Warbler (pitch pine/scrub oak barrens);
- Grasshopper Sparrows, Vesper Sparrows, Northern Harriers (grassland); and
- Great Blue Herons, Wood Ducks, Red-winged Blackbirds (palustrine wetlands).

Prey Impacts

Construction activities and habitat fragmentation and / or modification may temporarily reduce the availability of prey species. Increased predation from competing species may occur, further reducing the availability of some prey species.

Endangered, Threatened, and Other Listed Avian Species

Of the eight state-listed bird species observed at MMR, the Sharp-shinned Hawk (Special Concern) and Northern Parula (Threatened) are more dependent on woodland habitat (Massachusetts Army National Guard, 2001). Given that the proposed MMR Wind Park layout would primarily affect woodlands, there may be increased disturbance of these two species (and approximately 30 additional non-listed species found in woodlands at MMR at different times of the year) from Project construction activities. The four state-listed species that prefer grassland habitats (Northern Harrier, Upland Sandpiper, Vesper, and Grasshopper Sparrow) may also be disturbed by construction activities. Although the area of grassland that would be impacted is relatively small compared to woodland impact, grasslands are a regionally less common habitat (Massachusetts Army National Guard, 2001). Temporary and localized impacts on breeding, nesting, foraging, and migration activities are possible, depending on the Project schedule and mitigation measures adopted.

<u>Operation and Maintenance</u>

Avian impacts anticipated during Wind Park operation include disturbance/displacement of birds due to the presence of the turbines and associated structures, and bird collision with turbine rotors. In general, some limited impacts to bird breeding, nesting, foraging, and migration activities are possible during Wind Park operation, depending upon maintenance schedules and mitigation measures adopted.

Disturbance/Displacement

Habitat alteration, from WTGs protruding through the forest canopy and other new structures that may be unfamiliar to the birds that utilize the Alternative, may result in localized habitat displacement for certain individuals. Spacing between the 1.5 MW WTGs is estimated to be a minimum of 1260 feet (385 meters). Clearings for WTGs and cable ROWs would also fragment the generally continuous forest cover at the MMR Alternative. This would increase the amount of edge habitat, which may negatively affect certain interior forest species that do not tolerate fragmentation. For example, Kerlinger (2000b) found a decrease in the number of interior forest dwelling species after construction of 11 turbines in Searsburg, Vermont. The species studied (i.e., Swainson's Thrush and Red-eyed Vireo) were still present after construction, but not in close proximity (within

[57] A study of an existing wind park in Searsburg, Vermont found that habitat fragmentation associated with wind turbine installation caused increases in localized species richness (Kerlinger, 2000b). However, these increases were found to be the result of an increase of edge species at the expense of declining forest interior species (Kerlinger, 2000b). The density and proposed location of turbines at the MMR Site may adversely affect bird species which prefer forest interior habitats and may benefit edge species.

328 feet/100 m) to the turbines (Kerlinger, 2000b). Also, increase in edge habitat would allow for infiltration of brood parasites such as the brown-headed cowbird that could exploit forest dwelling birds like the wood thrush.

Similarly, habitat fragmentation caused by the presence of the Wind Park at MMR may negatively impact the state-listed Sharp-shinned Hawk (Special Concern) and Northern Parula (Threatened). The MMR's Integrated Natural Resource Management Plan calls for reducing habitat loss by maintaining contiguous tracts of forest and reducing fragmentation to protect these species (Massachusetts Army National Guard, 2001).

In addition, the presence alone of new structures in habitats similar to those at MMR may impact bird density in surrounding areas and habitats. Leddy et al. (1999) found that mean densities of grassland birds 55 feet (180 m) from wind turbines were four times greater than densities nearer to the turbines. Why certain bird species avoid wind turbines more than others is unknown, but may be related to the structures themselves, reduced cover (habitat), noise from the rotors, increased human presence, and/or the presence of maintenance roads/ROWs and associated activity.

Several studies of avian impacts at wind farms indicate that the extent to which the presence of wind turbines affects birds varies greatly by species. Some species may be affected positively (edge species), while others may be affected negatively (interior forest species) (Kerlinger 2000b). Several studies found that migratory birds may be negatively impacted by loss of habitat as they avoid turbines (Christensen et al., 2002; Pedersen and Poulsen, 1999; Still and Lawrence, 1996). However, studies have also shown that certain bird species (e.g., dark-eyed juncos) become habituated to and are relatively unaffected by the presence of turbines (Kerlinger, 2000b).

Collision

Bird collision with turbines is possible during Wind Park operation, especially during inclement weather. However, studies show that fatalities from wind turbines are low when compared to those that occur from other man-made structures such as buildings and communication towers (Erickson et al., 2001) as well as airplanes and automobiles (Biofile, 2004).

Erickson et al. (2001) provides a detailed summary of the mortality data collected at windplants and puts avian collision mortality associated with windpower development into perspective with other significant sources of avian collision mortality across the U.S. Erickson et al. (2001) found that only 0.01% to 0.02% of the estimated 200 to 500 million bird kills annually (from collision with man-made structures such as vehicles, buildings, powerlines, communication towers and wind turbines) occur as a result of wind turbines. While noting that large differences in total mortality amongst the various structures are strongly related to the differences in the number of structures in each category (i.e. 4.5 million commercial buildings; 80,000 communication towers; 15,000 commercial wind turbines) Erickson points out that "even if windplants were quite numerous (e.g., 1 million turbines), they would likely cause no more than a few percent of all collision deaths related to human structures."

Outside of the widely publicized bird kills at Altamont Pass, California, there have been relatively few fatalities or significant impacts to populations of birds from wind generation facilities (Kerlinger, 2003). Several factors particular to the Altamont Pass Wind Park are believed to contribute to the inordinate number of bird fatalities at that site including the high number and close spacing of turbines, the placement of turbines with regard to topography, the lattice type tower structures which provide increased perching opportunities, the high rotor speeds common to older turbine models (up to 72 rpm), and the abundance of prey species in the area (Kerlinger, 2003). The proposed MMR Wind Park layout would not include these features. The MMR layout would include large, modern turbines with slower rotors (10-20 rpm) spaced further apart. This would allow for birds to more easily avoid or fly between rotors. In addition, the proposed towers are tubular in design, diminishing perching opportunities compared to the lattice type towers found at Altamont Pass. For additional details on avian collision risks please refer to Section 5.7.

Lighting

It is widely understood that some birds, principally night-migrating songbirds, are attracted by certain types of lights, particularly in conditions of poor visibility. Certain birds become disoriented and fly toward towers, colliding with them and/or the guy wires supporting the structure (Erickson et al., 2001; Biofile, 2004). The proposed WTG lighting (generally, low intensity flashing red lights) does not possess the characteristics that are known to attract birds (high intensity, steady burning lights) and includes features recommended by the USFWS

in Guidelines for Communications Towers for reducing potential bird collisions on land (USFWS, 2000). As discussed in Section 3.4.3.4.8, proposed lighting (primarily LED type) would be set to flash at 20 Flashes per minute, which is the longest "off" cycle allowed by the FAA and is also in keeping with the USFWS guidelines.

Potential Species/Group Specific Impacts

Potential species/group-specific impacts are discussed below for the following birds known to utilize the area within MMR:

Shorebirds (Plovers, Sandpipers, and Allies). This type of collision risk does not seem to be applicable to shorebirds over land during migration. There is likely to be little risk to the large numbers of night migrating shorebirds that fly over MMR, as their altitude is generally well above turbine height (Kerlinger, 1995). Shorebirds that may land to rest and/or forage at MMR during the day or that take off on their migration most likely will see the turbines and avoid them. They may be at increased risk under inclement weather conditions.

Raptors. Outside of Altamont, collision risk to raptors is low and not biologically significant (Kerlinger, 2003). Similar to other species that migrate through the area, raptors will be at increased risk during take off from and landing in the area during migration and during inclement weather. Some raptors that are known to forage at high altitudes (up to a 100 feet) (i.e. kestrels) may be at greater risk than species that forage closer to the ground. The turbines will be constructed to minimize perching, likely decreasing collisions.

Passerines and Other Landbirds. Night migrating songbirds, for the most part, are likely to fly at altitudes well above the turbine rotors (approximately 417 feet) and would not be at substantial risk of collision (Kerlinger and Moore, 1989). Songbirds are likely to be attracted to steady burning lights during poor visibility conditions (i.e., rain, fog, snow, and low ceiling).). However, a comparison of lit and unlit wind turbines does not show any attraction differences between the two when using a flashing red FAA (L864) light (Kerlinger, 2004b). Thus, appropriate WTG lighting will be important to reduce the risk of songbird collisions (see Section 3.4.3.4.8). Lighting is the primary factor in collision mortality at communication towers (Erickson et al., 2001). Virtually all communication towers that kill large numbers of birds are greater than 500 feet in height, have guy wires and steady burning red lights (in Trapp, 1998; Kerlinger 2000a; Kerlinger, 2004b). Un-guyed towers (primarily lattice type communication towers) of less than 500 feet (153 m), which are similar to wind turbine towers, with appropriately sensitive lighting pose little threat to birds (Shire et al, 2000).

Individuals that use MMR as a stopover during migration or nest in the area may be at an increased risk during take off and landing. Once individuals are at their nesting sites they will be unlikely to collide with turbines because they rarely are observed at the height of the turbines (Kerlinger, 2004a.). However, species that have aerial courtship displays (woodcock and horn lark) which involve flying upward may be at increased risk during the breeding season.

Endangered, Threatened, and Other Listed Species. The eight state-listed species that are found within the MMR alternative may also be at increased risk from collision with turbines during migration.

Impacts to Migratory Species

Migratory species (including songbirds and raptors) that use MMR as a stopover site for foraging and/or resting may be affected by habitat loss or the need to avoid WTGs during Wind Park operation. Kerlinger (2000b) found that migrating songbirds decreased in numbers after Wind Park construction at other sites and inferred that migratory songbirds may have elected to avoid Wind Park structures by flying over or around Wind Park sites. Migrant collision with wind turbines is not expected to be significant at MMR because the majority of migrants fly between 300 and 2,000+ feet (92 and 615+ meters) above the ground; however, the average altitude of flight over land is approximately 1,400 –1,500 feet (427-457 meter)(Kerlinger, 1995; Kerlinger and Moore, 1989; Able, 1970). Migrants may fly as much as 5 to 10 miles out of their way to avoid wind turbines (Erickson et al., 2001). Therefore, the majority of migrants are expected to fly above or around operating turbines.

Nantucket Sound Alternative

This section describes potential impacts to avian resources and protected avian species in the Nantucket Sound Alternative. Potential avian impacts were evaluated based on available information on avian resources and

protected avian species (see Section 3.4.3.2.1), consultations with ornithological experts, and studies conducted at existing wind farms both offshore and at terrestrial sites in North America and Europe. These impacts include disturbance/displacement by turbines, collisions with turbines (and associated lighting and perchability influences), disturbance from vessel traffic, and effects on bird migration. Similar impacts to avian resources have the potential to occur at all three of the offshore alternatives. However, the extent of these impacts would vary by site depending on such factors as site-specific avian community composition, proximity of the site to key habitat or high use areas for birds, and distance to shore.

Construction and Decommissioning

Disturbance/Displacement

Temporary and localized impacts on avian breeding, nesting, foraging, and migration are anticipated during construction and decommissioning due primarily to noise, vessel traffic, and the presence of construction equipment, materials, and workers (Christensen et al., 2002). During construction/decommissioning, birds in the immediate vicinity of activities could be displaced out to a distance of several hundred meters from these activities (Guillemette, 1999). Bird species that utilize the area for foraging and/or resting purposes (e.g., tern, scoter, and gannet) may also avoid the immediate area of construction or decommissioning (see Appendix 5.7-A). However, these impacts are expected to be temporary and localized. The specific species potentially impacted by these activities would depend on the time of year. During the summer months, when there is a much lower density of avifauna in the area, there would be generally fewer bird disturbances. However, the federally-endangered roseate tern is prevalent in this vicinity during summer.

Some bird species are more likely to avoid the immediate area of construction/decommissioning than others (see Appendix 5.7-A). Species such as alcids, seaducks, loons, grebes, certain diving birds, and some pelagic species may be less likely to feed or rest in the immediate area during construction and decommissioning due to increased noise and vessel traffic. Other species of waterbirds such as terns, gulls, loons, and cormorants may be relatively unaffected by these activities and can be expected to continue feeding within a few feet of construction activities, because these species are known to habituate rapidly to human structures/presence and increased vessel presence (Still and Lawrence, 1996; Dirksen et al., 2000). In addition, construction vessels will affect only small portions of the Project area at any one time. Disturbance from construction activities to species such as migrating land birds is expected to be minimal, since these birds would typically be found at altitudes well above the construction activities (higher than 1,400 – 1,500 feet (427-457 meters) as stated above) (Johnson et al., 2000; Kerlinger and Moore, 1989).

Prey Impacts

During construction and decommissioning, disturbances to the seafloor from burying (or removing) the cables and installing (or removing) foundations would cause temporary and localized increases in turbidity and temporary displacement of benthic fauna (see Section 3.4.3.4.6). This could indirectly affect certain diving birds which feed primarily on benthic organisms (e.g., seaducks) by affecting their prey and food availability for a short period of time. While some benthic prey will be temporarily lost, thereby reducing prey availability, the increased availability of injured benthic prey might increase the localized availability of prey items to diving ducks. This impact would be in the immediate vicinity of the construction activity until the water clarity returned to ambient conditions. Certain birds (e.g., terns) may be temporarily impacted by increased suspended solids in the water column, increasing the difficulty of prey species identification (see Appendices 5.7-H and 5.7-I).

Endangered, Threatened, and Other Listed Avian Species

Temporary and localized impacts similar to those mentioned above under disturbance/displacement would be expected for listed avian species. Of the five state- and/or federally-listed species found in the vicinity of the Nantucket Sound Alternative (common loon, roseate tern, common tern, least tern, and piping plover), the common loon, roseate tern, and common tern are the only species that are regular offshore visitors. As stated above, the common loon, a winter resident and migrant, may be disturbed by increased vessel traffic and is less likely than other species to forage in the vicinity of construction activity due to its skittishness.

Common and roseate terns are regularly observed in summer foraging offshore within Nantucket Sound and transit through the area in the late summer and fall during their pre-migratory fall staging (Trull et al., 1999). These tern species are not expected to be impacted by increased vessel traffic, as they are regularly observed in

close proximity to fishing boats while foraging (see Appendices 5.7-H and 5.7-I). These terns may be temporarily impacted by increased TSS in the water column which may increase the difficulty of prey species identification (see Appendices 5.7-H and 5.7-I). However, the increased turbidity in the water column would be limited to the near vicinity of the bottom disturbance and generally last only a short period of time before normal ambient conditions return (see Appendix 5.2-C).

Least terns typically forage close to shore (Thompson et al., 1997) and nest on shore and so are unlikely to be disturbed during construction and decommissioning. Likewise, piping plovers primarily feed in the intertidal zone of, and nest on, coastal beaches (see Appendix 5.7-H) and are unlikely to be disturbed by offshore construction activities.

Operation and Maintenance

Potential avian impacts anticipated during Wind Park operation include disturbance/displacement of birds due to the presence of turbines and associated structures and bird collision with turbine rotors. In general, limited impacts are expected to avian roosting, foraging, and migration activities during Wind Park operation.

Disturbance/Displacement

Potential bird disturbance/displacement from turbine presence, motion, or noise as well as limited "barrier" effects from the presence of lines of turbines which might exclude individuals from certain areas (leading to loss of access to suitable habitat) may affect certain bird species which utilize this alternative location, especially those species that prefer open areas and tend to avoid tall vertical structures such as eiders (Leddy et al., 1999; Tulp et al., 1999). However, barrier effects such as those experienced at the Altamont, CA. wind park (where turbines are spaced as close as 30 feet (9 meters) between adjacent turbine rotors) are not anticipated due to the wide spacing between turbines (0.54 NM (1 km) by 0.34 NM (0.63 km) which allows ample space for unobstructed flight corridors and bird passage.

The Wind Park would present a new structural system to the surface of Nantucket Sound. The presence of new objects such as wind turbine arrays has been found to deter certain birds from entering into areas that would normally be available to them while foraging and migrating (see Appendix 5.7-A). Other species are less likely to be affected by WTG presence and operation. Studies in Europe and in North America found wind turbine arrays had varying effects on birds ranging from reduced nesting activity near turbines and avoidance of turbines by foraging waterfowl, to complete habituation to turbines by some raptors, shorebirds, and other species such as cormorants and terns (Painter et al., 1999; Appendices 5.7-H and 5.7-I; Still and Lawrence, 1996; Appendix 5.7-A).

The presence of the offshore WTG arrays is not expected to directly affect nesting activity, since nesting occurs on shore and the WTG Alternatives are located offshore. Some species of birds that occur in the Project vicinity, such as various species of waterbirds and waterfowl, may avoid or refrain from activity near these structures (Tulp et al., 1999). Avoidance behavior may include ceasing to rest or feed near the WTGs or migrating around them, effectively fragmenting habitat for certain species. Such avoidance behavior (primarily the minimum distance which birds will approach wind generation structures) is likely to vary among species. The European literature reports a variety of turbine avoidance behaviors by seaducks and other species, ranging from no avoidance to ceasing to fly or feed within hundreds of meters of the turbines (Winkelman, 1995). It is likely some seaducks, loons, grebes, alcids, pelagic birds, and other species would not feed or rest within the area beneath or near the turbines. Studies of eiders at a 10 turbine off-shore facility in Denmark found that eiders were reluctant to feed within 328 feet (100 m) of the turbines (Guillemette et al., 1998). The area that would potentially be impacted is the cumulative area within which birds would not fly or forage. This area could vary by species and over time with changes in habituation.

Terns are not expected to be greatly affected by the presence of the WTG array. However, during the period between their arrival in the spring and migration, terns forage and transit offshore in the vicinity of the Nantucket Sound Alternative (Appendices 5.7-H and 5.7-I; Perkins et al., 2003). Those that feed or forage in the vicinity of the WTG array would be expected to continue to have ample areas in which to forage, both within Nantucket Sound and in the Atlantic Ocean. Species such as common loons, seaducks, and grebes should also have ample

area available for foraging outside the Project area and any displacement from foraging or resting areas is expected to be minimal. See Figure 3-46.

Disturbance from the presence of the WTG array to migrating species (songbirds, raptors) is expected to be minimal, since these birds would typically be found at altitudes well above the turbine array (higher than 1,400 – 1,500 feet (427-457 meters) as stated above) (Johnson et al., 2000; Kerlinger and Moore, 1989).

It is possible, but unlikely, that a limited number of birds may refuse to enter the WTG array area. Songbirds and raptors have been found to routinely fly between turbines that are only 100 feet apart in older wind plants, which strongly suggests that birds habituate to these types of structures (Orloff and Flannery, 1992). During a study by Still and Lawrence (1996) at Blyth Harbour, England, eiders, gulls, and cormorants were found to habituate to turbines such that no discernable impacts were observed. It is likely that these birds habituated to the presence of the turbines which were constructed on a jetty (Lowther, 2000).

Collision

Collisions of birds with the WTG structures would not likely be biologically significant, especially when compared to bird-strike fatalities associated with other man-made structures such as windows, office buildings, tall exhaust stack and communication towers, or when compared to legal harvests by hunters. Erickson (2001) has found that bird collisions with wind turbines make up only a fraction of a percent of collisions with man-made structures and the fatalities were spread over more than 50 species of birds. Several attributes of structures contribute to the risk of collision. Clear glass or reflective panels on buildings of any size have been observed to cause collisions. These structures may be camouflaged or otherwise deceptive to birds, even those resident to the vicinity of the structure. Very tall structures such as stacks and communications towers also claim substantial numbers of birds. These taller structures would more likely cause collisions with birds that are migrating at higher altitudes, particularly at night when they are attracted by lights on these structures. The hunting harvest of waterfowl (Martin and Padding 2002) occurs in Nantucket Sound and nearby waters.

Even if many new WTGs are placed in an open area like Nantucket Sound where ESA species such as roseate terns are found, the likelihood of collision related fatalities would still be only a small fraction of that for other land-based man-made structures. Birds that are residents or visitors to the Sound would generally be able to see and avoid turbines during foraging or other flights. Spring or fall landbird (songbirds, shorebirds) migrants would be expected to be at altitudes above the WTG monopoles and the rotor swept zone. Seaducks, alcids, loons, and some others migrating through the area mostly fly within 10-20 m of the water, below the rotor swept area.

The flashing red obstruction warning lighting on the structures will be of the low intensity type that have been observed to be less attractive to birds than those traditionally found on tall communications towers and exhaust stacks. Furthermore, the spacing of the WTG's on Nantucket Sound will be roughly ½ mile by 1/3 mile apart; sufficient space for birds to maneuver around or between the turbines. For these reasons, even 130 turbines in a formerly open area of 25 square miles will not likely to result in the kind of collision numbers at other structures and as such, not likely to result in biologically significant mortality.

Lighting

It is widely understood that some birds, principally night-migrating songbirds, are attracted by certain types of lights, particularly in conditions of poor visibility (i.e. inclement weather). Certain birds become disoriented and fly toward towers, colliding with them and/or the guy wires supporting the structure (Erickson et al., 2001; Biofile, 2004). The proposed WTG lighting does not possess the characteristics that are known to attract birds and includes features recommended by the USFWS in Guidelines for Communications Towers for reducing potential bird collisions on land (USFWS, 2000). As discussed in Section 3.4.3.4.8, proposed lighting (primarily red LED type) would be set to flash at 20 flashes per minute, which is the longest "off" cycle allowed by the FAA and is also in keeping with the USFWS guidelines.

Bright spotlights (or mercury vapor lamps) similar to those used on oil rigs and large ships are not proposed for use on turbine and ESP platforms. These lights can attract several types of birds, including pelagic species like storm-petrels (Montevecchi et al., 2001) that could then be at increased risk of collision. These lights will be turned on only when needed for worker safety, to minimize potential impacts.

Potential Species/Group Specific Impacts

Potential species/group-specific impacts are discussed below for the following birds known to utilize use Nantucket Sound. Much of this data is derived from Appendix 5.7-A:

Oceanic/Pelagic Seabirds. Gannets, storm-petrels, shearwaters, and other seabirds frequent the Nantucket Sound Alternative in varying numbers and times of the year, depending on species. For gannets, the risk period is primarily during migration as they pass through the area and to a lesser degree the winter months when fewer individuals are present. Gannets are also at increased risk while foraging when they dive from high altitudes in pursuit of prey. Storm-petrels, shearwaters, and other pelagic species fly into the area and forage there in summer. However, their risk of collision increases if birds feed in the area for several days or months. It is likely that oceanic/pelagic seabirds actively migrating through the Alternative would avoid flying close to turbines or within the rotor swept area. However, pelagic species like Leach's storm-petrel are known to be attracted by bright lights (Montevecchi et al., 2001) such as those on oil rigs, city parking lots, and stadiums (especially mercury vapor lamps). These types of lights are not proposed for the structures of the Project. Given the proposed lighting scheme for the Project (in general low intensity flashing red lights) (for specific details on lighting see Section 3.4.3.4.8), it is unlikely the species listed above would fly close enough to the turbines to collide with the rotors in biologically significant numbers.

Gulls and Terns. Very small numbers of gulls have been involved in collisions with wind turbines at coastal sites (onshore) in California and Europe, and the risk to these birds has been reported to be small in published and unpublished studies. Gulls are present in the vicinity of the Alternative most of the year. They forage in the area, but more of their activity is within 3 miles of the shore than within the Alternative itself (see Appendices 5.7-F, 5.7-G and 5.7-K). Much of their flight occurs within the height of the rotor swept area. It is likely that if gulls habituate to the turbines (as they do with most other man-made structures), the risk of collision would be expected to decrease.

Results of studies from European wind generation facilities show that terns habituate to the presence of turbines and very few collisions occur, even though a significant number of individuals utilized the area (Painter et al., 1999 and 2002; Everaert et al., 2002). While some collision mortalities to terns may occur, numbers would be very low (too low to measure) and thus are unlikely to affect tern populations (see Appendix 5.7-H and Appendix 5.7-I).

Seaducks, loons and other diving seabirds. There is likely to be some degree of risk to these birds for the following reasons: they are present during nearly one-half of the year, they are present in large numbers, they make daily (sometimes nocturnal) movements to and from feeding areas within or near the Alternative, and their distribution is strongly affected by storms. European studies have found that collisions occurred involving small numbers of eiders ((less than 10 per year) at turbines built along jetties at Blythe Harbor in England (Still and Lawrence, 1996) and among diving ducks situated in saltwater lakes adjacent to the Wadden Sea (Winkelman, 1995). The European studies have also found that seaducks (eiders) avoid turbines and will not go within 328 feet (100 meters) of the structures (Winkelman, 1995 and Guillemette et al., 1998). Wind turbine facilities in North America located in Minnesota (Buffalo Ridge), Iowa (Clear Lake), Wisconsin, and California (Solano County and Altamont) are situated in areas that experience high use by waterfowl, mostly geese and dabbling ducks. At these sites, few waterfowl individuals have collided (fewer than 5 waterfowl at these sites per year) with turbines (Erickson et al, 2001). Though these waterfowl are dabbling ducks and geese, rather than seaducks and divers, they are likely to have similar visual physiology and have similar abilities to detect the presence of turbines.

Cormorants. Double-crested Cormorants have a window of seasonal presence within the Alternative that is approximately less than one-half of the year (typically in the summer months). It is unlikely that large numbers of these birds would spend significant time foraging in the area of the turbines. Great cormorants are present during an even smaller window, mostly in winter. Both species of cormorant are typically found along the coastline, frequently perched on large, man-made structures and spend little time in the vicinity of the Alternative. Perching sites on the turbines, and ESP may increase the risk of collision to these species by providing a means for the bird to frequent the area near the rotors. Perching opportunities are minimized by use of tubular monopole towers and bird deterrent devices which have proven effective on the Cape Wind SMDS and which are anticipated to reduce the risk of collision to these and other species. Cormorant migration over water

occurs mostly within daylight hours and frequently at the height of the rotor swept area. Individuals migrating through the Alternative may have some limited risk of collision .

Shorebirds (Plovers, Sandpipers, and Allies). Studies from the Netherlands – near the coast – have demonstrated that shorebirds can be at risk of colliding with wind turbines during migration stopovers. Collisions did not appear to occur during active migration, but instead were associated with local flights between foraging and resting areas. This type of collision risk does not seem to be applicable to shorebirds over open water in migration or among birds moving across the Sound. There is likely to be little risk to the large numbers of night migrating shorebirds that cross the Sound, as their altitude is generally well above turbine height (higher than 1,400 – 1,500 feet (427-457 meters) as stated above) (Kerlinger, and Moore 1989; Richardson, 1979). Shorebirds making diurnal flights between Monomoy and Nantucket Islands, or among other islands, may fly within the height range of rotors at times, but these birds are likely to see the turbines and avoid them if flying during daylight. In addition, the amount of time that most species of shorebirds spend in the area is restricted to about one-third of the year (May and August/September) limiting the potential collision risk.

Raptors. The number of individual raptors and raptor species that are likely to be present at more than 3 miles (4.8 km) from shore and within the Alternative is very small. Their presence would be most likely to occur during migration (April-May, September-October), for approximately one-third of the year. Individual birds migrating through the area will usually fly through the area only one time per season or per year. The risk during other months is virtually nonexistent, because these species simply will not be present except in rare instances. It has been suggested that raptors are more susceptible to collision with wind turbines than other types of birds (Orloff and Flannery, 1992 and 1996). However, raptor collisions are less likely offshore, because few species of raptors forage over water, especially more than 3 miles (4.8 km) from shore. Osprey and, to a far lesser extent, some falcons (peregrine and Merlin), forage over water, potentially increasing the time they spend in the vicinity of the Alternative. These species typically forage close to the coastline and would therefore not be at substantial risk.

Passerines and Other Landbirds. Night migrating songbirds, for the most part, are likely to fly at altitudes well above the turbine rotors and would not be at substantial risk of collision (Kerlinger and Moore, 1989). Songbirds are likely to be attracted to steady burning lights during poor visibility conditions (i.e., rain, fog, snow, and low ceiling). However, a comparison of lit and unlit wind turbines does not show any attraction differences between the two when using a flashing red FAA (L864) light (Kerlinger, 2004b). Thus, appropriate WTG lighting will be important to reduce the risk of songbird collisions (see Section 3.4.3.4.8). Lighting is the primary factor in collision mortality at communication towers (Erickson et al., 2001). Virtually all communication towers that kill large numbers of birds are greater than 500 feet in height, have guy wires and steady burning red lights (in Trapp, 1998; Kerlinger 2000a; Kerlinger, 2004b). Un-guyed towers (primarily lattice type communication towers) of less than 500 feet (153 m), which are similar to wind turbine towers, with appropriately sensitive lighting pose little threat to migrants (Shire et al, 2000).

Endangered, Threatened, and Other Listed Species. Of the two federally-listed species that are known to frequent the Alternative, only the roseate tern is likely to spend much time in the vicinity of the turbines. The piping plover may fly between Monomoy and Nantucket Islands (or over some portion of the Alternative), but flights are infrequent and mostly direct because neither is adapted for foraging over the open ocean. With respect to state-listed species, the common loon and common tern may be impacted on a limited basis from collision with turbines.

Impacts to Migratory Species

Migratory species (including songbirds and raptors) that use Nantucket Sound as a stopover site for foraging and/or resting may be affected by habitat loss or the need to avoid WTGs during Wind Park operation. Kerlinger (2000b) found that migrating songbirds decreased in numbers after wind park construction at other sites and inferred that migratory songbirds may have elected to avoid wind park structures by flying over or around wind park sites. Migrant collision with wind turbines is not expected to be significant within Nantucket Sound because the majority of migrants fly between 300 and 2,000+ feet (92 and 615+ meters) above the ground; however, the average altitude of most migration over water is slightly higher than over land (which as stated above is averaged to be 1,400 – 1,500 feet (427-457 meters)) (Kerlinger, 1995; Kerlinger and Moore, 1989). Migrants may fly as much as 5 to 10 miles (8 to 16 km) out of their way to avoid wind turbines (Erickson et al., 2001). Therefore, the majority of migrants are expected to fly above or around operating turbines.

South of Tuckernuck Island Alternative

This section describes potential Project impacts to avian resources at the South of Tuckernuck Island Alternative. The habitats and species that occur at this Alternative are relatively similar to those of the Nantucket Sound Alternative, although the South of Tuckernuck Island Alternative may have a somewhat lower species density due to its distance from the mainland and a somewhat higher density of pelagic species (e.g., shearwaters, jaegers, and fulmars). Therefore, the potential impacts of the proposed Wind Park are anticipated to be generally similar to those of the Nantucket Sound Alternative, with the exception of the differences discussed below.

Construction and Decommissioning

Disturbance/Displacement

Potential construction impacts of the proposed Wind Park are anticipated to be generally similar to those of the Nantucket Sound Alternative. A greater number of Project vessels over a longer period of time may be required at the South of Tuckernuck Island Alternative to install the more complex foundations that would be required at this Alternative compared to the other two offshore Alternatives. The only bird species present in large numbers that may be more susceptible to construction activities at the South of Tuckernuck Island Alternative is the long-tailed duck.[58] Activity and noise related to vessel traffic and construction equipment may be more likely to disturb long-tailed duck daily movements and displace them from foraging habitat than that associated with the Nantucket Sound Alternative.

Prey Impacts

Potential bird prey impacts are anticipated to be slightly greater than those of the Nantucket Sound Alternative, given increased area of benthic habitat disturbance due to the more complex foundations that would be required at this Alternative. However, much of the benthic prey will occur on the bottom beyond diving ducks normal depths, and with these greater depths, diving duck abundance is likely to be lower than at the Nantucket Sound Alternative or New Bedford Alternative.

Endangered, Threatened, and Other Listed Avian Species

Potential impacts to common loons would be similar at the South of Tuckernuck Island and Nantucket Sound Alternatives, but there would be fewer common terns and roseate terns during the breeding season at the South of Tuckernuck Island Alternative due to the distance from the main breeding colonies in Buzzards Bay. However, these tern species would be present South of Tuckernuck Island before and after the breeding season and may be disturbed by construction activities.

Least terns and piping plovers nest on Nantucket and/or Tuckernuck Islands to the north, but are unlikely to visit the area, except during migration. Daily foraging and movements between islands occur much less frequently at this Alternative area compared to the other two offshore alternatives.

Operation and Maintenance

Disturbance/Displacement

Potential impacts of the proposed Wind Park operation are anticipated to be generally similar to those of the Nantucket Sound Alternative, however, long-tailed ducks may be somewhat more affected at the South of Tuckernuck Island Alternative for the reasons stated above.

Collision

Collision impacts would also be similar to that of Nantucket Sound, except long-tailed ducks may be at an increased risk during their daily flights to forage in the waters South of Tuckernuck. These ducks have been observed flying over islands in this area at heights similar to the height of the proposed WTGs (see Appendix 5.7-A).

[58] An estimated 800,000+ long-tailed ducks were observed during the 2002 Christmas Bird Counts (CBC) within the Nantucket and Tuckernuck Islands circles. These impacts are not considered significant, because the main destination of these individuals is Nantucket Shoals, due east of the proposed study area (Davis, 1997).

Potential Species/Group Specific Impacts
Potential species/group-specific impacts are discussed below for the following birds known to utilize the water south of Tuckernuck Island:

Oceanic/Pelagic Seabirds. These species are found South of Tuckernuck in larger numbers than at the Nantucket Sound Alternative, increasing their collision potential.

Gulls and Terns. These species are expected to be less likely to collide with turbines South of Tuckernuck than at Nantucket Sound because fewer individuals are expected to utilize the area with its more oceanic conditions

Seaducks, loons and other divers. As discussed above, long-tailed ducks may have an increased risk of collision and therefore may be more prone to collision at South of Tuckernuck than at Nantucket Sound. Other species are probably less likely to be impacted than Nantucket Sound because they are less likely to spend time in this Alternative area.

Cormorants. Cormorants are less likely to collide with turbines South of Tuckernuck than at Nantucket Sound because fewer individuals use the area, except, perhaps, during migration.

Shorebirds (Plovers, Sandpipers, and Allies). Collisions involving these species are less likely South of Tuckernuck than at Nantucket Sound because fewer numbers use the area, except during migration.

Raptors. Impacts from raptor collisions with turbines are expected to be similar to Nantucket Sound at the South of Tuckernuck Island Alternative.

Passerines and Other Landbirds. Impacts from passerine and land bird collisions with turbines are expected to be similar if not slightly lower compared to the Nantucket Sound Alternative and the New Bedford portion of the New Bedford/Horseshoe Shoals Alternative because these species will be flying over this more oceanic Alternative before descending to land.

Endangered, Threatened, and Other Listed Species. These species are less likely to be impacted South of Tuckernuck than at Nantucket Sound because they are less prevalent at South of Tuckernuck.

Lighting
The lighting impacts for all offshore alternatives are the same as those previously discussed for the Nantucket Sound alternative.

Impacts to Migratory Species
Impacts to migratory species are expected to be similar to those discussed for Nantucket Sound.

<u>New Bedford/Horseshoe Shoal Alternative</u>

This section describes potential Project impacts to avian resources at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative. The habitats and species that occur at this Alternative are relatively similar to those of the Nantucket Sound Alternative, although the New Bedford area may have a somewhat higher species density due to its close proximity to the mainland. This Alternative is also utilized by more protected bird species than the other two offshore Alternatives. In addition, waterbirds (e.g., bay ducks, shorebirds) that are rarely found at offshore sites such as Nantucket Sound and South of Tuckernuck Island are common at the New Bedford area. Pelagic species (e.g., shearwaters and storm petrels) are also common at the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative (Office of Coastal Zone Management, 2002). Since the New Bedford sub-site is only one component of the New Bedford/Horseshoe Shoal Alternative, a true assessment of impacts involves the combination of impacts discussed below as well as those discussed above for the Nantucket Sound Alternative.

Construction and Decommissioning

Disturbance/Displacement

Potential construction impacts of the proposed Wind Park are anticipated to be greater in the New Bedford area than at the Nantucket Sound and South of Tuckernuck Island Alternatives, given the increased species diversity and higher number of protected bird species in this area. There are over 50 species that depend on these waters for some part of their life history, not including terrestrial species that migrate short and long distances over the area. Therefore, temporary and localized impacts on avian breeding, nesting, foraging, and migration are anticipated during construction and decommissioning.

Prey Impacts

Potential bird prey impacts are anticipated to be greater than those of the Nantucket Sound and South of Tuckernuck Island Alternatives, given the finer-grained sediments and higher turbidity potential in the New Bedford area. Sediment contamination at this area may mean increased bioaccumulation through bird consumption of benthic prey.

Endangered, Threatened, and Other Listed Avian Species

Impacts to the state-listed and/or federally-listed species are expected to be greater in the New Bedford area, because these species are more common at this area than the other two offshore Alternatives. The New Bedford component of the New Bedford/Horseshoe Shoal Alternative is the closest of the three offshore Alternatives to the primary feeding habitat for the largest roseate tern colonies in the region. There are also large numbers of common terns and piping plovers nesting in the area. Common loons are also found in the area. The only nesting leach's storm petrels in the state nest in close proximity to the Alternative.

Operation and Maintenance

Disturbance/Displacement

Potential impacts of proposed Wind Park operation are anticipated to be greater at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Island Alternatives, given the increased species diversity and higher number of protected bird species in this area. Wind Park operation would likely result in temporary and localized impacts on avian breeding, nesting, foraging, and migration.

Collision

Potential bird collision impacts during Wind Park operation are also anticipated to be greater at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Island Alternatives, given the increased species diversity and higher number of protected bird species in this area.

Potential Species/Group Specific Impacts

Potential species/group-specific impacts are discussed below for the following birds known to utilize the waters of Buzzards Bay near New Bedford:

Oceanic/Pelagic Seabirds. Impacts to these species are expected to be the same or less than those at the Nantucket Sound or South of Tuckernuck Alternatives.

Gulls and Terns. More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound Alternative because the New Bedford area is closer to shore and has higher bird species densities and numbers.

Seaducks, loons and other divers. Impacts to these species are expected to be similar at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative to the Nantucket Sound Alternative and greater than the South of Tuckernuck Alternative because bird numbers are comparable or higher for these species.

Cormorants. More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Alternatives because the New Bedford area is closer to shore and has higher bird species densities and numbers.

Shorebirds (Plovers, Sandpipers, and Allies). More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Alternatives because the New Bedford area is closer to shore and has higher bird species densities and numbers.

Raptors. More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Alternatives because the New Bedford area is closer to shore and has higher bird species densities and numbers. Ospreys tend to forage over the open water at coastal locations. They forage by flying over the open water in search of prey and plunging after the fish once located. This behavior in addition to infrequent short distance migration flights may make them more susceptible to collision with wind turbines. Other raptors that are regularly observed in the area during their seasonal migration include peregrine falcons and merlins.

Passerines and Other Landbirds. More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Alternatives because the New Bedford area is closer to shore and has higher bird species densities and numbers. Some landbirds may be at increased risk as they descend on their approach to land, rest, and forage during their seasonal migration. Also, because of the proposed proximity to land of this area, individuals taking off during migration may be at increased risk of collision while ascending to their cruising altitude.

Endangered, Threatened, and Other Listed Species. More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound or South of Tuckernuck Alternatives because the New Bedford area is utilized by more of these species, and in particular the roseate tern.

Lighting

The lighting impacts for all offshore alternatives are the same as those previously discussed for the Nantucket Sound alternative.

Impacts to Migratory Species

More impacts to these species are expected at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative than at the Nantucket Sound and South of Tuckernuck Alternatives because the New Bedford area is closer to shore, which gives migratory species less time to achieve high altitudes after taking off. Impacts to species that are already aloft are expected to be similar to those for the Nantucket Sound Alternative.

Comparative Summary of Impacts

This section describes potential impacts to avian resources at the four Alternatives under consideration. The New Bedford/ Horseshoe Shoal Alternative includes the resources found at both the New Bedford Harbor and Nantucket Sound Alternatives, and as a result will have the greatest overall impact to avian resources.

Similar types of impacts to avian resources have the potential to occur at all three of the offshore Alternatives. However, the extent of these impacts would vary by site depending on such factors as site-specific avian community composition, proximity of the site to key habitat or high use areas for birds (i.e., known daily movement flyways, migratory corridors), distance to shore, and weather conditions (i.e. fog, mist, low cloud ceilings). Impacts from proposed Project lighting is expected to be the same for all Alternatives.

The New Bedford component of the New Bedford/Horseshoe Shoal Alternative may have a somewhat higher species density due to its close proximity to the mainland. This area is also utilized by more Threatened, Endangered, or other listed bird species than the other two offshore Alternatives. In addition, waterbirds (e.g., bay ducks, shorebirds) that are rarely found at offshore Alternatives such as Nantucket Sound and South of Tuckernuck Island are common at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative.

Pelagic species (e.g., shearwaters and storm petrels) are also common in this area. The New Bedford component of the New Bedford/Horseshoe Shoal Alternative also has the potential for greater impacts to prey species due to finer grained sediments (resulting in increased turbidity during construction) and the potential for bioaccumulation from contaminated sediments.

A greater number of Project vessels over a longer period of time may be required at the South of Tuckernuck Island Alternative to install the more complex foundations that would be required at this Alternative compared to the other two Alternatives. The long-tailed duck, which is more prevalent at the South of Tuckernuck Island Alternative than at the other two offshore Alternatives, may be more affected by construction activities at this Alternative. The South of Tuckernuck Island Alternative may have a somewhat lower species density than the other two offshore Alternatives due to its distance from the mainland but a somewhat higher density of pelagic species (e.g., shearwaters, jaegers, and fulmars), therefore pelagic species are likely to be more affected at this Alternative.

The MMR Alternative was the only terrestrial Alternative evaluated for avian resources and therefore has the greatest potential to affect land birds, including woodland species such as warblers, raptors, and listed grassland species. In total, MMR has more Threatened, Endangered, or other listed species than any of the offshore alternatives.

3.4.3.4.2 Geology and Soils/Sediments

This section describes potential impacts to geology and soils/sediments in the four Alternatives under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Related impacts to upland environmental resources at MMR are discussed in Section 3.4.3.4.7, impacts to groundwater are discussed in Section 3.4.3.4.15, and impacts to benthic resources are discussed in Section 3.4.3.4.6.

Massachusetts Military Reservation

This section describes potential impacts to the geology and soils of the MMR Alternative.

Construction and Decommissioning

Potential impacts to geology and soils at the MMR Alternative during Project construction and decommissioning include vegetation clearing and land disturbance associated with the construction/decommissioning of the towers, installation/removal of inner-array cables, and the clearing of ROWs.

The Wind Park layout calls for a total of 132 towers located along the western and northern portions of the MMR. The footprint of each WTG foundation would occupy approximately 1,830 square feet (0.04 acres (162 m^2)), resulting in a total surface area covered by the foundations of approximately 239,580 square feet (5.5 acres (22,258 m^2)). In addition, the area within a 200-foot (61 m) radius of each WTG would be cleared of trees and shrubs. Clearing the WTG foundation sites and surrounding areas would result in approximately 16,552,800 square feet (380 acres/1,537,860 m^2) of clearing.

Approximately 56 miles (90 km) of inner-array cables would be required to accommodate the project layout. The underground cable network would be constructed in existing cleared ROWs wherever possible. Existing ROWs include transmission and gas line ROWs, and roadways and trails supporting military training activities at MMR. Approximately 42 miles (67 km) of inner-array cables would be installed in existing ROW (which may require some amount of widening), and approximately 14 miles (22.4 km) of new ROW would need to be cleared to a required width of 20 feet (6.1 m) resulting in new clearing of approximately 1,481,100 square feet (34 acres/137,600 m^2). Direct surface disturbance from installation of the cable trenches (maximum 10-feet (3.1 m) wide) along the entire 56 miles (90 km) of ROW would affect approximately 2,962,000 square feet (68 acres/275,196 m^2) of land surface.

Soil disturbance, in addition to vegetation removal, may potentially increase erosion throughout the Project layout. Underground trenching may undermine slope stability in areas with varying (steep) topography. Storm water runoff associated with the addition of impervious surfaces from the towers may also increase erosion

throughout the project layout. Decommissioning the wind farm by removing towers and the cable conduits would result in similar soil disturbances. Soil disturbance during land clearing and restoration would be minimized using appropriate erosion and sedimentation controls.

Contaminated Soils

The MMR was placed on the National Priorities List (NPL) of Superfund sites in 1989, due to previous soil and groundwater contamination by the military. Portions of MMR are under active remediation. Known contaminated sites are generally located south and east of the MMR Alternative, although contaminated groundwater is mapped in the vicinity of the Alternative (Air Force Center for Environmental Excellence, 2004).

An airborne magnetometer survey contour map for the central portion of MMR (Figure 3-52) indicates magnetic material may be present in soils at the adjacent MMR Alternative, particularly along the westernmost portion (Air Force Center for Environmental Excellence, 2004). Fewer magnetic readings were mapped along the northern leg of the MMR Alternative. The highest levels were shown within the center of the MMR, in what is called the Impact Area, outside of the MMR Alternative. As a result, an investigation of soils for unexploded ordnance and other subsurface hazards that may be present in the construction area would be required prior to the start of land disturbing activities. If live ordnance were found, deactivation of these ordnance and site clearance would be required prior to construction.

Also prior to land clearing activities, uncharacterized soils in construction areas would require testing and assessment for contamination. Based on soil testing results, dust control and other measures to limit mobilization of contaminants may be required, as well as special handling and disposal of excavated soils, in accordance with applicable state and federal requirements. Dewatering is not expected to be necessary given the shallow depth of required excavations, the lack of surface water bodies and the depth of groundwater in this upland area.

No bedrock is expected to be encountered during construction or decommissioning, so no blasting is anticipated. Glacial boulders may be encountered, but should be movable with heavy equipment to adjacent areas to allow construction of the Project structures at the planned locations.

Operation and Maintenance

Since exposed soils would be stabilized following construction, operation and maintenance of the Wind Park is not anticipated to adversely affect existing soil or geological conditions at the MMR. Available mapping indicates bedrock is so deep beneath the MMR that it would not be affected by operation or maintenance of the Project. Maintenance activities may cause temporary and localized disturbance to soils, which would be mitigated using erosion and sedimentation controls under an approved Erosion and Sedimentation Control Plan.

Nantucket Sound

This section describes potential impacts to geology and sediments at the Nantucket Sound Alternative.

Construction and Decommissioning

The Nantucket Sound Alternative would contain between 92 and 130 WTGs (depending on which sub-site within Nantucket Sound is considered), all with a monopile foundation design ranging from 16.7 (5.1 m) feet to 18 feet (5.5 m) in diameter. Use of the proposed monopile-type foundation system results in less seabed disturbance than other possible structural alternatives, such as the larger diameter gravity base foundation systems. This design would result in a maximum area of seabed occupation of 29,467 square feet (0.68 acres/2,752 m^2) from the WTG monopiles. Additional seabed would be occupied by 6 scour control mats (at 16.5 by 8.2 feet (5 by 2.5 m) each) to be placed around each of the monopile foundations. This is consistent at all the offshore Alternatives.

The pile foundation system proposed for this shallow water Alternative will likely be installed by mechanical hammer driving, thereby minimizing seabed disturbance and turbidity associated with other types of foundations, such as gravity base or drilled foundation installations. The majority of sediments dispersed during foundation installation are anticipated to settle within the immediate vicinity of the foundations. In addition, because the

monopiles are hollow and open-ended, subsurface sediments will be enclosed within the monopile, providing additional structural support and minimizing disturbance of sediments from installation activities. Installation of the monopile foundations will not require excavation or backfill of bottom sediments.

The maximum area of seabed occupation from the scour mats would be 105,300 square feet. (2.4 acres/9,713 m^2) for a total of approximately 135,000 square feet (3.1 acres/12,546 m^2) of permanent seabed occupation from 130 WTG monopiles and associated scour mats. The six 42-inch (107 cm) diameter ESP foundation pilings and 6 scour mats associated with each piling results in permanent seabed occupation of approximately 4,920 square feet. (0.11 acres/445 m^2). An approximate total of 139,920 square feet (3.21 acres/12,991 m^2) of seabed would be occupied by Project structures, including the WTG monopiles, ESP foundations and associated scour mats.

Sediment suspension related to anchoring, winching, and spudding activities associated with construction of the WTGs is anticipated to be short-term and localized. Scour mats will be installed around the WTGs and ESP following monopile foundation installation and will remain in place during inner array cable installation and during operation. As discussed in Section 4.0 and the scour analysis in Appendix 4.0-A, the artificial fronds on the scour mats are designed to slow water velocity at the seabed, allowing suspended sediments to settle on the mats, thereby eliminating local scour around each structure. The effectiveness of the scour control will be monitored by periodic diver inspection during construction.

A demonstration project involving the installation of two test scour mats around one of three piles supporting the SMDS was initiated in October of 2003 to evaluate the effectiveness of the artificial frond scour mat to prevent scour. Ocean and Coastal Consultants Inc. (OCC) conducted inspection of the scour mats around the SMDS pile on June 13, 2004. Visual inspection indicated that the scour mats are functioning as anticipated with an accumulation of approximately 0.82 feet (0.25 meters) of sand in various areas of the mats. The other two unprotected piles show scouring of up to approximately 2 feet (0.61 meters).

Temporary direct impacts to surface sediments would result from installation of the inner-array cables and anchoring activities associated with construction. The lengths of inner-array cabling required for the Nantucket Sound sub-sites range from 46-81 miles (73.6-129.6 km) and the expected maximum trench width of surface disturbance is 6 feet (1.8 m), plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons. This results in a temporary direct area of surface sediment disturbance from inner-array cable installation of 2,914,560 square feet to 5,132,160 square feet (67-118 acres (271,149 to 477,546 m^2)).

For the Nantucket Sound Alternative, the combined total temporary impacts to seafloor sediments from anchoring associated with the installation of the turbine towers, equipment, blades, the ESP platform, inner-array cable connection, and the scour protection mats is expected to be approximately 19,140,160 square feet (440 acres/1,780,680 m^2).

Trenching technology is described in Section 4.0. In brief, a skid/pontoon-mounted jet plow will be towed by the cable-laying barge. The jet plow blade is lowered onto the seabed, pump systems are initiated to fluidize sediments as the jet plow progresses along the pre-selected marine cable route, creating a trench approximately 4 to 6 feet wide (1.2 to 1.8 m) (top width) to a depth of 8 feet (2.4 m) below present bottom in order to insure a minimum of 6 feet of cover for the cable system. The cable system then settles into the trench through its own weight. One pass of the jet plow is expected to install each segment of the inner array cables.

In sandy sediments, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). Therefore, sediment resuspension associated with construction activities is expected to be temporary and localized due to the predominance of sands in this area, which settle more readily to the bottom than do finer-grained sediments. Resuspended sediments are expected to settle back to the sea floor within a short period of time (generally minutes to less than one hour at any fixed location). Given the dynamic environment, natural processes are anticipated to rapidly restore seabed topography following completion of construction.

Bedrock is not expected to be encountered within the maximum 85-foot (26 m) depth planned for WTG installation, so no blasting is anticipated. Intermittent cobbles and boulders may be present at depth, which may be movable with conventional offshore construction equipment. Subsurface boulders that may be encountered

would either be captured within the monopile or deflected during pile driving (depending upon size). If an obstruction is encountered, the monopile will be offset to an adjacent location within the immediate vicinity which would not significantly affect the overall grid spacing.

Project decommissioning is expected to result in temporary and localized impacts to sediments similar to or less than those described for construction. Decommissioning for the WTGs and the associated cables is essentially the reverse of the installation process with the exception that no pile driving would occur. The entire WTG will be removed with the monopile being cut off at the seabed followed by the removal of the sediments from the inside of the monopile to a depth of approximately 6.5 feet (2.0 meters). Once the sediments have been removed, the remaining monopile would be cut off at a depth of approximately 6.5 feet (2.0 meters) below the surface. The temporary void left in the seabed would infill as a result of the sandy side slopes and natural processes.For more details on Project decommissioning please refer to Section 4.5.

Operation and Maintenance

Once constructed, operation of the Wind Park should pose little or no adverse impact to geology or sediments. Limited scour is likely at the seabed-monopile interface around each WTG during Project operation. Artificial frond mats would be installed around each WTG to provide scour control. A network of scour control mats is proposed, which would stabilize the bottom by trapping sediments. This approach is considered more effective in the sandy bottom environment of Nantucket Sound than traditional boulder revetment. Scour control will be monitored by periodic post-construction diver inspection as discussed above.

Given the dynamic sedimentary environment across the shoals, natural processes are anticipated to rapidly restore seabed topography following completion of construction. Migration of sand waves across the shoals should not be substantially affected by the presence of the WTGs, which would be widely spaced (minimum of 2,066 feet (629 meters) between WTG edges) and have highly localized connections to the seabed. Maintenance activities, as described in Section 4.0, may cause temporary and localized disturbance to sediments. It is anticipated that the uncovering of the submarine cables due to natural processes is unlikely due to the minimum 6-foot burial depth and will be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables will be reburied.

South of Tuckernuck Island

This section describes potential impacts to geology and sediments at the South of Tuckernuck Alternative.

Construction and Decommissioning

The South of Tuckernuck Island Alternative would contain 130 WTGs, with 37 WTGs supported by a monopile foundation design ranging from 16.7 feet to 19 feet (5.1 to 5.8 m) in diameter and 93 WTGs supported by a quad-caisson foundation design (4 caissons per WTG, each with a diameter of 24.6 feet/7.5 m). The majority of the WTGs would be designed with the larger diameter quad caissons because of the design requirements for the greater water depths at this Alternative.

Foundation designs for this deeper water Alternative results in a maximum area of seabed occupation of 186,322 square feet (4.3 acres/17,402 m^2) from the WTG quad caissons and monopiles. As a result of the larger diameter quad caissons required as foundations at this Alternative, seabed occupation would be approximately six times greater than what would be anticipated at the other offshore Alternatives. Additional seabed would be occupied by scour control mats (a total of 331,100 square feet/7.6 acres/30,757 m^2) placed around each of the WTG foundations. More scour control mats would be required at the South of Tuckernuck Alternative compared to the other offshore Alternatives due to the greater number of caisson and monopile foundation supports at this Site.

Temporary direct impacts to seabed would result from installation of the inner-array cables and anchoring activities associated with construction. The length of inner-array cabling required for the South of Tuckernuck Island Alternative would be approximately 85.5 miles (137 km), and the expected maximum width of disturbance is anticipated to be 6 feet (1.8 m) plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons.

For the South of Tuckernuck Island Alternative, the combined total temporary impacts to seafloor sediments from anchoring associated with the installation of the pilings, interconnecting supports of the quad-caisson, the turbines, blades, connecting the inner-array cable to the WTG, and other equipment along with the construction of the ESP platform and installation of the scour control mats would be approximately 74,702,240 square feet (1,715 acres/6,940,605 m^2).

In sandy sediments, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). Therefore, sediment re-suspension associated with construction activities will be temporary and localized due to the predominance of sands in this area which settle more readily to the bottom than do finer-grained sediments. Re-suspended sand-sized sediments are expected to settle back to the sea floor within a short period of time (see Appendix 5.2-C). Given the dynamic environment, natural processes are anticipated to rapidly restore seabed topography following completion of construction. However, the greater number of foundation supports with larger diameters required for this Alternative would likely take longer to construct and affect a greater area of seabed than at the other Alternatives. Due to the distance from Nantucket, as well as the Project's proposed construction and scour control techniques, no erosion is anticipated along the Nantucket shoreline, as described below under Section 3.4.3.4.3.

Given the significant depth to bedrock encountered in a borehole advanced on Nantucket Island (approximately 1,500 feet (458 m)) (Oldale, Revision 2001), it is unlikely that bedrock would be penetrated during installation of the WTGs at this Alternative, so no blasting is anticipated. Intermittent cobbles and boulders may be present at depth, which may be movable with conventional offshore construction equipment. Subsurface boulders that may be encountered would either be captured within the monopile or deflected during pile driving (depending upon size). If an obstruction is encountered, the foundation will be offset to an adjacent location within the immediate vicinity which would not significantly affect the overall grid spacing.

Project decommissioning is expected to result in temporary and localized impacts to sediments similar to or less than those described for construction.

Operation and Maintenance

Once constructed, operation of the Wind Park should pose little or no adverse impact to geology or sediments. Limited scour is likely at the seabed-foundation interface around each WTG during Project operation, and will be monitored by periodic inspections. More scour control mats will be required at this Alternative than at other offshore Alternatives, due to the greater number of caisson and monopile foundation supports and the strong currents through Muskeget Channel. Artificial frond mats would be installed around each WTG to provide scour control. A network of scour control mats is proposed, which would stabilize the bottom by trapping sediments. This approach is more consistent with the sandy bottom environment of Nantucket Sound than traditional boulder revetment.

Given the dynamic sedimentary environment across the shoals, natural processes are anticipated to rapidly restore seabed topography following completion of construction. Migration of sand waves across the shoals should not be substantially affected by the presence of the WTGs, which would be widely spaced and have highly localized connections to the seabed. Maintenance activities may cause temporary and localized disturbance to sediments.

New Bedford / Horseshoe Shoal

This section describes potential impacts to geology and sediments at the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative.

Construction and Decommissioning

The New Bedford/Horseshoe Shoal Alternative would contain 139 WTGs, all with a monopile foundation design ranging from 16.7 feet to 18 feet (5.1 to 5.5 m) in diameter.

The foundation design for this Alternative results in a maximum area of seabed occupation of 31,580 square feet (0.72 acres/2.914 m^2) from the WTG monopiles. An additional 117,450 square feet (2.7 acres/10,927 m^2) of seabed would be occupied by scour control mats to be placed around each of the monopile foundations.

Temporary direct impacts to the seabed would result from installation of the inner-array cables and anchoring activities associated with construction. The length of inner-array cabling required for the New Bedford/Horseshoe Shoal Alternative is 84.1 miles (135 km), and the expected maximum width of surface disturbance is 6 feet (1.8 m) plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons.

For the New Bedford/Horseshoe Shoal Alternative, the combined total temporary impacts to seafloor sediments from anchoring associated with the installation of the pilings, the turbines, blades, scour control mats, connecting the inner-array cables to the WTG, and other equipment along with the construction of the ESP platform would be approximately 20,465,248 square feet (470 acres/1,902,090 m^2).

Sediments at this Alternative contain more fine sands, silts and clays than the other offshore Alternatives under consideration. These sediments also contain contaminants from historic industrial discharge into New Bedford Harbor and the sewage outfall at Clark's Point. The New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative is within the Outer Harbor Operable Unit of the 18,000-acre (72.54 km^2) New Bedford Harbor Superfund Site, designated in 1982 (see Figure 3-26). The Superfund site contains sediments contaminated primarily by metals and organic compounds, including PCBs (MCZM, 2002). These characteristics, coupled with the proximity of fish spawning grounds and shellfish beds (see Sections 3.4.3.4.5 and 3.4.3.4.6), raise concerns about the mobilization of these sediments during construction and decommissioning.

Relatively shallow bedrock may be present within portions of this Alternative layout. Rock drilling (or blasting) may be required to install the WTGs in areas of shallow bedrock, which would disturb sediment and biological communities in the area. Blasting would be minimized through use of blasting mats and other mitigation measures. A possible north-south trending bedrock fault is indicated just east of the New Bedford Sub-site on the Bedrock Geologic Map of Massachusetts (Zen, 1983). Two small earthquakes (estimated as 3.0 to 3.8 on the Richter scale) have occurred within ten miles (16 km) of the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative, though no epicenters were reported within the layout itself (USGS, February 2001).

Project decommissioning is expected to result in temporary and localized impacts to sediments similar to or less than those described for construction.

Operation and Maintenance

Once constructed, operation of the Wind Park should pose little or no adverse impact to geology or sediments. Limited scour is likely at the seabed-monopile interface around each WTG during Project operation. Artificial frond mats would be installed around each WTG to provide scour control. A network of scour control mats is proposed, which would stabilize the bottom by trapping sediments. Maintenance activities may cause temporary and localized disturbance to sediments as discussed above and in Appendix 5.2-C.

Comparative Summary of Impacts

The MMR Alternative is the only upland Alternative included in the alternatives analysis and, as such, differs from the offshore Alternatives in terms of its composition of glacially-deposited material. Soils at the MMR Alternative contain a variety of materials deposited during military training exercises. Some of these materials (including unexploded ordnance or residual contamination) will require specialized handling and disposal of soils at this Alternative.

The MMR Alternative and the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative are located within (MMR) and nearby (New Bedford) Superfund sites, although available information indicates that these Alternatives are located outside of the most contaminated portions of the Superfund sites (Air Force Center for Environmental Excellence, 2004; USEPA, 2003). Disturbance of marine sediments at the New Bedford Harbor

area would likely create more water column turbidity than at the other offshore Alternatives, as the New Bedford area contains more silts and fine-grained particles than the Nantucket Sound and South of Tuckernuck Alternatives. (This may have a minor potential for pollutant transport and exposure at the New Bedford Harbor area, as the higher proportions of fine sands and silts of New Bedford Harbor have become contaminated by numerous releases of pollutants that remain bound to Harbor sediments). The sandier sediments of the Nantucket Sound Alternative and the South of Tuckernuck Island Alternative are expected to be of good quality, due to the relative lack of contamination sources in the vicinity, indicating a lower risk of contaminated sediment suspension and transport at these Alternatives as compared to the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative.

The New Bedford portion of the New Bedford/Horseshoe Shoal Alternative has more rock outcrops than the other Alternatives given its harbor location and the relative thin mantle of glacially deposited sediments. Therefore, the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative may require more blasting and seabed/sediment disturbance than the other offshore Alternatives. An inferred north-south trending bedrock fault is indicated just east of the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative on the Bedrock Geologic Map of Massachusetts (Zen, 1983). The map shows onshore delineations only, with this fault indicated (by dashed line) as continuing to trend offshore, although unequivocal field confirmation is lacking (Zen, 1983). No other faults are indicated in the vicinity of the other Alternatives.

As discussed in Sections 3.4.3.4.2 and 3.4.3.4.6, temporary and localized sediment disturbance from construction vessel anchoring, anchor line sweep, and scour protection is anticipated during construction. The extent of these temporary impacts would be somewhat different for each offshore Alternative due to differences in length of cable, foundation systems, and scour protection required. The anticipated anchoring and scour protection impact for the Nantucket Sound Alternative is similar to that of New Bedford/Horseshoe Shoal Alternative and approximately one-quarter of that anticipated for the South of Tuckernuck Island Alternative. The South of Tuckernuck Island Alternative would result in more seabed impacts than the other Alternatives under consideration, due to its location in relatively deep water, which requires larger foundation supports for the WTGs. Table 3-51. provides temporary and permanent impacts in acres associated with the Wind Park at the three offshore Alternatives.

A historical compilation of earthquakes between 1638 and 1998 (USGS, February 2001) indicates no earthquakes measuring (or estimated) above 3.0 on the Richter Scale have occurred in the vicinity of the MMR Alternative, and the offshore Nantucket Sound and South of Tuckernuck Island Alternatives.

Two small earthquakes (estimated as magnitude 3.0 to 3.8 on the Richter scale) have occurred within ten miles of the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, though no epicenters were reported within the layout itself (USGS, February 2001).

Project structures will be designed, constructed, operated and maintained in accordance with applicable seismic provisions in the Uniform Buildings Codes and engineering standards, as appropriate for the selected Alternative. All Alternatives under consideration are located within the same Seismic Zone 2A, which encompasses all of southern New England and eastern New York (Uniform Building Code, 1997).

3.4.3.4.3 Oceanography

This section describes potential effects to water depth, wave conditions, and currents at the three offshore Alternatives under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Due to the similarities of potential impacts to oceanography during periods of both construction/decommissioning and operations/maintenance, the Project's potential impacts are presented in a consolidated format below.

As described in Section 3.4.3.2.3, water depth and tide/current data were gathered from available NOAA sources relative to each Alternative. Wind speed data were gathered from MTC/True Winds maps. Wave conditions for

the offshore Alternatives were characterized by using USACE Wave Information Study (WIS) wave hindcasting and extremal analysis data[59] for a variety of return periods.

Massachusetts Military Reservation

The MMR Alternative is located at an upland location. Therefore, no review of oceanographic resources is applicable.

Nantucket Sound, South of Tuckernuck Island and New Bedford / Horseshoe Shoal

Bathymetry

For each offshore Alternative, seabed elevations in the vicinity of the WTG's and inner-array cable will be modified slightly as a result of sediment displacement. Changes in seabed elevation would naturally occur through sediment transport in the absence of the WTGs. Any changes in seabed elevation occurring around each WTG will be limited to localized scour. A grouping of seabed scour control mats will be installed and anchored below the seabed to mitigate scour at each WTG. These mats are composed of artificial fronds designed to reduce the particle velocity at the seabed, allowing suspended sediments to settle on the mats as a result of decreased velocity. Analysis of this type of viscous drag frond system has shown it to eliminate scour conditions immediately upon installation.[60] Therefore, effects to bathymetry immediately around the WTGs are expected to be negligible and shoreline erosion will not be effected.

A slight depression (estimated to be between 0.5 to 2 feet/.15 to .6 m deep) is anticipated to result from installation of the inner-array cables. This slight depression is expected to fill in over time through natural sediment re-suspension, deposition, and consolidation.

Waves

Due to the proposed spacing of the WTGs (0.34 nautical miles from north to south, and 0.54 nautical miles from east to west), the Project would not be expected to have substantial impacts to wave conditions at any of the offshore Alternatives. At the smaller scale, a pile's influence on wave propagation in the immediate vicinity of each WTG depends on the ratio between the diameter of the pile and the wavelength of the incident wave. Piles with diameters less than one-tenth of the incident wavelength do not have an impact on waves since they pass the pile without reflection or diffraction. Piles with diameters greater than one-tenth of the incident wavelength do have an impact on incident waves in that they are reflected by the pile and diffracted around the pile. So, as wavelength increases, the effect the pile has on wave propagation decreases.

The Nantucket Sound and New Bedford/Horseshoe Shoal Alternatives exist in relatively sheltered waters in which the majority of waves are locally generated. Modeling of locally wind-generated waves indicated that these waves typically have wave periods between 2 and 4 seconds and thus have relatively short wave lengths (approximately 20 to 70 feet/6.1 to 21.4 m).[61] The South of Tuckernuck Island Alternative lies in the Atlantic Ocean and will be exposed to longer period waves. It is also possible that longer period waves enter Nantucket Sound and New Bedford Harbor area from the Atlantic Ocean. The average wave height of offshore waves approaching from easterly through southerly directions was determined from the Atlantic Ocean using NOAA WIS hindcast wave data.[62] The average height for these offshore waves is 4.5 feet (1.4 m) and the average wave period is 8 seconds. Thus, the average wavelength of these ocean waves is approximately 160 feet (49 m).

The proposed diameter of monopiles that would be used for WTGs at the Nantucket Sound and the New Bedford/Horseshoe Shoal Alternatives is 16.7 and 18 feet (5.1 and 5.5 m) respectively. The South of Tuckernuck Island Alternative would utilize four types of foundation designs: three different diameter monopiles (16.7 feet, 18 feet, and 19 feet/5.1, 5.5, and 5.8 m) and a quad-caisson, which consists of four separate piles, each 24.6 feet (7.5 m) in diameter (see Figure 3-45). Each of these pile diameters is greater than one-tenth the average locally-generated and ocean wavelengths. Thus, small-scale deflection and refraction of locally-generated and ocean waves would be expected to occur in the immediate vicinity of each WTG location. There may be

[59] http://www.frf.usace.army.mil/wis/
[60] Nantucket Sound Scour Analysis, January 16, 2003, Appendix 4.0-A.
[61] Woods Hole Group wave period modeling, 2002 and 2003.
[62] Woods Hole Group wave height modeling, 2002 and 2003.

somewhat more wave reflection and/or diffraction in the immediate vicinity of the WTGs located in the South of Tuckernuck Island Alternative than at the other two offshore Alternatives as a result of the need for grouped-pile foundation systems at the South of Tuckernuck Island Alternative. However, these effects are expected to be localized to the area immediately adjacent to each pile and not expected to change the overall wave climate at the offshore Alternatives.

Currents
Due to proposed wide spacing between the WTGs, the Project is not expected to have large-scale impacts to tidal or wind-driven currents at the offshore Alternatives. Small eddies may develop in the immediate vicinity of the WTGs, but these are expected to dissipate a short distance from the WTGs. Please refer to Appendices 4.0-A, 5.2-A and 5.2-B for more details.

Comparative Summary of Impacts

Effects on seabed elevations are expected to be similar for the three offshore Alternatives. These effects are expected to be localized and temporary. There may be somewhat more wave reflection and/or diffraction in the immediate vicinity of the WTGs located in the South of Tuckernuck Island Alternative than at the other two offshore Alternatives as a result of the need for grouped-pile foundation systems (quad-caisson) at the South of Tuckernuck Island Alternative.

Due to the proposed wide spacing between the WTGs, the Project is not expected to have large-scale impacts to tidal or wind-driven currents at any of the offshore Alternatives. Small eddies may develop in the immediate vicinity of the WTGs, but these are expected to dissipate a short distance from the WTGs.

3.4.3.4.4 Protected Marine Species

This section describes potential impacts to protected marine species at the three offshore Alternatives under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Based on consultation with the NMFS, the same marine species are evaluated for each of the three offshore Alternatives, as discussed in Section 3.4.3.2.4 and the sections below. These include three federally-listed endangered species of cetaceans, three federally-listed endangered or threatened species of marine reptiles, and the gray seal, a state-listed Species of Special Concern. Other marine mammal species protected under the Marine Mammal Protection Act (MMPA) that may occur in the area, including the harbor seal, are also discussed. Potential Project-related impacts to these species are discussed below.

Impacts Common to All Offshore Alternatives

The extent of impacts to marine mammals and sea turtles are anticipated to be similar for each offshore Alternative, but may vary somewhat based on site-specific Wind Park design requirements, the number of vessels required, the duration of construction activities, site-specific sediment and oceanographic characteristics, and the proximity of Project activities to high use areas for protected marine species. A discussion of impacts to protected marine species relevant to all Alternatives is presented in this section. A discussion of potential impacts specific to each of the Alternatives is presented in the site-specific sections below.

Construction/Decommissioning

Potential impacts to protected marine species (marine mammals and sea turtles) during Project construction and decommissioning include acoustical impacts from pile driving (or removal) and Project vessels, impacts related to vessel traffic, impacts related to elevated TSS concentrations, and marine mammal prey impacts and bioaccumulation. These impacts are anticipated to be localized and temporary.

Acoustical Impacts
Project construction, and to a lesser extent decommissioning, would generate localized and temporary underwater sound that has the potential to affect marine mammals or sea turtles if they are present in the Project area during these activities. The maximum submarine sound generated during construction at any of the Alternatives would occur during installation of the WTG foundations (see Section 3.4.3.4.14). Based on

simulations of maximum underwater sound expected to be generated by pile-driving activities, acoustical impacts to marine mammals or sea turtles are expected to be below the NMFS established 180 dBL threshold level for preventing injury or harassment to marine mammals and sea turtles beyond a 500 meter Initial Safety Radius[63] (Kurkul, 2002). Therefore, acoustical disturbances during construction are not anticipated to cause physical harm to marine mammals or sea turtles at any of the Alternatives. Project vessels would produce sound that can be detected by marine mammals and sea turtles, but these sounds would be too weak to cause physical harm to these species. If marine mammals or sea turtles are present in any one of the Alternatives during construction, they may react to short-term acoustic disturbances from pile-driving or Project vessels by avoiding or moving away from the sound source.

Vessel Traffic Impacts

Potential impacts related to vessel traffic in relation to marine mammals and sea turtles include harassment or vessel collisions with these species. Evidence from whale watching and fishing activities in Massachusetts waters indicates that humpback whales, fin whales, and seals readily acclimate to the presence of large or small motor vessels (Watkins, 1986) and that there is no evidence of long-term effects to these marine mammals due to the physical disturbance of motor vessels. Westerberg (1999) reported that gray seals rapidly habituated to construction activities at the Näsrevet Wind Farm in Sweden, only showing alarm when vessels moved within hundreds of meters of the seals. Sea turtles do not appear to be overly disturbed by the physical presence or sound produced by vessels, and may simply dive when approached by a vessel (NMFS, 2002). If marine mammals or sea turtles are present at any of the Alternatives during construction or decommissioning activities, they may exhibit avoidance behavior in response to Project-related vessel traffic.

The risk of marine mammal and sea turtle collisions with Project-related vessels is extremely low. Documented occurrences of marine mammal and sea turtle collisions indicate that these collisions occur primarily with large, fast moving vessels such as container ships, tankers, or military vessels (George *et al.*, 1994; NMFS, 2002; Kraus 1990; Laist et al., 2001). Vessels moving at slower speeds (less than 14 knots/16 miles per hour), such as the construction vessels that would work on the Project, are less likely to cause collisions (Laist et al., 2001) and can be avoided by most marine mammals and sea turtles. The extent of these impacts would vary by Alternative depending on the number of vessels required, the duration of construction or decommissioning, and the proximity of vessel routes to high use areas for protected marine species (see site-specific discussion below).

Suspended Sediment Effects

Temporary impacts to marine mammals or sea turtles from localized elevated TSS concentrations associated with WTG foundation and inner-array cable installation are expected to be minimal. The extent of these impacts will be similar for each Alternative, but are expected to vary based on site-specific design requirements, duration of construction activities, site-specific sediment and oceanographic characteristics, and the proximity of Project activities to high use areas for protected marine species. For more information on suspended sediments please refer to Section 5.2.4.

Prey Impacts and Bioaccumulation

Prey mortality and/or displacement and bioaccumulation from consuming contaminated prey are possible during Project construction and decommissioning. Prey organisms of marine mammals and sea turtles in the Project area may be temporarily affected by underwater sound generated during construction and by construction activities. Submarine anthropogenic sound may cause temporary and localized displacement of finfish, but is unlikely to cause displacement of benthic invertebrates or pelagic prey (i.e*.,* plankton) of marine mammals. Similarly, invertebrate prey items of sea turtles such as jellyfish are also unlikely to be affected by submarine sound. Benthic habitat loss would also be minimal (see Section 3.4.3.4.6). Feeding opportunities may increase in certain situations such as cable installation, when benthic prey are injured and become more vulnerable to predators.

[63] The 1,640–foot (500-meter) safety radius is based on a condition in the USACE Permit granted to the Applicant for construction and operation of the Scientific Measurement Devices Station (SMDS) [Permit No. 199902477]. The condition requires that sound level monitoring during pile driving procedures be conducted at an initial safety zone radius of 500 meters to determine compliance with the 180-dBL NMFS threshold. A similar safety radius was established by NOAA Fisheries for pile installation at the San Francisco-Oakland Bay Bridge [SRS Technologies. 2004. San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. Revised Marine Mammal Monitoring Plan.] [Illingworth & Rodkin, Inc. 2001. Pile Installation Demonstration Project Construction Report. *In:* San Francisco-Oakland Bay Bridge East Span Seismic Safety Project.]

Marine mammals and sea turtles bioaccumulate contaminants from their ocean environment almost exclusively through their food sources. Potential impacts to marine mammals and sea turtles from bioaccumulation of contaminated prey at a particular site are expected to be minimal; however, the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative has documented sediment contamination (see Section 3.4.3.2.2) and therefore poses a greater bioaccumulation risk to protected marine species compared to the other Alternatives that have no evidence of contamination.

Operation/Maintenance

Acoustical Impacts

During Wind Park operation/maintenance, marine mammals and sea turtles are not anticipated to experience substantial impacts from vibrations/underwater sound generated by the WTGs. The extent of acoustical impact is governed by both the underwater sound to be generated by the operating WTGs and the existing baseline underwater sound conditions in the area. As discussed in Section 3.4.3.4.14, the underwater operational sound generated by the WTGs is expected to be the same at all of the Alternatives under the design wind condition. In addition, based on ocean current, wind, surface waves and vessel traffic characteristics at each of the offshore Alternatives, Tech Environmental (2004) concluded that the baseline underwater sound conditions at each of the Alternatives are expected to be similar. Therefore, the baseline underwater sound measurements used in the acoustic analysis at the Nantucket Sound Alternative would be a reasonable estimate of baseline sound levels at the other two offshore Alternatives. These acoustic model simulations suggest that the predicted sound level from operation of an offshore WTG would only be slightly above baseline sound levels (1.9 dBL above baseline), and total sound levels are predicted to fall to baseline levels within approximately 360 feet (110 m) of the sound source. In addition, since the WTGs would be spaced at much greater distances than 360 feet (110 m) (approximately 2,066 to 3,281 feet/629 to 1,000 m apart), no cumulative impacts from operation of the WTGs would be expected.

Vessel Traffic Impacts

Impacts related to vessel traffic during operation (potential for harassment or vessel strikes) would be similar to those discussed in the construction/decommissioning section above. However, while the construction period will involve multiple vessels on a daily basis, operational vessel traffic will typically consist of one to three vessels.

EMF/Thermal Emissions

No impacts to marine mammals or sea turtles are expected at any of the Alternatives from EMF/thermal emissions emitted by inner-array cables (see Section 3.4.3.4.16).

Prey Impacts

Indirect impacts related to the shift in the habitat from a non-structure-oriented to structure-oriented system and WTG foundations acting as fish aggregating devices are not expected to be substantial (see Section 3.4.3.4.5) due to the wide spacing between monopiles and the relatively small amount of new hard surface area being introduced into the overall offshore area. Although potential fish aggregations around WTG foundations could provide a new prey base for marine mammals, particularly seals, finfish production and marine mammal populations are not expected to increase greatly in the Project area due solely to the presence of the WTG foundations.

Massachusetts Military Reservation

The MMR Alternative is located in an upland environment. Therefore, no review of protected marine species impacts is applicable.

Nantucket Sound

This section describes site-specific factors that may affect protected marine species at the Nantucket Sound Alternative.

Construction/Decommissioning

Acoustical Impacts

As discussed previously, acoustical disturbances during construction are not anticipated to cause physical harm to marine mammals or sea turtles. Marine mammals or sea turtles in the Project vicinity during construction activities may react to short-term acoustic disturbances from pile-driving or Project vessel traffic by avoiding or moving away from the sound source. The Nantucket Sound Alternative is not in close proximity to areas where historically high sightings of whales have occurred and does not appear to be an important area for whales (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data). Although sea turtles are known to occur in Nantucket Sound, as discussed above, they are not expected to be affected by short-term acoustical disturbances during construction or decommissioning since maximum underwater sound is expected to be below the NMFS threshold level for preventing injury or harassment to marine mammals and sea turtles beyond a 500 meter Initial Safety Radius.

The Horseshoe Shoal sub-site is located greater than 7 nautical miles from seal haul-out and breeding sites, reducing the likelihood of acoustic impact to seals. The Monomoy and Tuckernuck sub-sites within Nantucket Sound are, however, closer to seal haul-out and breeding sites on Monomoy Island, Tuckernuck Island, and Muskeget Island (USFWS, 2001; Waring, 2001). Therefore, construction and decommissioning activities have a greater chance of disturbing seals at these sub-sites compared to Horseshoe Shoal.

Vessel Traffic Impacts

Construction vessel routes to and from the Nantucket Sound Alternative would not occur in areas where there have been high concentrations of whale sightings (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data), reducing the potential for harassment/disturbance or vessel strikes. Although sea turtles and seals are known to occur in Nantucket Sound, they do not appear to be overly disturbed by the presence of vessels and can typically avoid slower moving vessels such as those which would be associated with Project construction (Vella 2001; NMFS, 2002; NMFS, 2001). As discussed above, potential impacts to seals related to vessel traffic are likely to be less of an issue at the Horseshoe Shoal sub-site than the Monomoy and Tuckernuck sub-sites, which are closer to seal haul-out and breeding sites (USFWS, 2001; Waring, 2001). In general, behaviors exhibited by marine mammals or sea turtles in response to Project vessels would likely be no different than avoidance behaviors observed in response to normal pleasure boat use, ferry traffic, or commercial fishing activity that occurs in Nantucket Sound.

Suspended Sediment Effects

Due to the predominance of fine- to coarse-grained sand in Nantucket Sound, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation and removal is expected to be temporary and localized to the area immediately surrounding the monopiles or inner-array cables. In addition, Nantucket Sound is a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters; therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment on an irregular basis and should not be substantially impacted by a temporary increase in turbidity as a result of Project construction or decommissioning. Since Nantucket Sound sediments are predominately sand and there is no evidence of high concentrations of pollutants in these sediments, marine mammals or sea turtles that may forage in the area are not expected to be at risk from bioaccumulation of potential contaminants in prey items.

Operation/Maintenance

Since the Nantucket Sound Alternative is not in an area of highly abundant protected species, operational impacts are similar to those described above as common to all the Alternatives.

South of Tuckernuck Island

This section describes site-specific factors that may affect protected marine species at the South of Tuckernuck Island Alternative.

Construction/Decommissioning

Acoustical Impacts

Although there have been more recorded sightings of whales, primarily Northern Atlantic right whales (see Figure 3 in Appendix 3-G based on NMFS NEFSC sightings data), in the vicinity of the South of Tuckernuck Island Alternative compared to the other two offshore Alternatives, for the reasons mentioned above, acoustical disturbances during Project construction and decommissioning are not anticipated to cause physical harm to marine mammals or sea turtles. The South of Tuckernuck Island Alternative is located closer to the Muskeget Island gray seal breeding colony and harbor seal haul out sites on Tuckernuck, Muskeget, and Skiff Islands compared to Horseshoe Shoal and New Bedford Harbor (USFWS, 2001; Waring, 2001; Crocker, 2004). Therefore, there may be a greater potential for acoustical disturbance impacts to seals at this Alternative compared to the other Alternatives. In addition, due to the greater number of foundation supports with larger diameters and the greater distance that this Alternative is located offshore, the South of Tuckernuck Island Alternative may require a longer construction timeframe, thereby resulting in greater (longer duration) acoustical impacts during construction and decommissioning compared to the other offshore Alternatives.

Vessel Traffic Impacts

Potential vessel routes to and from the South of Tuckernuck Island Alternative cross an area where there have been higher concentrations of whale sightings compared to the other Alternatives (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data), increasing the potential for whale harassment/disturbance or vessel strikes. Although sea turtles and seals are known to occur in the vicinity of this Alternative, these animals do not appear to be overly disturbed by the presence of vessels and can typically avoid slower moving vessels such as those which would be associated with Project construction (Vella 2001; NMFS, 2002; NMFS, 2001). Project vessel routes for the South of Tuckernuck Alternative would be fairly close to seal haul-out and breeding sites on Tuckernuck, Muskeget, and Skiff Islands (USFWS, 2001; Waring, 2001; Crocker, 2004), potentially posing a greater risk of disturbance impact to these species compared to the other Alternatives. In addition, a greater number of Project vessels may be required to install the more complex foundations at this Alternative compared to the other two Alternatives. In addition, vessel travel distances are the greatest for the South of Tuckernuck Island Alternative, assuming ports in Barnstable County are used.

Suspended Sediment Effects

The South of Tuckernuck Island Alternative is dominated by sand-sized particles; therefore, localized elevated TSS concentrations associated with WTG foundation and inner-array cable installation or removal is expected to be temporary and localized to the area immediately surrounding the WTG foundations or inner-array cables. However, since there are a greater number of foundation supports with larger diameters required for this Alternative, the construction duration may be longer, potentially resulting in greater impacts from sediment disturbance. Since the sediments at the South of Tuckernuck Alternative are dominated by sand, and there is no evidence of high concentrations of pollutants in these sediments, marine mammals or sea turtles that may forage in the area are not expected to be at risk from bioaccumulation of potential contaminants in prey items.

Prey Impacts

There is a potential for greater impact to prey species at the South of Tuckernuck Island Alternative compared to the other Alternatives given the greater potential benthic habitat disturbance at this Alternative and anticipated longer construction duration. In addition, the deeper areas of this Alternative (those with depths greater than 75 feet/22.9 m) would likely be characterized by benthic organisms prevalent in stable substrates, since there would be fewer disturbances due to wave energy not reaching the bottom in these areas; therefore, these organisms may not be as adapted to shifts in turbidity or sedimentation during jetting as those found in the other sites.

Operation/Maintenance

As previously discussed, acoustical simulations suggest that impacts to protected marine species from vibrations or underwater sound generated by the WTGs during operation are expected to be minimal. Due to the wide spacing of the WTGs, no cumulative impacts are expected. Impacts related to vessel traffic during operation (potential for harassment/disturbance or vessel strikes) are expected to be greater than the Nantucket Sound Alternative because of the proximity to higher abundance areas for whales and seals and the longer travel distance.

The greater number of individual foundation supports required at this Alternative (372 individual caisson supports and 37 monopile foundations) would introduce more structure into a non-structure oriented environment compared to the two other offshore Alternatives. This could potentially result in a greater impact to finfish community assemblages in the area and would provide a greater surface area for potential fish aggregations. Therefore, this Alternative may attract more seals and other marine mammals than the other two Alternatives by offering a greater prey base. Even with this additional structure, the spacing between each WTG would be similar to the other two offshore Alternatives and therefore is not expected to affect the overall environment, finfish species composition, or populations of foraging marine mammals in the area.

New Bedford / Horseshoe Shoal

This section describes site-specific factors that may affect protected marine species at the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative. The Horseshoe Shoal portion of this Alternative is discussed under the Nantucket Sound section above.

Construction/Decommissioning

Acoustical Impacts

As the New Bedford Harbor area is not considered a high-use habitat for whales (Buzzards Bay Project National Estuary Program, 1991; Howes and Goehringer, 1996), and for the reasons mentioned above, acoustical disturbances during construction are not anticipated to cause physical harm to marine mammals or sea turtles. Although sea turtles, primarily the leatherback, have the potential to occur in the New Bedford portion of this Alternative, as discussed above, they are not expected to be overly affected by short-term acoustical disturbances during construction or decommissioning since maximum underwater sound is expected to be below the NMFS 180 dBA threshold level for preventing injury or harassment to marine mammals and sea turtles beyond a 500 meter Initial Safety Radius. There are numerous harbor seal haul-out sites, as well as several sites for gray seals, located in outer portions of Buzzards Bay along the Elizabeth Islands (Crocker, 2004); however, these areas are located from 5.7 to 10 miles (9.1 to 16 km) south of the Alternative in New Bedford Harbor. Therefore, individual seals that may swim near the Alternative could experience some disturbance and will likely exhibit avoidance behavior during construction activity, but acoustical disturbances are unlikely to interfere with seal behavior at seal haul-out locations.

Vessel Traffic Impacts

Potential vessel routes to and from the New Bedford Harbor portion of this Alternative would not cross areas where there have been high concentrations of whale sightings (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data), reducing the potential for whale harassment/disturbance or vessel strikes. Although sea turtles and seals are known to occur in the New Bedford Harbor area, they do not appear to be disturbed by the presence of vessels and can typically avoid slower moving vessels such as those which would be associated with Project construction (Vella 2001; NMFS, 2002; NMFS, 2001). Project vessels transiting to the New Bedford portion of this Alternative may traverse close to some of the seal haul-out sites along the Elizabeth Islands, potentially disturbing seals at these sites. In general, behaviors exhibited by marine mammals or sea turtles in response to Project operation would likely be no different than avoidance behaviors observed in response to normal pleasure boat use or commercial fishing activity that occurs in the area. In addition, the vessel activity associated with the Project will represent a fraction of the vessel activity associated with the commercial port in New Bedford and the Cape Cod Canal.

Suspended Sediment and Sediment Quality Effects

The New Bedford portion of this Alternative is reported to be dominated by fine sands, silts, and clays (see Section 3.4.3.2.2). In those areas dominated by sand, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation or removal would be expected to be temporary and localized to the area immediately surrounding the monopiles or inner-array cables. However, in areas with greater silt or clay content, elevated TSS concentrations could occur over a wider area for a longer period of time. There is evidence of some chemical contamination in the sediments in New Bedford Harbor and portions of Buzzards Bay (see Section 3.4.3.2.2). Therefore, disturbance of sediments during construction and decommissioning activities in these areas has the potential to make these contaminants more bioavailable to

marine mammals or sea turtles that may forage in the area. Protected marine species therefore may be at an increased risk for bioaccumulation of these contaminants in prey items from the Project area compared to the other Alternatives.

Operation/Maintenance

As previously discussed, acoustical simulations suggest that impacts to protected marine species from vibrations or underwater sound generated by the WTGs during operation are expected to be minimal. Due to the wide spacing of the WTGs, no cumulative impacts are expected. Impacts related to vessel traffic during operation (potential for harassment/disturbance or vessel strikes) are expected to be the same as those discussed in the construction/decommissioning section above.

Comparative Summary of Impacts

This section describes potential impacts to protected marine species at the three offshore Alternatives under consideration. The New Bedford/Horseshoe Shoal Combination Alternative includes the resources found at both the New Bedford Harbor and Nantucket Sound areas.

Similar impacts to federally-endangered or threatened whale and sea turtle species, state-protected seal species, and other federally protected marine mammals have the potential to occur at all three of the offshore Alternatives. However, the extent of these impacts would vary depending on the proximity of the Alternative to key habitat or high use areas for protected marine species or due to differences in construction or operational methodologies. The Horseshoe Shoal sub-sites and the New Bedford Harbor area are not located in close proximity to historical sightings of whales (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data) or to seal haul-out and breeding sites (USFWS, 2001; Waring, 2001; Crocker, 2004). The Monomoy and Tuckernuck Shoal sub-sites are in closer proximity to seal haul-out and breeding sites. The South of Tuckernuck Island Alternative is closer to sensitive areas for protected marine species (Appendix 3-G; USFWS, 2001; Waring, 2001). Impacts associated with the New Bedford/Horseshoe Shoal Alternative are associated with the cumulative activities involved in constructing and operating WTGs at both locations.

The South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to protected marine species compared to the other two offshore Alternatives since there have been more recorded sightings of whales South of Tuckernuck Island (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data), it is located closer to breeding and haul out sites for seals (USFWS, 2001; Waring, 2001), and the Alternative would likely require a longer construction timeframe. Acoustical disturbances during construction or decommissioning are expected to be similar at the Nantucket Sound and New Bedford/Horseshoe Shoal Alternatives.

Impacts from Project vessels are not expected to be substantial at any of the Alternatives; however, there are some characteristics of each Alternative that may increase the potential for vessel harassment or collisions with marine protected species. Vessel routes for the Nantucket Sound Alternative and the New Bedford/Horseshoe Shoal Alternative are not located in close proximity to historical sightings of whales (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data). However, potential vessel routes to and from the South of Tuckernuck Island Alternative cross an area where there have been higher concentrations of whale sightings compared to the other Alternatives (see Figures 1-3 in Appendix 3-G based on NMFS shipboard and aerial sightings data), increasing the potential for whale harassment/disturbance or vessel strikes.

Although sea turtles and seals are known to occur in the vicinity of all of the Alternatives, these animals do not appear to be overly disturbed by the presence of vessels and can typically avoid slower moving vessels such as those which would be associated with Project construction (Vella 2001; NMFS, 2002; NMFS, 2001). Seals, however, are more disturbed when approached at their breeding or haul-out sites. Project vessel routes for the Horseshoe Shoal sub-site are not located in close proximity to seal haul-out or breeding sites (USFWS, 2001; Waring, 2001); whereas the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative and the South of Tuckernuck Island Alternative have the potential to operate closer to seal haul-out sites. In New Bedford, vessel traffic could operate close to seal haul-out sites on the Elizabeth Islands (Crocker, 2004) and at the South of Tuckernuck Alternative, vessel traffic would operate fairly close to seal haul-out and breeding sites on

Tuckernuck, Muskeget, and Skiff Islands (USFWS, 2001; Waring, 2001; Crocker, 2004), potentially posing a greater risk of disturbance impact to these species compared to the other Alternatives. In addition, a greater number of Project vessels may be required to install the more complex foundations at the South of Tuckernuck Alternative compared to the other two Alternatives.

Potential impacts from temporarily elevated levels of TSS would be temporary and localized at all Alternatives; however, due to the silt/clay sediments at the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, elevated TSS levels have the potential to occur over a wider area for a longer period of time compared to the Nantucket Sound and South of Tuckernuck Island Alternatives. In addition, the New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative contains some areas of contaminated sediments (see Section 3.4.3.2.2) and therefore poses a greater bioaccumulation risk to marine protected species compared to the other offshore Alternatives, which have no evidence of contamination.

The South of Tuckernuck Island Alternative requires a greater number of foundation supports and therefore introduces more structure into a non-structure oriented environment and a greater surface area for potential fish aggregations compared to the other Alternatives. Therefore, the South of Tuckernuck Island Alternative may have more potential to attract seals or other marine mammals by offering a new prey base. However, due to the spacing between WTGs, the new additional structure is not expected to affect the overall environment, finfish species composition, or populations of foraging marine mammals in the area.

There is a potential for greater impact to prey species at the South of Tuckernuck Island Alternative compared to the other Alternatives given the greater potential benthic habitat disturbance at this Alternative and anticipated longer construction duration.

3.4.3.4.5 Fisheries

This section describes potential impacts to finfish resources, Essential Fish Habitat (EFH), commercial fisheries, and recreational fisheries in the three offshore Alternatives under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal.

A qualitative review of finfish resources consisting of a summary of the key species and resources documented to occur at each of the three offshore Alternatives is presented in Section 3.4.3.2.5. At all three of the offshore Alternatives, limited impacts to finfish and finfish habitat from construction, operation/maintenance, and decommissioning of the proposed Wind Park may occur. A discussion of potential impacts to finfish relevant to all Alternatives is presented first. A discussion of potential impacts specific to each of the Alternatives is presented in the site-specific sections below.

Impacts Common to All Offshore Alternative

Construction/Decommissioning

Potential impacts to finfish resources, including EFH, during construction and decommissioning of the Wind Park include: habitat loss and alteration, localized finfish displacement/mortality, temporary impacts related to elevated TSS concentrations such as localized elevated turbidity levels and contaminant bioaccumulation in finfish prey, temporary acoustical impacts, and general disturbance from project vessels. The extent of these impacts will be similar for each offshore Alternative, but may vary somewhat based on site design, duration of construction activities, site-specific sediment and oceanographic characteristics, and number of vessels required as discussed below.

Habitat Impacts and Alteration

Installation of WTG foundations would result in benthic habitat occupation at each of the offshore Alternatives. The extent of benthic habitat occupation would vary by site based on site design. (Refer to Section 3.4.3.4.6).

The installation of WTG foundations and inner-array cables at each of the offshore Alternatives would physically displace sediment at specific locations. Installation of inner-array cables by jet plow embedment would result in temporary impacts to finfish habitat through sediment suspension, transport, and deposition. As with other

projects involving submarine cable embedment in the seabed using jet plow technology in sandy sediments, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). In most cases, demersal finfish would be able to find suitable benthic habitat adjacent to the Project area until construction/decommissioning activities were completed.

As discussed in Sections 3.4.3.4.2 and 3.4.3.4.6, temporary and localized sediment disturbance from construction vessel anchoring, anchor line sweep, and scour protection is anticipated. The extent of these temporary impacts would be somewhat different for each offshore Alternative due to differences in length of cable, foundation systems, and scour protection required. The anticipated anchoring and scour protection impact for the Nantucket Sound Alternative is similar to that of New Bedford/Horseshoe Shoal Alternative and approximately one-quarter of that anticipated for the South of Tuckernuck Island Alternative.

For the Nantucket Sound Alternative, the combined total temporary impact from anchoring associated with the installation of the turbine towers, equipment, blades, the ESP platform, inner-array cable connection, and the scour protection mats is expected to be approximately 19,140,160 square feet (440 acres (1,780,680 m^2)).

For the South of Tuckernuck Island Alternative, the combined total temporary impact from anchoring associated with the installation of the pilings, interconnecting supports of the quad-caisson foundations, the turbines, blades, connecting the inner-array cable to the WTG, and other equipment along with the construction of the ESP platform and installation of the scour control mats would be approximately 74,702,240 square feet (1,715 acres (6,940,605 m^2)).

For the New Bedford/Horseshoe Shoal Alternative, the combined total temporary impact from anchoring associated with the installation of the pilings, the turbines, blades, scour control mats, connecting the inner-array cables to the WTG, and other equipment along with the construction of the ESP platform would be approximately 20,465,248 square feet (470 acres (1,902,090 m^2)). Please refer to Table 3-51 for more information on temporary and permanent impacts.

Finfish Displacement/Mortality

The construction and decommissioning methodologies for WTG foundations and inner-array cable installation are not expected to cause mortality to adult or juvenile finfish, since these life stages are highly mobile and capable of avoiding disturbances typically associated with activities such as jet plow embedment and pile-driving. Therefore, displacement of finfish is expected to be temporary and localized. The temporary impacts to finfish that may occur from localized elevated TSS concentrations associated with WTG foundation and inner-array cable installation are expected to be minimal. Demersal eggs and larvae of finfish are more at risk from direct burial (and mortality) during construction and decommissioning because they have limited mobility. Therefore, these life stages will experience some adverse effects if construction or decommissioning occurs during spawning periods.

Finfish Prey Displacement/Mortality

Indirect impacts during Project construction or decommissioning may include limited prey displacement/mortality or avoidance behaviors that lead to short-term use of sub-optimal habitats that reduce foraging success. Some benthic habitat loss and mortality to benthic organisms (i.e., prey of finfish) is expected. However, these impacts to benthic resources are expected to be temporary and localized, as many benthic invertebrates are capable of opportunistically recolonizing after seabed disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads *et al.,* 1978; Howes *et al.,* 1997).

Acoustical Impacts

Temporary acoustical impacts from pile-driving (or removal) and underwater sound from Project vessels would occur at each of the Alternatives which typically triggers finfish avoidance mechanisms without damaging fish sensory organs. Based on simulations of maximum underwater sound expected to be generated by pile-driving activities, sound levels are expected to be below levels that would cause permanent damage to finfish. Therefore, acoustical impacts to finfish are expected to be temporary and localized.

General Disturbance from Project Vessels
Potential impacts to finfish from the presence of construction vessels are expected to be minimal, with finfish in the Project area displaying temporary avoidance behaviors to vessels similar to behavioral responses exhibited in response to the commercial and recreational vessels that regularly cross these areas.

Commercial and Recreational Fishing
Impacts to fishing activities associated with Project construction and decommissioning would be temporary and localized. Once the Wind Park becomes operational, fishing could resume as normal. Some bottom-dragging trawlers would have to maneuver around towers, but the wide tower spacing (0.34 to 0.54 nautical miles/0.63 to 1.0 km apart) of these monopile structures allows for such maneuverability. As discussed above, the WTG and ESP foundations are expected to act as fish aggregating devices, increasing fish concentrations locally around these structures and improving recreational fishing opportunities, as has been the case in other regions where offshore structures have been installed (MMS, 2004).

Operation/Maintenance

Habitat Modification/Occupation
Longer-term impacts to finfish resources that could occur during operation at each of the offshore Alternatives include the shift in habitat type from a non-structure oriented to structure-oriented system and WTG foundations acting as fish aggregating devices. Similarly, potential impacts could occur after decommissioning and removal of these structures when the habitat shifts back to a non-structure oriented system and the WTG foundations are removed and can no longer serve as fish aggregating devices. In general, habitat and finfish species compositions are not anticipated to change substantially after Wind Park installation due to the burial of the cables and the wide spacing of the WTGs.

Acoustical Impacts
During Wind Park operation, finfish resources, including EFH, could experience minimal impacts from vibrations/underwater sound generated by the WTGs and temporary impacts related to maintenance vessel traffic. Underwater sound modeling simulations suggest that impacts to finfish from WTG operation will be minimal or non-existent (see Section 3.4.3.4.14).

General Disturbance from Project Vessels
Potential impacts to finfish from the presence of maintenance vessels are expected to be minimal, with finfish displaying the same type of temporary avoidance behavior as exhibited to the commercial and recreational vessels that regularly cross these areas.

EMF and Shading
No impacts to finfish are expected at any of the Alternatives from EMF/thermal emissions emitted by inner-array cables (see Section 3.4.3.4.16) or from the minimal shading effect from the ESP. The use of three-conductor cables, rather than a flat arrangement of single conductor cables in separate trenches, minimizes the spacing between phases, which in turn reduces the magnetic field strength. While a burial depth of 4 feet (1.2 m) is typically specified by USACE Guidelines (USACE-NED Regulation No. 1110-1-9 (October 18, 1995) for this type of submarine cable installation, the design choice of 6-foot (1.8 m) burial reduces the magnetic field strength on the sea floor to about 45% of what it would be with a 4-foot (1.2 m) deep cable (see Appendix 5.13-A).. Therefore, impacts from EMF have been minimized, and no adverse impacts to finfish or other marine organisms that cue into the earth's geomagnetic field are expected to occur from EMF along the cable routes.[64]

Commercial and Recreational Fishing
Operation of the Wind Park is not anticipated to have substantial impacts to commercial fishing activities at any of the Alternatives, because there would be no restriction on fishing activities, the WTGs are spaced at sufficient distances (0.34 nautical miles by 0.54 nautical miles apart) to allow vessel maneuverability between and around the WTGs, and the inner-array cables will be buried to a minimum of 6 feet (1.8 m) below the seabed. Cable burial would minimize the potential for anchor dragging or entanglement with fishing gear. It is anticipated that

[64] Special sense organs, such as "compass-needle" type receptor for steady magnetic fields, are known to exist for some animals, including elasmobranch fishes (Kirschvink et al., 2001), but such a receptor would not be affected by power line, 60-Hz magnetic fields, which alternate in direction, and average to zero over 1/60th of a second (Adair, 1994; Valberg et al., 1997)

the uncovering of the submarine cables due to natural processes is unlikely due to the minimum 6-foot burial depth and will be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables will be reburied. For the same reasons, recreational fishing activities should not be adversely affected. In addition, the presence of the WTG foundations may enhance recreational fishing for certain species of finfish most likely to benefit from artificial structures such as those with demersal, philopatric, territorial, and reef-obligate life histories (Bohnsack, 1989) such as Atlantic cod, black sea bass, and scup.

Massachusetts Military Reservation

The MMR Alternative is located in an upland environment and does not affect freshwater ponds or other waterbodies containing fish. Therefore, no review of fisheries impacts is applicable to this Alternative.

Nantucket Sound

General impacts relevant to all of the offshore Alternatives are discussed above. This section focuses on site-specific factors that may affect the magnitude of these impacts at the Nantucket Sound Alternative. As discussed in Section 3.4.3.2.5, Nantucket Sound supports a variety of finfish species including migratory and resident species. In addition, Nantucket Sound has designated EFH for 22 federally-managed species (52 life stages).

Habitat Impacts and Alteration

The Nantucket Sound Alternative would contain between 92 and 130 WTGs (depending on which sub-site within Nantucket Sound is considered), all with a monopile foundation design ranging from 16.7 feet (5.1 m) to 18 feet (5.5 m) in diameter. This design results in a maximum area of benthic habitat occupation of 29,467 square feet (0.68 acres (2,752 m^2)) from the WTG monopiles. Additional benthic habitat would be occupied by scour control mats to be placed around each of the monopile foundations.

Temporary Sediment and Benthic Habitat Disturbance

Temporary direct impacts to benthic habitat would result from installation of the inner-array cables and anchoring activities associated with construction. The length of inner-array cabling required for the Nantucket Sound Alternative ranges from 46-81 miles (74 to 130 km) and the expected maximum width of disturbance is 6 feet (1.8 m), plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons. This results in a temporary direct area of benthic habitat disturbance from inner-array cable installation of 2,788,000 to 5,018,000 square feet (64 to 115 acres (259,008 to 465,405 m^2)). Additional temporary disturbances from anchoring associated with inner-array cable installation and monopile installation will also occur.

These temporary benthic habitat disturbances are not expected to substantially interfere with finfish in the area. Since benthic habitat is similar throughout Nantucket Sound, finfish in the area will likely be able to find suitable benthic habitat adjacent to the Project area or in other areas of the Sound during construction or decommissioning activities. Finfish would be expected to rapidly return to these areas once construction in a specific area is complete. Project decommissioning is expected to result in temporary and localized impacts to finfish similar to or less than those described for construction.

Suspended Sediment Effects

Due to the predominance of fine to coarse-grained sand in Nantucket Sound, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the monopiles or inner-array cables. In addition, Nantucket Sound is a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters; therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment on an irregular basis and should not be substantially impacted by a temporary increase in turbidity as a result of Project construction or decommissioning. However, demersal eggs and larvae of finfish are more at risk from direct burial (and mortality) during construction and decommissioning because they have limited mobility. Therefore, these life stages will experience some adverse effects if construction or decommissioning occurs during spawning periods.

Finfish are not expected to be at risk from bioaccumulation of potential contaminants in prey items from the Project area since Nantucket Sound sediments are predominately sand and there is no evidence of pollutants in these sediments.

South of Tuckernuck Island

General impacts relevant to all the offshore Alternatives are discussed above. This section focuses on site-specific factors that may affect the magnitude of these impacts at the South of Tuckernuck Island Alternative. As discussed in Section 3.4.3.2.5, the South of Tuckernuck Island area supports a variety of finfish species including migratory and resident species and may have a greater number of fish species that typically occur in deeper, cooler waters compared to the other offshore Alternatives. In addition, the South of Tuckernuck Island site has designated EFH for 32 federally-managed species (86 life stages), the most EFH designations of the three offshore Alternatives.

Habitat Impacts and Alteration

The South of Tuckernuck Island Alternative would contain 130 WTGs, with 37 WTGs supported by a monopile foundation design ranging from 16.7 feet (5.1 m) to 19 feet (5.8 m) in diameter and 93 WTGs supported by a quad-caisson foundation design (4 caissons per WTG, each with a diameter of 24.6 feet (7.5 m). The majority of the WTGs would be designed with the larger diameter quad caissons because of the design requirements for the greater water depths at this Alternative. This design results in a maximum area of benthic habitat occupation of 186,322 square feet (4.3 acres (17,310 m^2)) from the WTG quad caissons and monopiles. As a result of the larger diameter quad caissons required as foundations at this Alternative, benthic habitat occupation would be approximately six times greater than what would be anticipated at the other offshore Alternatives. Additional benthic habitat would be occupied by scour control mats to be placed around each of the WTG foundations. More scour control mats would be required at the South of Tuckernuck Alternative compared to the other offshore Alternatives due to the greater number of caisson and monopile foundation supports at this Alternative.

The greater number of individual foundation supports required at this Alternative (372 individual caisson supports and 37 monopile foundations) would introduce more structure into a non-structure oriented environment compared to the two other offshore Alternatives. This could potentially result in a greater impact to finfish community assemblages in the area and provides greater surface area for potential use as fish aggregating devices. However, the spacing between each WTG is similar to the other two offshore Alternatives and therefore is not expected to affect the overall environment or finfish species composition in the area.

Temporary Sediment and Benthic Habitat Disturbance

Temporary direct impacts to benthic habitat utilized by finfish would result from installation of the inner-array cables and anchoring activities associated with construction. The length of inner-array cabling required for the South of Tuckernuck Island Alternative would be approximately 85.5 miles (137 km), and the expected maximum width of disturbance is anticipated to be 6 feet (1.8 m) plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons. This results in a temporary direct area of benthic habitat disturbance from inner-array cable installation of 5,296,896 square feet (122 acres (493,734 m^2)). Additional temporary disturbances from anchoring associated with inner-array cable installation and WTG foundation installation will also occur and are expected to be greater than the anchoring impacts at the other Alternatives due to the greater number of individual components comprising the quad-caisson foundation designs.

These temporary benthic habitat disturbances are not expected to substantially interfere with finfish in the area. It is likely that finfish will be able to find suitable benthic habitat adjacent to the Project area or in other nearby areas during construction or decommissioning activities. Finfish would be expected to rapidly return to these areas once construction in a specific area is complete. Project decommissioning is expected to result in temporary and localized impacts to finfish similar to or less than those described for construction.

Suspended Sediment Effects

The South of Tuckernuck Island Alternative is dominated by sand-sized particles; therefore, localized elevated TSS concentrations associated with WTG foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the WTG foundations or inner-array cables. However, demersal eggs and larvae of finfish are more at risk from direct burial (and mortality) during

construction and decommissioning because they have limited mobility. Therefore, these life stages will experience some adverse effects if construction or decommissioning occurs during spawning periods. Since there are a greater number of foundation supports with larger diameters required for this Alternative, construction may take longer, resulting in greater impacts from sediment disturbance. The deeper areas of this Alternative (those with depths greater than 75 feet) would likely be characterized by organisms prevalent in stable substrates (some of which are prey for finfish), since there would be fewer disturbances due to wave energy not reaching the bottom in these areas; therefore, these organisms may not be as adapted to shifts in turbidity as those found in Nantucket Sound.

Finfish are not expected to be at risk from bioaccumulation of potential contaminants in prey items from the Project area since the sediments at the South of Tuckernuck Alternative are dominated by sand and there is no evidence of high concentrations of pollutants in these sediments.

Acoustical Impacts
Since construction may take longer at the South of Tuckernuck Island Alternative for the reasons outlined above, acoustical impacts will be of longer duration during construction and decommissioning compared to the other offshore Alternatives.

General Disturbance from Project Vessels
A greater number of Project vessels may be required to install the more complex foundations compared to the other two Alternatives. During construction, decommissioning, and operation, finfish are expected to display avoidance behavior to Project vessels. This Alternative is removed from heavily navigated waters, as most larger vessels travel by way of the Main Channel in Nantucket Sound to the north, which provides an inside passage to vessels avoiding Nantucket Shoals. Therefore, finfish in this area may not be as accustomed to vessel traffic as at the other Alternatives.

New Bedford / Horseshoe Shoal

General impacts relevant to all the offshore Alternatives are discussed above. This section focuses on site-specific factors that may affect the magnitude of these impacts for the New Bedford/Horseshoe Shoal Alternative. As discussed in Section 3.4.3.2.5, this Alternative supports a variety of finfish species including migratory and resident species in both the New Bedford and Horseshoe Shoal portions of the Alternative. The New Bedford Harbor portion of this Alternative is closer to spawning grounds utilized by several anadromous fish species such as American shad, striped bass, and alewives than the other two offshore Alternatives. Therefore, there may be greater impacts to these species at this Alternative compared to the other Alternatives if construction or decommissioning activities take place during seasonal migrations of these species. In addition, the New Bedford/Horseshoe Shoal Alternative has designated EFH for 26 federally-managed species (70 life stages) , which is less than the number of EFH designations for the South of Tuckernuck Island Alternative but more than for the Nantucket Sound Alternative.

Habitat Modification/Occupation
The New Bedford/Horseshoe Shoal Alternative would contain 139 WTGs, all with a monopile foundation design ranging from 16.7 feet (5.1 m) to 18 feet (5.5 m) in diameter. This design results in a maximum area of benthic habitat occupation of 31,580 square feet (.72 acres (2,914 m^2)) from the WTG monopiles. Additional benthic habitat would be occupied by scour control mats to be placed around each of the monopile foundations.

Temporary Sediment and Benthic Habitat Disturbance
Temporary direct impacts to benthic habitat utilized by finfish would result from installation of the inner-array cables and anchoring activities associated with construction. The length of inner-array cabling required for the New Bedford/Horseshoe Shoal Alternative is 84.1 miles (135 km), and the expected maximum width of disturbance is 6 feet (1.8 m) plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons. This results in a temporary direct area of benthic habitat disturbance from inner-array cable installation of 5,296,896 square feet (122 acres (493,734 m^2)). Additional temporary disturbances from anchoring associated with inner-array cable installation and monopile installation would also occur

These temporary benthic habitat disturbances are not expected to substantially interfere with finfish in the area. It is likely that finfish will be able to find suitable benthic habitat adjacent to the Project area or in other nearby areas in Buzzards Bay during construction or decommissioning activities. Finfish would be expected to rapidly return to these areas once construction in a specific area is complete. Greater impacts could be experienced by migrating anadromous fish species if construction or decommissioning activities present a temporary barrier or change the behavior of these species during migration to their upstream spawning areas. Project decommissioning is expected to result in temporary and localized impacts to finfish similar to or less than those described for construction.

Suspended Sediment Effects

The New Bedford portion of this Alternative is reported to be dominated by fine sands, silts, and clays. In those areas dominated by sand, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the monopiles or inner-array cables. However, in areas with greater silt or clay content, elevated TSS concentrations could occur over a wider area for a longer period of time. Demersal eggs and larvae of finfish are more at risk from direct burial (and mortality) during construction and decommissioning in both sand and silt/clay sediments because they have limited mobility. Therefore, these life stages will experience some adverse effects if construction or decommissioning occurs during spawning periods. There is evidence of chemical contamination in the sediments in New Bedford Harbor and portions of Buzzards Bay (see Section 3.4.3.2.2). Therefore, disturbance of sediments during construction and decommissioning activities in these areas has the potential to make these contaminants more bioavailable to finfish and may increase the potential for finfish to bioaccumulate these contaminants through consumption of affected prey items in the Project area.

Comparative Summary of Impacts

Similar impacts to finfish resources, EFH, commercial fisheries, and recreational fisheries have the potential to occur at all three of the offshore Alternatives. However, some of the Alternatives would have greater impacts to these species due to site-specific habitat conditions or differences in construction or operational methodologies. The New Bedford/ Horseshoe Shoal Alternative includes the resources found at both the New Bedford Harbor and Nantucket Sound Alternatives. Operation of the Wind Park is not anticipated to have substantial impacts to commercial fishing activities at any of the Alternatives, because there would be no restriction on fishing activities, the WTGs are spaced at sufficient distances (0.34 nautical miles by 0.54 nautical miles apart) to allow vessel maneuverability between and around the WTGs, and the inner-array cables will be buried to a minimum of 6 feet (1.8 m) below the seabed. Cable burial would minimize the potential for anchor dragging or entanglement with commercial fishing gear. Recreational fishing activities should not be adversely affected at any of the offshore alternatives, and are likely to experience an increase in fish concentrations locally around the structures resulting in improved recreational fishing opportunities.

The South of Tuckernuck Island Alternative would require a greater number of foundation supports with larger diameters. Therefore, construction at that Alternative would be expected to result in greater benthic habitat modification and occupation (approximately six times greater) compared to the other Alternatives. The greater number of foundation supports required at the South of Tuckernuck Island Alternative would also introduce more structure into a non-structure oriented environment and offer a greater surface area for potential fish aggregations compared to the other Alternatives. However, due to the spacing between WTGs, the additional structure is not expected to affect the overall environment or finfish species composition in the area. In addition, the South of Tuckernuck Island Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance, resulting in greater impacts from sediment disturbance compared to the other two offshore Alternatives.

Potential impacts from temporarily elevated levels of TSS are expected to be minimal at all Alternatives; however, due to the silt/clay sediments in the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, elevated TSS levels have the potential to occur over a wider area for a longer period of time compared to the Nantucket Sound and South of Tuckernuck Island Alternatives, which contain more coarse-grained sand. In addition, the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative has documented sediment contamination and therefore poses a greater bioaccumulation risk to finfish compared to the other Alternatives that have no evidence of contamination.

Acoustical disturbances during construction or decommissioning are expected to be similar at the Nantucket Sound and New Bedford/Horseshoe Shoal Alternatives. The South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to finfish compared to the other two offshore Alternatives, since that Alternative would likely require a longer construction timeframe. During operation, acoustical simulations suggest that impacts from underwater sound/vibrations will be minimal and similar at all of the Alternatives. The analysis of sound effects for the Project utilized baseline sound level monitoring and acoustic modeling both above water (airborne sound) and underwater according to the methods outlined in Section 5.11. Underwater sound measurements conducted for comparable projects are provided in Section 2.3 of Appendix 5.11-A.

Impacts from Project vessels are not expected to be substantial at any of the Alternatives; however, the South of Tuckernuck Island Alternative may require a greater number of Project vessels and a longer construction timeframe, thereby resulting in the potential for greater vessel-related impacts.

3.4.3.4.6 Benthos

This section describes potential impacts to benthic habitat, benthic community composition and abundance, shellfish resources, commercial shellfishing, and the lobster fishery in the three offshore Alternatives under consideration: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Available literature from site-specific studies by benthic experts was used as the basis for this analysis including published reports for areas that included each of the three offshore Alternatives.

A review was conducted of benthic resource data for each of the three offshore Alternatives consisting of a detailed summary of the habitat variables that most influence benthic community composition (i.e., water depth, temperature, and clarity; and sediment grain size and total organic carbon content) as well as benthic species composition and organism abundance and diversity (see Section 3.4.3.2.6). Information on shellfish and lobster harvests was obtained from available trawl survey reports, personal communications with Massachusetts fisheries managers, and published scientific literature.

Each of the offshore alternative sites has sediment conditions primarily consisting of unconsolidated marine sediments dominated by sand sized particles (Theroux and Wigley, 1998; Poppe et al., 1989; Pratt, 1973). As a result, the benthic habitat and associated organisms present at each offshore Alternative are similar (Section 3.4.2.6). Potential impacts to benthic and shellfish resources associated with the construction, operation, maintenance and decommissioning of the Project relate directly to the area of seafloor either temporarily disturbed by the Project or altered for a longer term by the presence of the Project. Additional potential impacts may also be attributable to sediment that is suspended due to construction of the Project. Construction activities potentially affecting benthic and shellfish resources within each of the three offshore Alternatives include jet plowing for cable embedment, pile-driving of foundations, scour control mat installation, and vessel anchoring and/or jack-up during construction.

As with any marine construction project that would disturb shellfish areas, if determined to be desirable the resource could be harvested prior to construction.

Massachusetts Military Reservation Alternative

The MMR Alternative is located in an upland environment. Therefore, there are no benthic resources associated with the MMR Site.

Nantucket Sound Alternative

This section describes potential impacts to benthic habitat, benthic community composition and abundance, shellfish resources, commercial shellfishing, and the lobster fishery in the Nantucket Sound Alternative.

Construction and Decommissioning

Benthic Habitat Disturbance

Impacts to the seafloor are anticipated from construction activities associated with cable embedment, tower and WTG installation, scour protection, and Project decommissioning. Construction and decommissioning impacts are expected to have only a temporary effect on benthos and benthic habitat and recovery of disturbed areas is expected to be relatively rapid as the area is recolonized from adjacent undisturbed areas. Due to the limited width of direct impact anticipated during submarine cable installation activities, mobile invertebrates (such as amphipods, polychaetes, oligochaetes, etc.) living in adjacent, undisturbed areas should be able to colonize the disturbed area. These invertebrates are considered "pioneer" species, and are expected to be the earliest colonizers of the disturbed areas. In addition, many benthic invertebrates with relatively long life cycles disperse through reproduction (i.e., bivalves) and may recolonize the disturbed area during subsequent spawning seasons as larvae are transported into the area from existing stocks.

The area of potential seafloor impact was based on the maximum anticipated area of impact calculated from the proposed Project design and construction methodologies. The assumptions used for these calculations are believed to be conservative estimates of the true area of potential impact.

The Nantucket Sound Alternative would contain between 92 and 130 WTGs (depending on which sub-site within Nantucket Sound is considered), all with a monopile foundation design ranging from 16.7 feet to 18 feet (5.1 to 5.5 m) in diameter. This design results in a maximum area of permanent benthic habitat disturbance of 29,467 square feet (0.68 acres (2,752 m^2)) from the WTG monopiles.

Temporary direct impacts to benthic habitat would result from installation of the inner-array cables. Within the Nantucket Sound Alternative there are three potential sub-sites being considered. The length of inner-array cabling required for the Nantucket Sound Alternative ranges from 46-81 miles (74 to 130 km) and the expected maximum width of disturbance is 6 feet (1.8 m), plus an additional 6 feet (1.8 m) from disturbance related to the jet plow pontoons. This results in a temporary direct area of benthic habitat disturbance from inner-array cable installation of 2,914,560 square feet to 5,132,160 square feet (67-118 acres (271,149 to 477,546 m^2)).

Due to the relatively shallow water depths in Nantucket Sound, shallow draft vessels/barges which typically use anchors for positioning are necessary for installation. Deeper draft vessels equipped with dynamic positioning thrusters therefore cannot be used. Impacts associated with the anchoring, positioning, and movement of cable installation barges are expected to occur along all cable installation paths. The area of this impact will vary depending upon bottom material composition, water depth, and sea and weather conditions; however, given the properties of anchor behavior as described by the U.S. Navy (Taylor 2002; NCEL 1987; NAVFAC 1985), it is possible to determine an average area of impact per anchor deployment. It is estimated that up to 7,230 square feet (0.2 acres (809 m^2)) per linear mile of cable corridor would be temporarily impacted from anchoring activities.

The anchor impact would disturb the sediment to a depth of approximately 4 feet (1.2 m) at each anchor deployment that will leave a temporary irregularity to the seafloor with localized mortality of infauna. In addition, the area of seafloor swept by the anchor line as the jetting barge moves along the cable route was calculated to be 311,880 square feet (7 acres (28,329 m^2)) per linear mile of cable. The total anchor and anchor sweep impact anticipated during the installation of the maximum 81 miles of inner-array cables would be approximately 25,847,910 square feet (593 acres (2,399,871 m^2)). This impact would be minimized through the use of mid-line anchor buoys. The anchor line sweep impacts would be expected to disturb sediment to a depth of up to 6 inches (15 cm), although this includes the most biologically active zone. Organisms that would likely be impacted by anchor line sweep would include mollusks, polychaetes, mat-forming amphipods, and other sessile species. Mobile organisms, such as crabs and lobsters would be able to avoid the area being swept. Predation of organisms or organism remains by mobile predators such as fish and crustaceans may be increased in the impact area during disturbance.

Each of the wind turbine tower foundations (monopiles or caissons) would require scour protection from prevailing currents. Several options were considered, however, it was determined that use of synthetic fronds mats designed to mimic seafloor vegetation would afford the necessary scour protection while minimizing

potential impacts to the benthic and fish communities typical of the region. This is because the synthetic frond scour control mats, when secured to the bottom as a network, trap sediments and become buried. This scour protection approach is more consistent with the low bottom relief of Nantucket Sound than traditional boulder revetment. The area to be protected with scour control mats around each piling would be 810 square feet (0.02 acre (81 m^2)), which yields a total area of scour protection of 105,300 square feet (2.4 acres (9,713 m^2)) for the 130 wind turbine towers and 4,860 square feet (0.11 acre (445 m^2)) for the 6 ESP pilings.

There would also be temporary impacts to the benthos associated with vessel anchoring and the jack-up barges that will be used to erect each tower. It may be possible to employ jack-up barges without the use of anchors but this would be dependant upon sea conditions at the time of installation. To be conservative, it was assumed that anchoring would be required at all WTG locations during each phase of construction.

It is anticipated that 4 anchors would be deployed to position and stabilize the construction vessel at each of the 130 wind turbine locations as well as for each of the 6 ESP pilings. The area of seafloor that would be temporarily disturbed would be highly dependent on the type of sediment, the depth of water, and sea and wind conditions. Assuming that each of the 4 anchors disturbs an area of bottom approximately 10.6 feet (3.2 m) wide (width of anchor including stabilizer bar) and up to 12 feet (3.7 m) long (the length of drag necessary to set the anchor), the average area of seafloor that would be temporarily disturbed to install each of the 130 turbine tower pilings and the 6 ESP pilings would be 509 square feet (0.01 acre (40.5 m^2)) per piling or a total of 69,224 square feet (1.6 acres (6,475 m^2)). Anchor line sweep associated with the installation of the 130 pilings would be anticipated to impact 9,202 square feet (0.21 acre (850 m^2)) per anchor for a total of 36,808 square feet (0.84 acre (3,399 m^2)) per piling location and a total of 5,005,888 square feet (114 acres (461,358 m^2)). In addition to anchoring, the four to six jacking legs of the jack-up barge are anticipated to have pads that contact the sea floor with an area of 172 square feet (0.004 acre (16.2 m^2)) each. Therefore, the maximum anticipated area of temporary impact associated with the jack-up barge legs for installation of the WTG and ESP pilings (136 in total) would be 140,352 square feet (3.2 acres (12,950 m^2)).

Temporary anchoring and anchor line sweep impacts to the seafloor are also anticipated during installation of turbines, blades, and other equipment. A vessel would need to anchor at each piling as part of this process and would have jacking leg, anchor, and anchor line sweep impacts similar to those described above. A vessel would also need to anchor in the vicinity of the ESP pilings in order to construct the ESP platform. A vessel would need to anchor to connect the inner-array cables to each WTG tower. A vessel would then need to anchor at each of the pilings in order to install scour protection mats that surround each piling. It is assumed that vessels would anchor once at each of the 130 turbine pilings and once at each of the 6 ESP pilings for each of these tasks resulting in a total of 3 vessel visits to each WTG location following the initial visit in which the piling was installed into the seafloor. The combined total temporary impact from anchoring, anchor line sweep and use of the jack-up barge, associated with the installation of the turbine towers, equipment, blades, the ESP platform, inner-array cable connection, and the scour protection mats is therefore expected to be approximately 15,646,392 square feet (359 acres (1,452,873 m^2)).

With regard to decommissioning, impacts associated with the removal of all Project-related structures are expected once the Project exceeds its useful life. Removal of the structures (wind turbine towers, foundations, ESP, submarine cables, and scour control mats) would result in temporary seafloor impacts of a magnitude comparable to that incurred during installation. Anchoring, anchor line sweep and use of the jack-up barge during the removal process would result in temporary impacts to approximately 15,646,392 square feet (359 acres (1,452,873 m^2)) of seafloor. Removal of established scour control mats would result in the temporary impact of up to an additional 110,160 square feet (2.5 acres (10,118 m^2)).

Benthic Community

As discussed above, most benthic invertebrates are able to opportunistically re-colonize unoccupied areas after disturbance. For these reasons, disturbance of the benthic community at the Nantucket Sound Alternative would still be localized and temporary.

Indirect impacts to benthic fauna and shellfish from inner-array cable and piling installation activities are also anticipated to be temporary and localized. It is widely recognized that benthic invertebrates are able to opportunistically re-colonize unoccupied areas after disturbance (Hynes, 1970; Rosenberg and Resh, 1993;

Rhoads *et al.*, 1978; Howes *et al.*, 1997). Due to the limited width of direct impact anticipated during inner-array cable installation activities, mobile invertebrates (such as amphipods, polychaetes, and oligochaetes) living in adjacent, undisturbed areas should be able to re-colonize the area of disturbance soon after construction. In addition, the substrate over much of Nantucket Sound is mobile and influenced by wave action and tidal currents, particularly in shallower waters and during storm events. Consequently, most organisms living on or in these fine sediments are adapted for movement or settlement and recovery from burial and should not be adversely impacted by Project construction. This is particularly true of gastropod species such as conch, which have relatively good mobility in sandy sediments such as are found in Nantucket Sound, with this adaptation supported by the presence of a relatively healthy population that supports a conch fishery.

Suspended Sediment Effects

Due to the predominance of fine to coarse-grained sand in Nantucket Sound, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the monopiles or inner-array cables. In addition, Nantucket Sound is a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters; therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment on an irregular basis and should not be substantially impacted by a temporary increase in turbidity as a result of Project construction or decommissioning. In addition, as evidenced by the sand waves described in Section 3.4.3.4.2 (Surficial Geology), bedload transport is active, with many of the benthic species adapted to shifting substrates. A process with similar impacts will occur with the settling out of the sandy sediments that are jetted during cable installation. Benthic organisms inhabiting this type of environment are adapted to shifting sediments and have behavioral mechanisms that allow them to adjust their position vertically and horizontally within the sediments to accommodate moving sediments and minimize harm from burial. Since Nantucket Sound sediments are predominately sand and there is no evidence of high concentrations of pollutants in these sediments, benthic organisms are not expected to be at risk from bioaccumulation of potential contaminants in prey items from the Project area.

Shellfish Resources and Commercial Shellfishing

Shellfish in the vicinity of the inner-array cables during installation may be exposed to short-term turbidity generated from jet plow embedment as well as additional overburdening with re-deposited sediments. However, analyses of sediment chemistry in the area of the Nantucket Sound Alternative indicate that sediments are relatively free of contamination and should pose little or no long-term risk to water quality and aquatic life (see Section 3.4.3.2.2). Although some mortality of shellfish residing in the area of direct disturbance resulting from monopile and inner-array cable installation is anticipated, such impacts would be limited by the low transport potential of the relatively coarse-grained sediments in this area. Spawning shellfish are more at risk from direct burial (and mortality) during construction and decommissioning because they have limited mobility. Therefore, these life stages will experience some short-term and localized adverse effects if construction or decommissioning occurs during spawning periods. Shellfish in the direct zone of the jet nozzles are likely to experience some mortality due to the high pressure water jets which if valves (shells) are not rapidly closed, will result in tissue damage. However, this affect is mitigated by the jet sled induced sediment vibration/pressure waves that are transmitted through the sediments in front of the advancing jet sled, thereby stimulating the shellfish to close their valves. Evidence for this phenomenon is available from the commercial shellfishing industry where hydraulic dredging does not result in a high level of tissue damage in collected shellfish because the organisms close their valves before the water jets near the front of the dredge are actually encountered.

American Lobster Fishery

Direct impacts to lobsters are expected to be minimal, with potential mortality limited to less mobile individuals in the direct path of construction activities. Hydraulic jet-plow embedment will limit these impacts to a very narrow corridor. Since the majority of the monopile and cable installation will occur within areas dominated by sandy sediments, the impacts from suspension of sediments from these activities (including anchoring) is not expected to result in significant indirect impacts as these sediments tend to settle very quickly as compared to finer muds and clays. Indirect impacts from sediment suspended within the water column will be temporary, as suspended sediment is expected to settle quickly.

Adult lobsters are mobile and have complex sensory capabilities that allow them to avoid temporary disturbances of seabed sediments (Jury et al., 1995). Lobsters naturally occur in turbid areas (Stewart, 2000) and, therefore,

should not be adversely affected by temporary and localized sediment disturbance associated with Project construction. A review of the scientific literature conducted by the USACE in 1991 concluded that most aquatic organisms, including juvenile lobsters, are not seriously affected by temporary exposure to increased suspended solids such as those associated with dredging operations (USACE, 1991).

The buried cables will not create a physical barrier that could interfere with lobster or other shellfish migration or use of existing habitats or nursery areas. Lobsters are able to traverse complex terrain and travel over substantial topographic features. As with projects utilizing similar submarine cable embedment methods, if a temporary minor depression in the seabed remains after cable installation it is not expected to prevent lobsters from crossing the cable areas and is not expected to interfere with lobster migration (Fogerty, 2000).

Operation and Maintenance

Benthic Habitat Occupation

Limited long-term impacts associated with the physical space occupied by the pilings needed to support the wind turbine towers and the ESP are also anticipated to affect the benthic resources at the Nantucket Sound Alternative. The wind park design for this Alternative would result in a maximum area of benthic habitat occupation of 29,467 square feet (0.68 acre (2,752 m^2)) from the WTG monopiles. Scour control mats placed around each of the monopile foundations would occupy additional benthic habitat. Since the scour control mats will accumulate sediments, this area should become restored to pre-construction conditions. Similarly, the area along the inner-array cables is expected to become restored through natural processes to approximate pre-existing conditions (Section 5.3).

Benthic Community Ecology

The vertical structure that would be created from the installation of wind turbine towers is not anticipated to result in adverse impacts to the ecology of the immediate Project area or to Nantucket Sound. The walls of the towers represent a source of new hard substrate with a vertical orientation in an area that has a limited amount of such habitat. Species that may initially be supported by such structures are likely to include algae, barnacles, hydroids, sponges, tunicates, bryozoans, anemones, and possibly mussels, all of which occur in other areas of hard substrate within Nantucket Sound. Additional organisms, such as crabs, gastropods, nudibranchs, polychaetes, and nematodes may also utilize the structures once algal growth becomes established. Several isolated rocks and areas of course glacial till do exist in each of the offshore alternative areas and are likely to support communities similar to those that may become established on the WTGs. Although the monopile foundations would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates, the additional amount of surface area being introduced represents a minor addition to the hard substrate that is already present. Assuming that the average tower in Nantucket Sound has a 16 foot (4.9 m) diameter and a 30 foot (9.2 m) height below MHW, then each tower is going to create about 1,200 square feet (0.03 acres (111 m^2)) of hard surface. However, the wide spacing (0.34 to 0.54 nautical miles apart) of these monopile structures might be similar to the patches of hard substrate currently present throughout the shoals of Nantucket Sound. Therefore, it is likely that these isolated structures would generate a small amount of additional patch reef type habitat, common in the Sound, and would not substantially alter the ecology of Nantucket Sound.

The scour control mats would be suitable for colonization by benthic organisms following installation, since the mats trap sediments that move onto them from the surrounding area and become buried. Therefore, no long-term impacts to the ecology of the Nantucket Sound Alternative are anticipated as a result of the placement of the scour control mats.

American Lobster Fishery

The buried inner-array cables would not create a physical barrier that could interfere with lobster migration or use of existing habitats or nursery areas. Lobsters are able to traverse complex terrain and travel over substantial topographic features. As with Projects utilizing similar submarine cable embedment methods, if a temporary minor depression in the seabed remains after cable installation, this is not expected to prevent lobsters from crossing the cable areas and is not expected to interfere with lobster migration (Fogerty, 2000).

South of Tuckernuck Island Alternative

This section describes potential impacts to benthic habitat, benthic community composition and abundance, shellfish resources, commercial shellfishing, and the lobster fishery in the South of Tuckernuck Island Alternative.

Construction and Decommissioning

Benthic Habitat Disturbance

The area of potential seafloor impact at the Project Alternative located South of Tuckernuck Island was calculated based on the proposed Project design and construction methodologies in a manner similar to that described above for the Nantucket Sound Alternative. The South of Tuckernuck Island Alternative would contain 130 WTGs, with 37 WTGs supported by a monopile foundation design ranging from 16.7 feet (Type A) to 19 feet (Type C) (5.1 to 5.8 m) in diameter and 93 WTGs supported by a quad-caisson foundation design (Type E - 4 foundation pilings per WTG each with a diameter of 24.6 feet (7.5 m)see Figure 3-45). The majority of the WTGs would be designed with the larger diameter quad-caissons because of the design requirements for the greater water depths at this Alternative. This design results in a maximum area of benthic habitat disturbance of 186,321 square feet (4.3 acres (17,402 m^2)) from the WTG quad-caissons and monopiles.

The length of the inner-array cables required at the South of Tuckernuck Island Alternative will be 85.5 miles (137 km). Therefore, the maximum area of seafloor anticipated to be disturbed during installation of the inner-array cables would be approximately 5,417,280 square feet (124 acres (501,828 m^2)) of sea bottom within the South of Tuckernuck Island Alternative.

Additionally, impacts associated with the anchoring and anchor line sweep required to position and move the cable installation barges would also be expected to occur along cable installation paths. The total anchoring impact during the installation of the 85.5 miles (137 km) of inner-array cables would be approximately 27,283,905 square feet (626 acres 2,533,422 m^2)).

It is anticipated that 4 anchors would be deployed to position and stabilize the construction vessel at each of the 409 pilings required to construct the 130 WTGs and the 6 pilings of the ESP. The area of seafloor that would be temporarily disturbed by anchoring and anchor line sweep in order to install these 415 WTG and ESP pilings would total 15,480,555 square feet (355 acres (1,436,685 m^2)). In addition to anchoring, the four to six jacking legs of the jack-up barge are anticipated to have pads that contact the sea floor with an area of 172 square feet (0.004 acre (16.2 m^2)) each. Therefore, the maximum anticipated area of temporary impact associated with the jack-up barge for installation of the WTG and ESP pilings (415 in total) would be 428,280 square feet (9.8 acres (39,661 m^2)).

Each of the wind turbine tower pilings and ESP pilings would require scour protection from prevailing currents. The total area to be protected with artificial frond scour control mats in the South of Tuckernuck Island Alternative would be approximately 336,150 square feet (7.7 acres (31,162 m^2)).

Additional anchoring impacts were estimated by assuming that vessels would anchor four additional times at each of the 409 tower foundation pilings and three additional times at each of the 6 ESP pilings at this Alternative. The combined total temporary impact from anchoring, anchor line sweep and the use of the jack-up barge associated with the installation of interconnecting supports of the quad-caisson, the turbines, blades and other equipment at the WTGs, connecting the inner-array cable to the WTG, along with the construction of the ESP platform and installation of the scour control mats at WTG and ESP pilings, would be approximately 63,429,246 square feet (1,456 acres (5,892,432 m^2)).

With regard to decommissioning, removal of the structures is expected once the Project exceeds its useful life. Removal of the structures (wind turbine towers, foundations, ESP, submarine cables, and scour control mats) would result in temporary seafloor impacts of a magnitude comparable to that incurred during installation. Anchoring, anchor line sweep and use of the jack-up barge during the removal process would result in temporary impacts to approximately 63,429,246 square feet (1,456 acres (5,892,432 m^2)) of seafloor. Removal of established scour control mats would result in the temporary impact of an additional 336,150 square feet (7.7 acres (31,162 m^2)).

Benthic Community

Since the benthic community at the South of Tuckernuck Island Alternative is slightly more diverse than that at the Nantucket Sound Alternative (see Section 3.4.3.2.6), it is likely that the impacts to the benthic community from jet plowing or other activities at this Alternative would be slightly greater than they would be at the Nantucket Sound Alternative, assuming equal areas of impact. However, the area of direct impact at the South of Tuckernuck Island Alternative would be nearly twice that of the Nantucket Sound Alternative.

As stated above, it is widely recognized that benthic invertebrates are able to opportunistically re-colonize unoccupied areas after disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads *et al.*, 1978; Howes *et al.*, 1997). Due to the limited width of direct impact anticipated during inner-array cable installation activities, mobile invertebrates (such as amphipods, polychaetes, and oligochaetes) living in adjacent, undisturbed areas should be able to re-colonize the area of disturbance soon after construction. For these reasons, disturbance of the benthic community at the South of Tuckernuck Island Alternative, despite being greater in area, would still be localized and temporary.

Suspended Sediment Effects

The South of Tuckernuck Island Alternative is dominated by sand-sized particles; therefore, localized elevated TSS concentrations associated with WTG foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the WTG foundations or inner-array cables. However, since there are a greater number of foundation supports with larger diameters required for this Alternative, construction may take longer, resulting in greater impacts from sediment disturbance. The deeper areas of this Alternative (those with depths greater than 75 feet) would likely be characterized by organisms prevalent in stable substrates, since there would be fewer disturbances due to wave energy not reaching the bottom in these areas; therefore, many of these organisms may not be as accustomed to increases in turbidity and subsequent sediment deposition as those found in Nantucket Sound. Since the sediments at the South of Tuckernuck Alternative are dominated by sand and there is no evidence of high concentrations of pollutants in these sediments, benthic organisms are not expected to be at risk from bioaccumulation of potential contaminants in prey items from the Project area.

Shellfish Resources and Commercial Shellfishing

Impacts to shellfish at the South of Tuckernuck Island Alternative during construction and decommissioning are expected to be similar to those described above for the Nantucket Sound Alternative although the greater area will affect larger numbers of organisms. Fewer gastropods that make up the conch fishery exist at this Alternative than the other two Alternatives. However, there is greater potential for direct disturbance to shellfish at the South of Tuckernuck Island Alternative due to the greater anticipated area of seafloor impact at this Alternative.

American Lobster Fishery

The types of impacts to the American lobster fishery at the South of Tuckernuck Island Alternative during construction and decommissioning are expected to be similar to those described above for the Nantucket Sound Alternative; however, there is greater potential for direct disturbance to lobsters at the South of Tuckernuck Island Alternative due to the greater anticipated area of seafloor impact at this Alternative.

<u>Operation and Maintenance</u>

Benthic Habitat Occupation

Limited long-term impacts associated with the physical space occupied by the pilings needed to support the wind turbine towers and the ESP are also anticipated to affect the benthic resources at the South of Tuckernuck Island Alternative. The wind park design for this Alternative would result in a maximum area of benthic habitat occupation of 186,322 square feet (4.3 acres (17,402 m^2)) from the WTG quad-caissons and monopiles. As a result of the larger diameter quad-caissons required as foundations at this Alternative, benthic habitat occupation would be approximately six times greater than what would be anticipated at the other offshore Alternatives. Additional benthic habitat would be occupied by scour control mats to be placed around each of the WTG foundations. More scour control mats would be required at the South of Tuckernuck Alternative compared to the

other offshore Alternatives due to the greater number of caisson and monopile foundation supports at this Alternative.

Benthic Community Ecology

The vertical structure that would be created from the installation of the wind turbine towers is not anticipated to result in substantial adverse impacts to the ecology of the area for the same reasons described above for the Nantucket Sound Alternative. However, the amount of colonizable structure introduced to the waters of the South of Tuckernuck Island Alternative (3,183,428 square feet/73 acres/29,543 m^2) would be 10 times the surface area that would be introduced at the Nantucket Sound Alternative (312,064 square feet/7.2 acres/29,138 m^2) resulting from the required quad-caisson style tower foundations at the South of Tuckernuck Island Alternative. Hence the development of a hard substrate ecology is more prominent at this Alternative than the other two Alternatives where monopole towers will be employed.

The scour control mats will be suitable for colonization by benthic organisms following installation since the mats trap sediments that move onto them from the surrounding area and become buried. Therefore, no long-term impacts to the ecology of the Project Alternative or the surrounding waters are anticipated as a result of the placement of the scour control mats.

American Lobster Fishery

Impacts to American lobster at the South of Tuckernuck Island Alternative during operation and maintenance of the Project would be similar to those described above for the Nantucket Sound Alternative.

New Bedford/Horseshoe Shoal Alternative

This section describes potential impacts to benthic habitat, benthic community composition and abundance, shellfish resources, commercial shellfishing, and the lobster fishery in the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative. For Information on the Horseshoe Shoal portion of this Alternative, please see the Nantucket Sound section, above.

Construction and Decommissioning

Benthic Habitat Disturbance

The area of potential seafloor impact at the New Bedford/Horseshoe Shoal Alternative was calculated based on the proposed Project design and construction methodologies in a manner similar to that described above for the Nantucket Sound Alternative. The anticipated area of disturbance is more than what would be disturbed at the Nantucket Sound Alternative but less than that of the South of Tuckernuck Island Alternative. The New Bedford/Horseshoe Shoal Alternative would contain 139 WTGs, all with a monopile foundation design ranging from 16.7 feet to 18 feet (5.1 to 5.5 m) in diameter. This design results in a maximum area of benthic habitat disturbance of 31,580 square feet (0.72 acres (2.914 m^2)) from the WTG monopiles.

The length of the inner-array cables required at the New Bedford/Horseshoe Shoal Alternative would be 84.1 miles (135 km). Therefore, the maximum area of seafloor anticipated to be disturbed during installation of the inner-array cables would be approximately 5,328,576 square feet (122 acres (493,734 m^2)) of sea bottom within the New Bedford/Horseshoe Shoal Alternative.

Impacts are expected to occur along all cable installation paths in association with anchoring and anchor line sweep in order to position and move the cable installation barge. The total anchoring and anchor line sweep impact during the installation of the 84.1 miles (135 km) of inner-array cables would be approximately 26,837,151 square feet (616 acres (2,492,952 m^2)).

There would be temporary impacts to the seafloor in the vicinity of each proposed wind turbine tower associated with the anchors that will be deployed while erecting each tower. At the New Bedford/Horseshoe Shoal Alternative, it is estimated that the 139 proposed tower foundations would be based on a monopile design with diameters of either 16.7 feet (5.1 m) (Type A) or 18 feet (5.5 m) (Type B) at the seafloor (Figure 3-45). It is anticipated that 4 anchors would be deployed to position and stabilize the construction vessel at each of the 139 monopiles as well as for each of the 6 ESP pilings. The area of seafloor that would be temporarily disturbed by

anchoring and anchor line sweep in order to install the 139 pilings and the 6 ESP pilings would be 37,576 square feet per piling, or a total of 5,410,965 square feet (124 acres (501,828 m^2)). In addition to anchoring, the four to six jacking legs of the jack-up barge are anticipated to have pads that contact the sea floor with an area of 172 square feet (0.004 acre (16.2 m^2)) each. Therefore, the maximum anticipated area of temporary impact associated with the jack-up barge for installation of the WTG and ESP pilings (145 in total) would be 149,640 square feet (3.4 acres (13,760 m^2)).

Each of the wind turbine tower pilings and ESP pilings would require scour protection from prevailing currents. The total area to be protected with artificial frond scour control mats in the New Bedford/Horseshoe Shoal Alternative would be 117,450 square feet (2.7 acres (10,927 m^2)).

Additional anchoring impacts were estimated by assuming that vessels would anchor three additional times at each of the 139 tower foundation pilings and at each of the 6 ESP pilings. The combined total temporary impact from anchoring, anchor line sweep and use of the jack up barge associated with the installation of the pilings, the turbines, blades and other equipment at the WTGs, scour control mats, and connecting the inner-array cables to the WTG along with the construction of the ESP platform would be approximately 22,092,780 square feet (507 acres (2,051,829 m^2)). This is slightly greater than the anchoring impacts for the Nantucket Sound Alternative and approximately one-third the impacts anticipated for the South of Tuckernuck Island Alternative.

Benthic impacts could also be different for the alternatives depending upon if the construction procedures and WTG locations need to be changed during the construction period. Attempts to install monopile towers may fail due to unsuitable geology, in which case an alternate location would be used, thereby increasing seafloor disturbance. In addition, although the Applicant has specified construction procedures that would be used, it is possible on a project of this magnitude, that unanticipated procedures or equipment may need to be called upon during the construction period. The new procedures or equipment could have additional or alternate impacts on benthos.

With regard to decommissioning, removal of the structures is expected once the Project exceeds its useful life. Removal of the structures (wind turbine towers, foundations, ESP, submarine cables, and scour control mats) would result in temporary seafloor impacts of a magnitude comparable to that incurred during installation. Anchoring, anchor line sweep and use of the jack-up barge during the removal process would result in temporary impacts to approximately 22,092,780 square feet (507 acres/2,051,829 m^2) of seafloor. Removal of established scour control mats would result in the temporary impact of an additional 117,450 square feet (2.7 acres/10,927 m^2).

Benthic Community

As discussed above and in Section 5.3, benthic invertebrates are able to opportunistically re-colonize unoccupied areas after disturbance. For these reasons, disturbance of the benthic community at the New Bedford/Horseshoe Shoal Alternative would still be localized and temporary.

Indirect impacts to benthic fauna and shellfish from inner-array cable and piling installation activities are also anticipated to be temporary and localized. However, since the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative is dominated by fine sands, silts, and clays, sediment suspension and re-deposition may occur over a larger area for a longer period of time compared to the other two Alternatives that contain coarser grained sands. There is evidence of chemical contamination in the sediments in New Bedford Harbor and portions of Buzzards Bay (PCBs and other sediment contamination) (see Section 3.4.3.2.2). Therefore, the re-suspension of these sediments during foundation placement and cable embedment may adversely impact marine water quality and aquatic biota. Re-suspension of contaminated sediments has the potential to increase bioaccumulation of the contaminants.

The substrate of the New Bedford Harbor Site is mobile and influenced by wave action and tidal currents, particularly in shallower waters. Consequently, most organisms living on or in these fine sediments are adapted for movement or settlement and recovery from burial and should not be adversely impacted by Project construction. However, the project will also have the greatest potential to affect areas of rocky reefs, since there are more marked reefs in and adjacent to the New Bedford site than at the other offshore alternative sites.

These reefs could be affected by suspended sediments or during the anchoring process if care is not taken to avoid anchor cable sweeps or anchor placement on the rocky reefs.

Shellfish Resources and Commercial Shellfishing

Impacts to shellfish at the New Bedford/Horseshoe Shoal Alternative during construction and decommissioning are expected to be similar to those described above for the Nantucket Sound Alternative. However due to sediment composition, there is a greater potential for elevated TSS concentrations to occur over a larger area for a longer period of time and a greater potential for bioaccumulation of contaminants in shellfish from surrounding sediments compared to the other two offshore Alternatives.

American Lobster Fishery

Impacts to American lobster for the New Bedford/Horseshoe Shoal Alternative during construction and decommissioning are expected to be similar to those described above for the Nantucket Sound Alternative, although with a higher number of individuals involved since this alternative includes work in both New Bedford and Horseshoe Shoal within Nantucket Sound.

Operation and Maintenance

Habitat Occupation

Limited long-term impacts associated with the physical space occupied by the foundations needed to support the wind turbine towers and the ESP are also anticipated to affect the benthic resources at the New Bedford/Horseshoe Shoal Alternative. The wind park design for this Alternative would result in a maximum area of benthic habitat occupation of 31,580 square feet (0.72 acres (2,913 m^2)) from the WTG monopiles. Additional benthic habitat would be occupied by scour control mats to be placed around each of the monopile foundations, although it is expected that these mats will accumulate sediment and be suitable for colonization by most benthic organisms. If the mats fail to function as anticipated, alternative scour protection measures may need to be implemented during the operational period, which might consist of importing material for placement around scoured WTG towers, or installation of a different type of scour control device. These alternative approaches might have minor localized impacts during the operational period that are not currently envisioned or described.

Benthic Community Ecology

The vertical structure that would be created from the installation of the wind turbine towers is not anticipated to result in adverse impacts to the ecology of the area for reasons described above for the Nantucket Sound Alternative and in Section 5.3. The amount of colonizable structure introduced to the waters of the New Bedford/Horseshoe Shoal Alternative (296,931 square feet/6.8 acres/27,520 m^2) would be slightly less than that introduced to the Nantucket Sound Alternative (312,064 square feet/7.2 acres/29,138 m^2) due to lower average water depths and a heavier reliance on smaller diameter (Type A) monopiles. The New Bedford / Horseshoe Shoal Alternative would introduce nearly 11 times less vertical surface area for colonization than would be introduced at the South of Tuckernuck Island Alternative.

The scour control mats will be suitable for colonization by benthic organisms following installation since the mats trap sediments that move onto them from the surrounding area and become buried. Therefore, no long-term impacts to the ecology of the Project Alternative or the surrounding waters are anticipated as a result of the placement of the scour control mats.

American Lobster Fishery

Impacts to American lobster at the New Bedford / Horseshoe Shoal Alternative during Project operation and maintenance are expected to be similar to those described above for the Nantucket Sound Alternative.

Comparative Summary of Impact

This section describes potential impacts to benthic resources at the three offshore Alternatives under consideration. The New Bedford/ Horseshoe Shoal Alternative includes the resources found at both the New Bedford Harbor sub-site and Nantucket Sound Alternative Horseshoe Shoal sub-site. Table 3-51 provides a comparative summary of the acreages of seafloor disturbance and impact from various components of the project construction for each of the alternatives.

No impacts to benthos are anticipated for the MMR Alternative since this is an upland alternative. Impacts to benthic resources have the potential to occur at all three of the offshore Alternatives. However, there could be differences in the extent of impacts that occur at the three offshore Alternatives that may vary somewhat by site due to site-specific habitat conditions, minor differences in benthic community composition, or differences in construction or operational methodologies. To be conservative in this alternatives analysis, it was assumed that 100% infauna and epifauna mortality would occur in any seafloor area disturbed. Since the benthic communities at each of the offshore Alternatives are relatively similar in composition, the nature of impacts to the benthic composition would be expected to be similar for each of the offshore Alternatives.

Each offshore Alternative, except the New Bedford component of the New Bedford/Horseshoe Shoal combination Alternative, will require an ESP that will be sized and constructed similarly at each location. Each offshore Alternative will require inner-array cables to link the WTGs to the ESP. The nature and extent of the impact from their installation will be essentially the same, since each Alternative will require a similar length of cable (between 81.0 and 85.5 miles (130 and 137 km)) to be installed into similar soft-bottom material. For the New Bedford component of the combination alternative, the interconnection of the cables would go directly to an upland substation without need for an ESP. The Horseshoe Shoal component of the combination Alternative will have an ESP.

The risk of impacts to benthic habitat from oil, fuel, hydraulic fluid, or other fuels and lubricants associated with the construction machinery are also likely to be similar at each offshore Alternative and will be minimized through the implementation of a Spill Prevention Control and Countermeasure (SPCC) Plan. It is possible that the risk of spills would be somewhat greater at the South of Tuckernuck Island Alternative since more time would be required to construct the quad-caisson WTG foundations. Adverse sea conditions are also expected to occur more regularly at this Alternative, since it is not as protected as the two other Alternatives.

The most obvious difference among the offshore Alternatives is at the South of Tuckernuck Island Alternative, where a greater number of foundation supports (a quad-caisson foundation design) with larger diameters would be required due to the deeper water depths at the Alternative. Therefore, construction at that Alternative would be expected to result in greater benthic habitat modification and occupation (approximately six times greater) compared to the other Alternatives. The additional pilings, cross-braces, and scour protection required at this Alternative substantially increase (by more than 10 times) the vertical habitat structure available for colonization by benthos. More scour control mats would also be required at the South of Tuckernuck Alternative compared to the other offshore Alternatives due to the greater number of caisson and monopile foundation supports at this Alternative. In addition, the South of Tuckernuck Island Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance, resulting in greater impacts to benthos from sediment disturbance compared to the other two offshore Alternatives.

Anchoring impacts would be similar for the New Bedford/Horseshoe Shoal and Nantucket Sound Alternatives, approximately one-quarter the anchoring impacts anticipated for the South of Tuckernuck Island Alternative.

Potential impacts from temporarily elevated levels of TSS are expected to be minimal at all Alternatives; however, due to the silt/clay sediments in the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, elevated TSS levels have the potential to occur over a wider area for a longer period of time compared to the Nantucket Sound and South of Tuckernuck Island Alternatives, which contain more coarse-grained sands. In addition, the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative has the greatest potential to have contaminated sediments and therefore poses a greater bioaccumulation risk to benthos compared to the other Alternatives, which have no evidence of contamination.

The amount of colonizable structure introduced to the waters of the New Bedford/Horseshoe Shoal Alternative (296,931 square feet/6.8 acres/27,520 m^2) would be slightly less than that introduced to the Nantucket Sound Alternative (312,064 square feet/7.2 acres/29,138 m^2) and nearly 11 times less than what would be introduced at the South of Tuckernuck Island Alternative.

The benthic community at the New Bedford component of the New Bedford/Horseshoe Shoal Site is reported to be slightly more diverse than that at both the South of Tuckernuck Island and the Nantucket Sound Alternatives,

which may mean that impacts to the benthic community from jet plowing and other construction activities would be slightly greater at the New Bedford component of this alternative. However, the area of direct impact at the South of Tuckernuck Island Alternative would be nearly twice that of the Nantucket Sound Alternative, likely resulting in greater overall impact to benthos at the South of Tuckernuck Island Alternative. In addition, the New Bedford Alternative has the greatest number of marked rocky reefs that would be affected should anchoring or anchor cables occur on these reefs during construction.

3.4.3.4.7 Upland Environmental Resources

This section describes potential impacts to upland environmental resources and protected species in the MMR Alternative. No upland environmental resources occur in the three offshore Alternatives: Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. Impacts to soils, geology, water resources, and avian resources at the MMR Alternative are discussed in other sections of this alternatives analysis. Soils and geology impacts are discussed in Section 3.4.3.4.2. Water resource impacts are discussed under Section 3.4.3.4.15 and impacts to avian use of the Alternative are discussed in Section 3.4.3.4.1.

Massachusetts Military Reservation

Potential impacts to upland environmental resources at the MMR Alternative include habitat loss and fragmentation as well as wildlife disturbance or displacement due to construction vehicle and equipment traffic and the presence of Wind Park towers and turbines during Project construction, operation, and decommissioning.

Construction and Decommissioning

Potential impacts to upland environmental resources at the MMR Alternative during Project construction and decommissioning include vegetation clearing and land disturbance associated with the construction/decommissioning of the towers, installation/removal of inner-array cables, and the clearing of rights-of-way (ROW). Potential impacts to vegetative communities; Rare, Threatened, or Endangered (RTE) species; and wildlife are discussed below.

The Wind Park layout calls for a total of 132 towers located along the western and northern portions of the MMR (in the Camp Edwards portion of MMR). The towers would be grouped into one of eight networks which would be connected to a substation located at the north of the MMR Alternative by a series of underground inner-array cables (see Figure 3.44).

Each tower foundation would have an approximate area of 1,830 square feet (0.04 acres/162 m^2). Therefore, the total surface area covered by tower foundations would be approximately 239,580 square feet (5.5 acres/22,258 m^2). Each tower would require an area clear of vegetation 400 feet (122 m) in diameter centered on each tower, which would result in a cleared area of approximately 125,660 square feet (2.88 acres/11,655 m^2) per tower. This would result in approximately 16,552,800 square feet (380 acres/1,537,860 m^2) of clearing.

Approximately 56 miles (90 km) of inner-array cables would be required to accommodate the project layout. The underground cable network would be constructed in existing cleared ROW wherever possible. Approximately 42 miles (67 km) of inner-array cables would be installed in existing ROW, and no vegetation clearing would be required. , In addition, approximately 14 miles (22.4 km) of new ROW would need to be cleared to a required width of 20 feet (6.1 m) resulting in new clearing and disturbance of approximately 1,481,100 square feet (34 acres/137,600 m^2). Overall, cable trenches along the entire 56 miles (89.6 km) of ROW would affect approximately 1,089,000 square feet (25 acres/101,175 m^2) (excluding clearing of the 14 miles/22.4 km of new ROW).

Table 3-52 summarizes potential impacts associated with the clearing of vegetation and the construction of wind towers and cable installation.

Soil disturbance, in addition to vegetation removal, may potentially increase erosion throughout the project layout. Underground trenching may undermine slope stability in areas with varying (steep) topography.

Stormwater runoff associated with the addition of impervious surfaces from the towers may also increase erosion throughout the project layout.

Decommissioning the Wind Park by removing towers and the inner-array cables would result in similar soil disturbances. Vegetative communities would be allowed to return to their former state but may experience long-term effects due to the extent of disturbance and successional processes.

Impacts to Vegetative Communities

As shown in Figure 3-51, there are six major habitats within the MMR Alternative (in order of dominance): 1) mixed woodlands; 2) pitch pine scrub oak forest; 3) hardwood forest; 4) scrub oak barrens; 5) grassland habitat; and 6) open water/wetlands of various types (Massachusetts Army National Guard, 2001). In fact, Figure 3-51 shows that no wetlands or extensive grassland areas will be directly impacted by the project. The MMR Plant Community Data Layer (Massachusetts National Guard, 2003) was used to determine impacts to each of the vegetative communities listed above.[65] Cover type and wetland polygons were digitized and the Wind Park layout was overlaid for the purposes of quantifying impacts to each cover type.

Table 3-50 summarizes anticipated impacts to the upland forest, pitch pine/scrub oak forest and barrens, and grassland vegetative communities based on the proposed Wind Park layout.

As shown in Figure 3-51, the greatest impacts would occur to upland forested areas. This includes both mixed and hardwood forest types. Impacts to pitch pine/scrub oak forest are also relatively high. Impacts to grasslands are somewhat less, however, because this habitat type is locally and regionally less common, its loss may significantly impact species that depend on grassland habitat (e.g., grasshopper sparrow). The Project layout is located in close proximity to wetland areas and may include wetland resource area and/or buffer zone. Impacts to wetland areas are discussed in Section 3.4.3.4.15 (Water Quality and Water Resources).

Impacts to Rare, Threatened or Endangered Plant Species

Vegetation clearing has the potential to impact habitat of Rare, Threatened, or Endangered (RTE) plant species identified as present on the MMR Alternative. These include horse gentian (Endangered), ovate spikerush (Endangered) and Torrey's beak rush (Endangered), adders tongue fern (Threatened), and star grass (Special Concern) (Commonwealth of Mass Military Division, 1996). Based on information about each species' preferred habitat from the Massachusetts NHESP, the following general assumptions were made regarding potential Project impacts.

Horse gentian, also referred to as broad tinker's-weed, is a coarse herbaceous plant typically found in dry open wooded areas (MHNESP, 1993). If present, populations of horse gentian may be impacted by vegetation clearing. Since the majority of the Alternative is forested, the current layout may impact horse gentian populations.

Ovate spikerush and Torrey's beak rush typically inhabits the edges of ponds and wetland areas (Rook, 2002). Torrey's beak rush does not grow well with shrubs and other coarse vegetation (MNHESP, 1988c). The Wind Park layout at MMR may cross a limited number of wetland areas, so impacts to both species are possible.

Star grass typically inhabits woods and open thickets (University of Wisconsin, 2004). If present, populations of star grass may be impacted by vegetation clearing. Adders tongue fern typically inhabits marshes, bogs, and moist woods when clearings are present (MNHESP, 1990c). Since adders tongue prefers open areas, vegetation clearing may benefit this species.

Habitat Fragmentation and Invasive Species

Several utility ROWs and roadways currently exist throughout the MMR Alternative. Although the Project layout utilizes existing ROWs to the extent possible, additional ROW clearing and improved gravel roadway clearing would be necessary to construct and maintain the Wind Park. Introducing additional ROW may potentially

[65] From MMR FEIR Documentation webpage (http://www.eandrc.org/publications.htm). It is important to note that the Plant Community Data Layer has not been field verified and is available at a scale unsuitable for micro-analysis. Also, portions of the Alternative could not be digitized due to unavailable information for those areas. The analysis of this map information was intended to provide insight as to potential large-scale impacts this layout may have on vegetative communities, wildlife, and wetlands at MMR.

fragment the remaining continuous stretch of forested habitat at MMR. Although the number of species in a fragmented habitat may increase initially, the species richness would most likely decline in the long-term (Smith, 1996). Furthermore, introducing cleared areas in existing forestlands may allow predatory species like cats, raccoons, crows, and weasels to increase predatory pressure on interior species.

Currently, invasive species are relatively uncommon at the MMR Alternative (Massachusetts National Guard, 2003). They do occur heavily in localized areas but are not widespread throughout the property. The invasive species observed on site include Japanese knotweed (*Lonicera japonica*), common reed (*Phragmites australis)*, Russian olive (*Eleagnus umbellata*), bittersweet (*Celastrus orbiculatus*), black locust (*Robinia pseudoacacia*), Scotch pine (*Pinus sylvestris)*, Japanese barberry (*Berberus thunbergii*), and knapweed (*Centaurea maculosa*). Disturbance of existing vegetative communities may leave the areas susceptible to colonization by invasive species.

Wildlife

The MMR is utilized by numerous species of mammal, amphibian, reptile, and invertebrate. Impacts to wildlife species documented to occur in the MMR are discussed in the sections below. (Avian use of the Alternative is discussed in Section 3.4.3.2.1. and avian impacts are discussed in Section 3.4.3.4.1)

Mammals

A small mammal survey performed at the Camp Edwards Training Site (Massachusetts National Guard, 1999) indicates that the white-footed mouse, red-backed vole, meadow vole, masked shrew, long-tailed weasel, northern short tailed shrew, eastern chipmunk, and red squirrel are common mammalian species found at the MMR. Other species include the white tailed deer, coyote, red fox, raccoon, eastern cottontail, gray squirrel, mink, raccoon, striped skunk, and the woodchuck (Massachusetts National Guard, 1999).

Bat surveys within the Camp Edwards portion of MMR were conducted during 1999 and 2000. Four species were documented during the preliminary survey, including the big brown bat, red bat, northern myotis, and the eastern pipistrelle (MAARNG, 2001).

The vegetation clearing and land disturbance associated with the construction/decommissioning of the towers, installation/removal of inner-array cables, and the clearing of ROW may impact the habitat of forest dwelling bats at MMR. Construction/Decommissioning may also result in mortality to a limited number of bats that may be roosting/hibernating in areas affected by the Project and cannot avoid construction.

The National Guard survey also found that the mixed-woodland communities exhibited the greatest mammal species richness (Massachusetts National Guard, 1999). As mentioned above, clearing the mixed-woodland communities would most likely reduce species richness in these areas (Smith, 1996).

Avoidance of active construction areas by wildlife is expected. Localized mortality from vegetation clearing, road clearing and earthmoving activities during construction would not be expected unless the species are physically prevented from relocating to other areas. Therefore, wildlife disturbance is anticipated to be temporary and localized resulting from active construction. However, limited additional impacts to mammal populations may occur if denning or nesting sites are present and are destroyed within areas of disturbance.

Amphibians and Reptiles

Various species of amphibians and reptiles have been observed at the MMR Alternative. The majority of species are associated with aquatic habitat, however, there have been reptile and amphibian species observed that utilize terrestrial/upland habitat as well as aquatic habitat. These include red-back salamander, spotted salamander, eastern box turtle, black racer, and ringneck snake (Massachusetts National Guard, 1999).

Impacts related to vegetation clearing, road clearing, installation of the inner-array cables, and wind tower infrastructure installation may result in injury or mortality from contact with construction equipment as well as disturb/interrupt nesting, foraging, and overwintering areas for these species.

Rare, Threatened, or Endangered Amphibians or Reptiles

The four-toed salamander, a state-listed species of Special Concern, has been observed on the MMR (location unknown). Eastern box turtle and the spotted turtle have also been documented to occur on the MMR property. Both species are state-listed species of Special Concern (Massachusetts National Guard, 1999).

Since the locations of the four-toed salamander and spotted turtle are undocumented at the Alternative, it is difficult to assess potential impacts to these species from the Project layout. Although both species are associated with aquatic habitats, potential Project impacts are possible since these species also utilize upland areas. Impacts related to vegetation clearing, road clearing, installation of the inner-array cables, and wind tower infrastructure installation may result in injury or mortality from contact with construction equipment as well as disturb/interrupt nesting, foraging, and overwintering areas for these species.

The habitat of the eastern box turtle includes both dry and wet thickets, deciduous forests and, in Cape Cod, pine-barrens and oak thickets (MNHESP, n.d.(e)). The extensive vegetation clearing of the box turtle's preferred habitat would likely result in injury or mortality from contact with construction equipment as well as loss of foraging habitat for turtle populations in the Project Area at MMR.

Invertebrates

The vegetation clearing has the potential to impact the habitat of several state-listed invertebrate species (moths, dragonflies, and damselflies) on the MMR Alternative. The barrens daggermoth (*Acronicta albarufa)* (Threatened), coastal barrens buckmoth (*Hemileuca maia ssp*.) (Threatened), Gerards underwing (*Catocala herodias gerhardi)* (Threatened), Melsheimers sack bearer *(Cicinnius melsheimeri)* (Threatened), and the chain-dotted geometer *(Cingilia catenaria)* (Special Concern) are dependent on scrub oak barren habitat (Massachusetts National Guard, 2003). Clearing of this vegetative community type may have a localized impact on these species. The blueberry sallow (*Apharetra dentate)* (Special Concern), and the coastal swamp metarranthis *(Metarranthis pilosaria)* (Special Concern) typically inhabit pine/oak barrens (Massachusetts National Guard, 2003). Extensive vegetation clearing may impact these populations as well.

Three species of damselflies, the pine barrens bluet *(Enallagma recurvatum)* (Threatened), tule bluet *(Enallagma carunculatum*) (Special Concern), and the New England bluet *(Enallagma laterale)* (Special Concern), have been identified by MNHESP as occurring on the MMR Alternative. Two species of dragonflies, the comet darner *(Amax longipes)* (Special Concern) and the spatterdock darner *(Aeshna mutata)* (Endangered), have also been identified as occurring on the MMR Alternative. These species' habitats include coastal plain freshwater ponds and lakes. Depending on the specific location of these species on the Alternative, ROWs may intersect their habitat.

Operation and Maintenance

Approximately 1,071,576 square feet (24.6 acres/995,562 m^2) of ROW would receive long-term impacts associated with ROW and Wind Park facility operation and maintenance. Operation and maintenance activities that may potentially affect vegetation include routine mowing in order to maintain a clear ROW, including as much as a 400 foot (122 m) radius around each tower, and gravel roadway maintenance. Trench work associated with periodic cable replacement/inspection may also impact local plant populations.

Impacts to Vegetative Communities

The greatest impacts to vegetative communities would occur to mixed woods forest and to pitch pine scrub oak forest (see Figure 3-51). Operation and maintenance of Project ROWs and improved gravel roadways would prevent the reestablishment of these forest cover types at the Alternative for the life of the Project.

Impacts to Rare, Threatened or Endangered Plant Species

Horse gentian, a state-listed endangered plant species, and star grass prefer open wooded areas. Long-term vegetation clearing of approximately 428 acres of upland forested and pitch pine/scrub oak vegetative communities may impact habitat for this species. Ovate spikerush, adders tongue, and Torrey's beak rush typically inhabits the edges of ponds and wetland areas. Surveys for these species would need to be conducted to document occurrence within the Project area. If documented, populations of these species would likely be impacted by long-term vegetation clearing and road maintenance.

As the Wind Park layout at MMR crosses a limited number of wetland areas, impacts to ovate spikerush, adders tongue, and Torrey's beak rush are possible, but unlikely, from long-term mowing and trench work.

Habitat Fragmentation and Invasive Species

Maintaining cleared ROW would fragment the remaining continuous stretch of forested habitat at MMR. Disturbance of existing vegetative communities from clearing and trenching may leave the areas in and adjacent to the ROW susceptible to colonization by invasive species such as Russian olive, bittersweet, glossy buckthorn, and common reed.

Wildlife

The MMR is utilized by numerous species of mammal, amphibian, reptile, and invertebrate. Impacts to wildlife species documented to occur in the MMR are discussed in the sections below. (Avian use of the Alternative is discussed in Section 3.4.3.2.1.)

Mammals

Operation and maintenance activities (ROW mowing, roadway maintenance and trench work) may cause localized mortality to mammalian species that are physically prevented from relocating to other areas. Predatory mammal species may benefit from the addition of cleared ROWs as a means to better access prey formerly located in interior forest areas.

Four species of bats are documented on the Alternative. Bats could be impacted by operation of the facility especially if the turbines are located within migratory corridors or in highly used foraging areas. However, bats have the ability to avoid obstacles in their path by quickly altering their direction. Operation and maintenance activities (e.g., ROW mowing, roadway maintenance and trench work) may cause mortality to bats roosting/hibernating in the Project vicinity. High bat mortalities occurred at the Mountaineer Wind Energy Center in West Virginia, an industrial wind energy facility with 44-turbines (350-ft/107 m tall) located over several miles along the crest of a prominent Appalachian ridge. Searchers collected 475 carcasses of at least eight different bat species that died after colliding with these turbines between April and November 2003, the first year of the wind farm's operation (Safe Wind Info, 2003). However, bats at the MMR site are solitary or small group roosting species and the density and abundance of bats are much less than in parts of Appalachia and this level of impact would not be expected.

Amphibians and Reptiles

Routine ROW clearing and roadway maintenance would be an impact on sedentary reptile and amphibian species that are unable to avoid mowing or possibly grading equipment during post-cable excavation. These include red-back salamander, spotted salamander, and eastern box turtle. Also, increased predation pressure from cats, raccoons, crows, and weasels may result in lower populations since these species would be able to use new ROWs to access the interior habitats (Smith, 1996).

Rare, Threatened, or Endangered Amphibians or Reptiles

The four-toed salamander, eastern box turtle, and spotted turtle have been documented to occur on the MMR property. As mentioned above, routine ROW clearing and maintenance would impact sedentary reptiles and amphibians unable to avoid mowing devices.

Invertebrates

Operation and maintenance activities such as periodic mowing, gravel roadway maintenance and cable maintenance have the potential to impact habitat of several state-listed invertebrate species (moths, dragonflies, and damselflies) on the MMR Alternative. The barrens daggermoth, coastal barrens buckmoth, Gerards underwing, Melsheimers sack bearer, and the chain-dotted geometer are dependent on scrub oak barren habitat. Long-term mowing of this vegetative community may locally impact these species. The blueberry sallow and the coastal swamp metarranthis typically inhabit pine/oak barrens. Extensive vegetation clearing may also impact these populations.

Three species of damselflies (the pine barrens bluet, tule Bluet and the New England bluet) have been identified by MNHESP as occurring on the MMR Alternative. Two species of dragonflies (comet darner and the spatterdock darner) have also been identified as species occurring on the MMR Alternative. These species prefer coastal plain

freshwater ponds and lakes. The Project layout is located in the vicinity of approximately five water bodies. It is unknown if these ponds function as habitat for RTE invertebrates. If so, vegetation mowing and trench work in or adjacent to these ponds would likely impact populations of RTE invertebrates at the Alternative.

Nantucket Sound, South of Tuckernuck Island and New Bedford / Horseshoe Shoal

There are no upland resources associated with the three offshore Alternatives other than the cable landfall and onshore routes, which are addressed in Section 3.5.

Comparative Summary of Impacts

The MMR Alternative was the only terrestrial Alternative considered as part of this alternatives analysis. As described above, MMR has the potential for extensive terrestrial resource impacts, including vegetation, wildlife, bats, and invertebrates that are avoided by the offshore Wind Park Alternatives.

3.4.3.4.8 Aviation

This section describes impacts associated with aviation usage of the airspace in and around the four Alternative sites under consideration. Due to the similarities of potential impacts to aviation during periods of both construction/ decommissioning and operations/maintenance, the Project's potential impacts are presented in a consolidated format below.

The USACE is coordinating with the FAA, and the Military, in the review of potential impacts to air navigation for all alternative sites. In addition to input from the FAA, evaluation of the terrestrial alternative at MMR was largely based upon input from Air Force, Massachusetts Air National Guard, US Coast Guard and other military personnel knowledgeable in the use of the MMR airspace.

The FAA has authority to promote the safe and efficient use of the navigable airspace, whether concerning existing or proposed structures (derived from 49 United States Code, Section 44718). Title 14, Code of Federal Regulations, Part 77 (Objects Affecting Navigable Airspace) was adopted to establish notice criteria for proposed construction or alteration that would protect aircraft from encountering unexpected structures. The primary objective of an evaluation (or aeronautical study) under Part 77 is to ensure the safety of air navigation and efficient utilization of navigable airspace by aircraft. The FAA must be notified of the proposed construction of any structure with a height greater than 200 feet (61 meters). Notification to the FAA is made by filing a *Notice of Proposed Construction or Alteration (FAA form 7460-1)* for each structure, which is followed by distribution and comment concerning the proposed structure's effects:

- On existing and proposed public-use and military airports
- On existing and proposed visual flight rule (VFR) / instrument flight rule (IFR) aeronautical departure, arrival and en route operations, procedures, and minimum flight altitudes.
- Regarding physical, electromagnetic, or line-of-sight interference on existing or proposed air navigation, communications, radar, and control systems facilities.
- On airport capacity, as well as the cumulative impact resulting from the structure when combined with the impact of other existing or proposed structures.
- Regarding whether marking and/or lighting is necessary.

A *Notice of Proposed Construction or Alteration (FAA form 7460-1)* was filed with the FAA, for each proposed offshore WTG location. In consultation with the FAA, it was determined that the filing of 7460's at MMR was unnecessary, given the amount of information available directly from military sources.

The height of individual WTGs will exceed 200 feet (61 m); therefore, lighting/marking for the safety of pilots, and the completion of an aeronautical study by the FAA will be required to determine if the turbines pose a hazard to aeronautical safety. A lighting design for the alternative sites has been proposed to make the WTG structures sufficiently conspicuous to pilots in order to ensure aeronautical safety, while minimizing visual impacts to viewsheds and potential attraction impacts to avian communities. Each of the individual WTGs will be lighted by two FAA approved obstruction lights located on the top of the generator housing (nacelle), horizontally

separated to ensure that at least one of the flashing lights on the nacelle is visible at all times. In addition, each of the offshore WTGs will have two flashing amber USCG lights on the lower access platform. Lights will vary in intensity depending on the specific location of the individual turbine, with perimeter WTGs generally lit at a higher intensity than those located within the interior of the Wind Park. Perimeter WTGs located at corners / turning points and no more than one mile (1.6 km) apart (every other perimeter WTG) will be lighted at night with two flashing dual medium intensity red FAA L-864 / white FAA L-865 (maximum 2000 candela red) lanterns on the nacelle. The balance of the perimeter WTGs and all interior WTGs will be lighted with two flashing red lanterns comparable to a low intensity FAA L-810 fixture (approximately 32 candela) on the nacelle. The lighting design has been developed based on the following:

- Consultations with FAA New England Region staff;
- Review of FAA Advisory Circular 70/7460-1K, Obstruction Marking and Lighting;
- Consultations with USCG Private Aids to Navigation (PATON) – District One staff;
- Review of regulations for Private Aids to Navigation (PATON);
- USFWS recommendations (September 14, 2000 Memo: Service Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers);
- International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommendations for marking offshore wind parks;
- Cape Wind Associates Scientific Measurement Devices Station (SMDS) approved lighting design;
- Avian consultant (Dr. Paul Kerlinger);
- Lighting contractor (Automatic Power Inc.); and
- European wind park experience (Horns Rev).

The FAA determined during its Aeronautical Study (#2002-ANE-804-OE) and "Determination of No Hazard to Air Navigation" for the Cape Wind Scientific Measurement Devices Station (SMDS) (08/01/02) that when lighting a structure in open waters a lower intensity fixture, such as the FA-249-155 mm Marine Lantern, can be used to achieve the same safety effect as a higher intensity lighting that is normally recommended by the FAA for land based structures.

Massachusetts Military Reservation

Following consultation with the FAA and the military it was decided that the filing of the FAA 7460-1 forms for the proposed turbines at this alternative location was unnecessary in light of the significant military impacts identified.

Consultation with MMR staff and representatives from the US Coast Guard, Massachusetts Air National Guard, and US Air Force indicate that due to the high level of helicopter and fixed wing aircraft activity taking place on a regular basis throughout the MMR, siting of the proposed wind turbine array would have a "devastating"[66] affect on the training and operational missions of the largest military base in New England. Impacts would include:

- Elimination of Otis Air Base as an emergency landing option for the NASA Space Shuttle. The height of the southern turbines in the proposed layout would force the shuttle to land at too steep of an angle.
- The location and height of the southern turbines would present a hazard to the F-15's and other fixed wing military aircraft taking off and landing on instruments during periods of limited visibility due to the steepness of approach that would be required to maintain the required 500 feet (153 m) of vertical separation.
- MMR is the center for low-level helicopter training for New England, not only for the military but for police and fire rescue as well. Much of the training is done as low as 20 feet (6.1 m) off the deck and at night with night vision goggles that would be affected by turbine lighting. If turbines were sited at MMR it would eliminate all helicopter training in eastern New England, forcing troops to train at Westover AFB in western Massachusetts.
- Air National Guard and US Coast Guard have operational missions operating from MMR (as opposed to training missions) for Search and Rescue and homeland security that would be affected by turbines sited in proximity to the runways.

[66] LTC Mary Mixson; HQ Camp Edwards Training Site; MMR / USACE Joint Consultation Meeting February 6, 2004

Nantucket Sound

The FAA has completed an aeronautical study of each of the proposed WTG locations in Nantucket Sound, which included the distribution of public notices and a 30-day public comment period. Following review of the three separate study areas, the FAA has issued a "Determination of No Hazard to Air Navigation" for all three Nantucket Sound Alternative sub-sites.

The Aeronautical Studies conducted by the FAA found that the WTG's within the Nantucket Sound Alternative (including all three sub-sites) would:

- Not have an adverse effect on air traffic operations enroute through the Nantucket Sound airspace under Visual Flight Rule (VFR) conditions;
- Not have an adverse effect on any air traffic operations either inbound to or outbound from any Nantucket Sound vicinity airport under VFR conditions;
- Not have an adverse effect on air traffic operations inbound, outbound, or enroute through the Nantucket Sound airspace under Instrument Flight Rules (IFR) conditions;
- Not have an adverse effect on any existing or planned runway length;
- Not have an adverse effect or derogation to any airport efficiency;
- Not have an adverse effect on any planned IFR and VFR airport operations indicated by plans on file; and
- Not be located within any airport traffic pattern and would not have an effect on traffic.

As previously discussed the FAA has determined that the Nantucket Sound Alternative as proposed does not present a hazard to air navigation. Each WTG will be lighted as previously described above. In order to assist USCG in SAR, direct communication will be established between Air Station Cape Cod SAR personnel and the CWA Operations Center (manned 24 hours/365 days per year) in order to facilitate rapid remote WTG shut down in the event of bad weather SAR by air, at the request of USCG.

The specific location of the Wind Park will be charted and published in Special Notes to Pilots and noted on all applicable aeronautical charts.

South of Tuckernuck Island

The location of each of the 130 WTGs for the South of Tuckernuck Alternative has been filed with the FAA to determine aviation impacts. An aeronautical study has been conducted and the FAA has issued a Determination of No Hazard to Air Navigation (dated May 10, 2004), similar to that described above.

New Bedford / Horseshoe Shoal

The FAA has completed its aeronautical studies for the 25 proposed New Bedford turbines, similar to that described above for the Nantucket Sound Alternatives, and issued a Determination of No Hazard to Air Navigation dated March 26, 2004.

Comparative Summary of Impacts

Each of the offshore alternatives has received a "Determination of No Hazard to Air Navigation" by the FAA as a result of their aeronautical studies (Appendix 5.12-C).

Siting of wind turbines on the MMR Site appears to have the greatest impact to air navigation, effectively eliminating all military flight training and operations involving helicopters or low altitude fixed wing aircraft, and as an emergency-landing site for the NASA Space Shuttle.

3.4.3.4.9 Telecommunications

This section describes potential impacts to telecommunication resources for the four potentially feasible Alternatives under consideration. Due to the similarities of potential impacts to telecommunication during periods

of both construction / decommissioning and operations / maintenance, the Project's potential impacts are presented in a consolidated format below.

Massachusetts Military Reservation

The existing permitted antennae in the study area are made up of cellular phone towers, local emergency response communication towers, radio towers, and television towers. Additionally the Alternative contains the PAVE PAWS radar system, and experiences a large amount of mobile military radio communications related to its training mission.

To ensure that there will be no multi-path interference from a Wind Park at MMR, Comsearch (Spectrum Management Solutions) of Ashburn, Virginia, was retained to perform an incumbent licensed microwave search. The analysis evaluated the potential effects of the Alternative to existing microwave telecom systems. Comsearch identified microwave paths that intersect the defined Project area, and calculated a Worse Case Fresnel Zone for each path. Comsearch results are presented in full in Appendix 3-J.

Preliminary clearance calculations showed that seven proposed WTG locations at the MMR Alternative might obstruct microwave paths. Five of the seven WTG locations might obstruct a 940-960 MHz microwave path between Sandwich and Bourne licensed to Southern Energy Canal LLC under FCC call signs WNEP388 and WNEP389. The other two WTG locations might obstruct a 2.1 GHz microwave path between Shoot Flying Hill and Bourne licensed to Commonwealth Electric Company under FCC call signs WIA288 and WIA290 and a 6.1 GHz microwave path between Pocasset and Barnstable licensed to Southwestern Bell Mobile Systems LLC, MA under FCC call signs WLA209 and WMT 258. The preliminary calculations were based on worst-case (mid-path) horizontal Fresnel radius clearance.

The PAVE PAWS radar system has a two-fold mission: to provide early warning of in-coming ballistic missiles and to provide space surveillance to track satellites and other objects. When operating in missile warning mode the beam scans approximately 3 degrees above the horizon. It is anticipated that WTGs sited in the areas closely adjacent to the Flat Rock Hill PAVE PAWS site will negatively impact the radar signals generating the missile warning surveillance "fence". It is less likely that the WTGs would impact the radar when the system is operating in space surveillance mode that scans at a much greater angle.

The use of older technology military mobile radios (which rely on line-of-sight) is likely to be affected due to the numbers of towers proposed for the installation in the primary training areas of the northern MMR. The Military staff raised this concern during the February 6, 2004 consultation with the USACE.

According to US Coast Guard personnel it is unlikely that the turbines would impact communications from the Coast Guard Communication Center at MMR because the majority of their signals are transmitted to the east, away from the proposed turbine locations.

Nantucket Sound

Because of the height above the water, the WTGs were evaluated for possible interference with existing and proposed telecommunication towers on the Cape and Islands. The proposed inner-array cable system will be buried beneath the seafloor and therefore, no interference with the telecommunications towers, marine VHF radio, or radar is anticipated from the inner-array cables.

Most telecommunication devices operate on a line-of-sight basis. This means that the source of the transmission and the receiving antennae communicate in a linear path. Variables such as major obstructions and distance can impede the transmission of line-of-sight signals. The interference caused by major obstructions is referred to as shading. Mountains and large buildings are examples of natural and manmade sources of shading respectively.

The WTGs will not create any shading effects on the existing and proposed telecommunications towers. An evaluation of the FCC permitted antennae in the study area with the positions of the proposed WTG locations was conducted by Comsearch and yielded no impact to line of sight telecommunications. The existing, permitted, and proposed FCC antennae on Martha's Vineyard and Nantucket will be able to maintain unimpeded line-of-sight with

existing and permitted corresponding antennae on Cape Cod. Therefore, communication between towers on Cape Cod and communication within or between the Islands would not be in a path that would approach the location of the WTGs.

Preliminary clearance calculations did not find any WTGs for the Horseshoe Shoal sub-site within microwave paths.

Preliminary clearance calculations did show that one of the proposed WTG locations at the Tuckernuck Shoal sub-site might obstruct a 950 MHz microwave path between Barnstable and Nantucket Island licensed to Radio Nantucket, Inc. under FCC call signs WLD332 and WLD333. The preliminary calculations were based on worst-case (mid-path) horizontal Fresnel radius clearance. This turbine location could be moved to alleviate the interference.

Preliminary clearance calculations did not find any WTGs for the Monomoy-Handkerchief Shoal sub-site within microwave paths.

The FAA has conducted an aeronautical study for each of the sub-sites in the Nantucket Sound Alternative (see Appendix 5.12-C). As part of these studies, the FAA analyzed the potential for the WTGs to affect aviation radar. Based on the completion of the aeronautical studies, the FAA has issued a “Determination of No Hazard to Air Navigation”.

Analysis of marine communication (VHF radio and radar) at the Horns Rev Wind Farm, off the coast of Denmark has shown that vessels, of various sizes, working amongst the grid of 80 WTGs experienced no difficulty communicating with each other or the nearby port of Esbjerg. There were no observations or reports of problems with vessel mounted VHF communication or shadows on radar from rotating turbine blades.

Based on the results of the evaluations described above, no adverse impact to telecommunications is anticipated.

South of Tuckernuck Island

Preliminary clearance calculations conducted by Comsearch did not find any WTGs for the South of Tuckernuck Alternative within microwave paths.

The FAA has conducted an aeronautical study for each of the South of Tuckernuck Alternative WTGs (see Appendix 5.12-C). As part of these studies, the FAA has analyzed the potential for the WTGs to affect aviation radar. Based on the completion of the aeronautical studies, the FAA has issued a “Determination of No Hazard to Air Navigation”.

As described above, analysis of marine communication (VHF radio and radar) at the Horns Rev Wind Farm indicated that there were no observations or reports of problems with vessel mounted VHF communication or shadows on radar from rotating turbine blades.

Based on the results of the evaluations described above, no adverse impact to telecommunications is anticipated.

New Bedford/Horseshoe Shoal

Preliminary clearance calculations conducted by Comsearch did not find any WTGs for the New Bedford/Horseshoe Shoal Alternative within microwave paths.

The FAA has conducted an aeronautical study for the New Bedford portion of the New Bedford/ Horseshoe Shoal Alternative (see Appendix 5.12-C). As part of these studies, the FAA analyzed the potential for the WTGs to effect aviation radar. Based on the completion of the aeronautical studies, the FAA has issued a “Determination of No Hazard to Air Navigation”.

As described above, analysis of marine communication (VHF radio and radar) at the Horns Rev Wind Farm indicated that there were no observations or reports of problems with vessel mounted VHF communication or shadows on radar from rotating turbine blades.

Based on the results of the evaluations described above, no adverse impact to telecommunications is anticipated.

Comparative Summary of Impacts

The Federal Aviation Administration (FAA) has conducted Aeronautical Surveys on all of the Alternative Sites except for the MMR Alternative Site. A specific Aeronautical Study was not initiated for the MMR Alternative Site due to its use for military purposes, which both restricts public use of the airspace and results in potential military aviation and radar issues. The FAA review of the Project at all of the offshore alternative sites determined that the composition of the turbine structures would not affect aviation or radar. The three offshore Alternatives were determined to have no adverse impacts to telecommunication, however a number of WTG locations for the terrestrial Alternative on MMR could likely interfere with microwave signals. The siting of WTGs on MMR would also negatively impact military communications and the operation of the PAVE PAWS radar system.

3.4.3.4.10 Navigation

This section describes potential impacts to navigation resources for the four Alternatives under consideration. Vessels operating in the Atlantic Ocean, Buzzards Bay, and Nantucket Sound (including recreational vessels) operate under the International Regulations for Preventing Collisions at Sea 1972 (COLREGS). In preparing this assessment of potential impacts to marine navigation, it is assumed that all mariners will adhere to the COLREGS as required, and will operate their vessels in a safe and prudent manner. Risks and impacts associated with failure to comply with the COLREGS or unsafe vessel operation cannot be evaluated and are beyond the scope of this assessment.

The COLREGS have been implemented by the US Coast Guard as part of the International and Inland Navigation Rules (USCG, 1999). The US Coast Guard is responsible for ensuring compliance with the International and Inland Navigation Rules as well. The following is a sampling of COLREGS rules that pertain to navigation around the proposed Wind Park.

- Rule 1 of the COLREGS requires that all vessels operating in the area comply with the regulations, and duly regard all dangers of navigation and collision.
- Rule 2 states that nothing in the COLREGS exonerates any vessel, owner, master, or crew member from the consequences of failure to comply with the COLREGS or take the necessary precautions required by ordinary practice or special circumstances. In other words, the mariner is responsible for safe operation of the vessel regardless of the navigational situation.
- Rule 5, “Lookout” states that “Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.”
- Rule 6 states in part that “every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid a collision and be stopped within a distance appropriate to the prevailing circumstances and conditions.” The proximity of other vessels, structures, as well as other factors must be taken into account when determining a safe speed. Therefore, vessels must operate at speeds within and around the Wind Park that allow the vessel to stop or avoid collision with another vessel or a WTG.
- Rule 7a states “every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.” The vessel is therefore required to continually assess the potential for collision with another vessel or a WTG while navigating in the Wind Park.
- Rule 8e requires that if more time is necessary to assess the situation or avoid collision, a vessel shall slow down or stop. As with Rule 7a, the vessel is therefore required to continually assess the potential for collision with another vessel or a WTG while navigating in the Wind Park.
- Rule 8a states “any action to avoid a collision shall, if the circumstances of the case admit, be positive, made in ample time, and with due regard to the observance of good seamanship.” The vessel is required to take appropriate action to prevent collision with another vessel or a WTG.

- Rule 19b states that every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. Even in clear daylight weather, the presence of the WTGs will present a momentary condition of restricted visibility by shielding small vessels as described in Section 4.3.1 of the Navigational Risk Assessment (Appendix 5.12-A). Under this rule, the vessels must take the presence of the WTGs into account as a momentary restricted visibility condition, and must adjust the vessel's safe speed and distance from the WTG accordingly.

These rules make it very clear that properly assessing the potential risk of collision, operating at safe speeds, and taking necessary action to avoid collision is the responsibility of the vessel's captain. The mariner must remain cognizant of the presence of the WTGs, and adjust operation of his or her vessel accordingly to be in compliance with the COLREGS.

The characteristics and routes of every vessel that uses, or could potentially use, the waters in and around each Alternative cannot be known with certainty because marine vessel traffic is not closely regulated and routes are generally not restricted to designated corridors. Thus, it is reasonable to expect that, where not limited by water depth or sea and weather conditions, marine vessels would navigate any of the offshore Alternatives.

Massachusetts Military Reservation

The MMR Alternative is located in an upland environment. While a portion of the MMR is in the near vicinity of the Cape Cod Canal between the Bourne and Sagamore Bridges, there would be no direct interaction of the proposed WTG array with the canal at the MMR Alternative. Therefore, no review of impacts to marine navigation resources is applicable for the MMR Alternative. However, according to the Massachusetts National Guard (Appendix 3-L) siting of the WTGs at MMR would "eliminate Army land navigation training" as the WTGs would be visible and could be used as a point of reference.

Nantucket Sound

Construction and Decommissioning

There will be limited temporary impacts to navigation in the immediate vicinity of ongoing construction operations. Any temporary restrictions to navigation are expected to be limited in proximity to active work areas, would only be implemented as necessary to protect the safety of mariners, and will be implemented in coordination with the USCG.

Details of the marine based construction will be closely coordinated with the USCG and local Harbor Pilots. During construction, it is likely that temporary vessel or channel access restrictions in the immediate vicinity of construction operations may be required to protect public safety. These restrictions, however, will be limited to small sections of the Wind Park as each WTG is constructed, and as the cable embedment process is completed. Any vessel transit or navigation channel restrictions will be closely coordinated with the USCG. Notice to Mariners will likely be posted and called on a daily basis or at intervals required by the USCG. The construction vessels will display the appropriate day shapes and/or lighting, and will monitor VHF Ch. 13 and Ch. 16 during operations.

Should decommissioning become necessary at any time, the same procedures and restrictions would apply. Like the construction impacts, these decommissioning impacts would be temporary in nature.

Operation and Maintenance

Installation of the WTGs will result in structures being present where no structure has previously existed. While the spacing between WTGs (0.54 NM (1 km) by 0.34 NM (0.63 km) grid) provides adequate watersheet area for most vessels to navigate through, vessels will need to navigate a course that avoids impact with the WTGs. As such, the presence of the Wind Park will require that all mariners (including recreational boaters) be more attentive to the types of navigational equipment needed onboard to safely operate in and around the Wind Park, their vessel's position, and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the Wind Park. Navigation of larger commercial vessels will remain unaffected, as they are likely to remain in the marked navigation channels that are outside of the Wind Park.

During operations, CWA will have work vessels in the Wind Park conducting routine monitoring and maintenance during daylight hours when the seas are less than 6 feet (1.8 m). These work vessels will be able to assist vessels in distress within the Wind Park during these times, and will do so either upon receipt of a request for assistance from the vessel or from the USCG. Personnel on these vessels will be trained in first aid, CPR, and marine survival skills.

Proposed Aids-to-Navigation

Installation of the Wind Park will result in the presence of additional aids-to-navigation in Nantucket Sound that can be used by mariners in the area. Each WTG will essentially serve as an ATON simply by its presence on the Nantucket Sound Alternative. The WTGs will be marked on NOAA navigation charts, and will serve as points of reference for mariners navigating in and around Nantucket Sound. Each WTG will be clearly marked with an alphanumeric designation that will also assist mariners in determining their position within the Wind Park.

In addition, CWA, following consultation with USCG staff, has committed to providing private ATONs within the Wind Park to assist mariners when navigating in and around the Wind Park. These private ATONs will consist of light and sound signals that will add to the existing network of USCG maintained ATONs, and will provide more navigational references for mariners. CWA will receive a Permit to Establish and Operate a Fixed Aid-to-Navigation pursuant to 33 CFR 66.0 prior to constructing the ATONs.

In addition to the proposed private ATONs, each WTG will be equipped with lighting that meets FAA standards for aircraft avoidance. These lights may provide another point of reference for mariners.

South of Tuckernuck Island

Provided that the construction and WTG array spacing remain the same, the potential impacts to navigation at the South of Tuckernuck Island Alternative will be equivalent to the potential impacts for the Nantucket Sound Alternative, if not less since there is on average less vessel traffic in the area of the South of Tuckernuck Island Alternative. Unlike the other two offshore Alternatives, there are no marked navigation channels in proximity to a Wind Park at the South of Tuckernuck Island Alternative, which limits traffic in and around the area.

As indicated in the impact analysis for the Nantucket Sound Alternative above, installation of the WTGs will result in structures being present where no structure has previously existed and mariners will need to navigate with consideration of these new structures. Also, as described above, installation of the Wind Park will result in additional aids-to-navigation in the Atlantic Ocean that can be used by mariners in the area. The WTG array itself would serve as an ATON, and additional private ATON's would be established to assist mariners when navigating in and around the Wind Park.

The only potential difference would be the amount of time that Project work vessels would be in the Wind Park conducting routine monitoring and maintenance. Because the South of Tuckernuck Island Alternative lies in relatively open water in the Atlantic Ocean, the likelihood of seas of 6 feet (1.8 m) or higher is greater than it is in Nantucket Sound. As a result, the amount of time that Project maintenance vessels would be in the area and able to render assistance would be reduced.

New Bedford / Horseshoe Shoal

As previously stated, the potential impacts at the New Bedford / Horseshoe Shoal Alternative will be equivalent to the potential impacts for the Nantucket Sound Alternative, provided the construction and WTG array spacing remains the same.

As discussed for the Nantucket Sound Alternative, installation of the WTGs will result in structures being present where only open water has previously existed. Therefore, all mariners (including recreational boaters) must be more attentive to navigation in this area. It is possible that larger vessels approaching the New Bedford channel from the southwest that in the past might have navigated across the area in the southern portion of the Wind Park will no longer find it feasible. However, with the presence of small reefs in and adjacent to the Wind Park

and the lack of information on how much large vessel traffic occurs in this area, changes in vessel traffic patterns due to construction and operation of the Wind Park are assumed to be negligible.

Additional aids-to-navigation in Buzzards Bay and Nantucket Sound that can be used by mariners in the area will result from the installation of the Wind Park. The WTG array itself would serve as an ATON, and additional private ATON's would be established to assist mariners when navigating in and around the Wind Park.

Comparative Summary of Impacts

The construction and operation of the Wind Park at the three offshore Alternatives, and the installation of the inner-array cable systems are not expected to have adverse impacts to recreational, commercial, or passenger vessel navigation in or around the Wind Park. Those vessels not physically restricted from anchoring or operating in the vicinity of the Alternatives under consideration due to existing physical depth limitations will still be able to use these waters.

Installation and operation of the WTGs will result in structures being present where no structure has previously existed. As such, the presence of the Wind Park at any of the offshore Alternatives will require that all mariners (including recreational boaters) be more attentive to the types of navigational equipment needed onboard to safely operate in and around the Wind Park. Mariner's knowledge and awareness of vessel position and the proximity of other vessels to their own vessel will be imperative as they navigate in and around the Wind Park. This is likely to affect some mariners, particularly those that have navigated these areas prior to the installation of the Wind Park and are accustomed to the lack of structures.

The spacing between the WTGs, in combination with NOAA chart revisions and establishment of private aids-to-navigation, will provide adequate watersheet area for unrestricted and safe navigational access in and around the WTG arrays at each Alternative. A vessel's ability to safely navigate in and around the WTGs must be determined by each vessel's captain. As described, each WTG will essentially serve as an aid-to-navigation simply by its presence. In addition, CWA has committed to providing private ATONs within the Wind Park to assist mariners when navigating in and around the WTG array.

The Navigational Risk Assessment (Appendix 5.12-A) for the Alternative sub-site on Horseshoe Shoal (one of three sub-sites included in the Nantucket Sound Alternative as well as a sub-site of the New Bedford/Horseshoe Shoal Alternative) has been reviewed and appears to sufficiently address the key navigational issues raised to-date. The USCG determined that the findings of the Horseshoe Shoal Navigational Risk Assessment are generally applicable to all of the offshore alternative site locations, provided the construction specifications and WTG array spacing remain the same for each site. The USCG further stated that they would be able to meet required SAR standards for all Alternative locations. Consequently, the potential impacts to navigation resulting from construction and operation of the Wind Park are anticipated to be generally equivalent at each of the three offshore Alternatives.

3.4.3.4.11 Cultural/Historical Properties

This section describes potential impacts of Project construction and operation to historic properties within each Alternative's APE. Section 3.4.3.2.11 identified the historic properties and their associated APEs for each Alternative.

Potential Project impacts to historic properties are considered to be physical impacts, such as destruction or disturbance, as well as visual impacts. To assess visual impacts, photo renderings were prepared to show expected day time and night time visibility of the aboveground components at each Alternative, as they would be seen from the closest onshore historic property offering open unobstructed views of the proposed WTGs. Section 3.4.3.4.12 describes the methodology for day time and night time photo renderings, viewpoint selection, and simulation of the WTGs at each Alternative from the closest historic property. This information is also included in Appendix 3-K. No night time rendering was prepared for the MMR Alternative, as discussed herein and in Section 3.4.3.4.12.

In general, locations selected for photo renderings (shown on Figures 3-53 through 3-65 for this section) represent "worst case" visibility of each Alternative. As noted, these locations were the most open unobstructed publicly available view from the closest historic property to each Alternative. Most locations within the selected historic districts have much more limited/screened views of the seascape toward the Alternatives. The viewpoints were oriented to capture both the closest and highest number of the WTGs in the field of view as possible, and do not consider the screening effects of the curvature of the earth at distances of more than 3 miles (4.8 km) (see Section 3.4.3.4.12). Lastly, the renderings illustrate the Wind Park as it would be seen under clear sky conditions, again a worst case portrayal of visual impacts and a scenario not likely to occur often in consideration of cloud and weather patterns typical to the region.

Below, potential impacts to archaeological resources are identified at each Alternative followed by a comparative summary of impacts. The aforementioned individual day and night photo renderings are also described. For consistency, all day time renderings used the same lighting conditions, with the WTGs slightly backlit from the midday sun, to throw the structures into some shadow and enhance contrast. All night time renderings used the same undeveloped nightscape with virtually no ambient light.

Massachusetts Military Reservation Alternative

Construction and Decommissioning

Intensive archaeological surveys have already been conducted within site-specific areas of the MMR Alternative (see Section 3.4.3.2.11). All of the archaeological sites identified within this Alternative during these surveys have been evaluated and none have been determined to represent significant archaeological resources. Many of the sites are located in areas that have since been reclassified as either low sensitivity or disturbed.

Some of the remaining areas of the MMR Alternative have been assigned moderate to high sensitivities for discovery of previously unidentified archaeological resources. If ground disturbance is proposed in these areas, an intensive (locational) archaeological survey would be conducted under permit from MHC, to locate and identify archaeological resources in those areas. No historic structures listed in the NRHP are located within the MMR Alternative, although two structures recently evaluated eligible for the list are located within the southern portion of the MMR Alternative in the town of Bourne (see Table 3-20). These are the Camp Edwards Range Control and the Camp Edwards Ammunition Supply Point historic properties. Locations are shown on Figure 3-30. If MMR were to be selected, efforts would need to be made to avoid, minimize or mitigate impacts to these historic properties, in accordance with Section 106 of the National Historic Preservation Act (NHPA), as amended.

If any historic structures are found in the area, none of the Project's construction sound levels are expected to be able to physically damage or affect them. If significant archaeological resources are identified within the noise APE of the selected Alternative, an assessment of potential noise impacts will be made prior to commencement of construction activities. These findings are applicable to all the Alternatives under consideration.

With respect to potential visual effects to aboveground historic properties, construction equipment would likely be largely screened by mature foreground vegetation and topography. Construction equipment such as cranes could be visible from portions of the Cape Cod Canal, which is a National Civil Engineering Landmark, and from other nearby historic properties listed in Table 3-20 and shown on Figure 3-30. Visual effects of construction and decommissioning activities would be temporary.

Operation and Maintenance

As noted above, two historic properties are located within the southern portion of the MMR Alternative. Development of the MMR Alternative would require that efforts be made to avoid, minimize or mitigate impacts to these historic properties.

Figure 3-53 shows the day time view of the proposed built Project from the Sagamore Bridge. The view is similar to what would be experienced along the Cape Cod Canal, at the Bourne Bridge, and in portions of the locally designated Old Kings Highway Regional district in northwestern Sandwich. The simulation indicates that the upper portions of the WTGs would be visible from the Sagamore Bridge during Project operation, with the bases

obscured to varying degrees by mature forested vegetation and topography. WTGs in the field of view range from 0.81 to 6.25 miles (1.3-10 km) from the viewer at this viewpoint. Additional WTGs will be visible outside the field of view of the photograph.

The photograph for this simulation was taken from a higher vantage point than at the Cape Cod Canal. Areas along the Canal are at lower elevations than the viewpoint shown, where the bases of the WTGs would be further screened. Areas immediately adjacent to the south side of the Canal would likely experience less visibility than along the north side, due to the intervening topography and foreground vegetation to the south.

No night time simulation was completed at this location due to the difficulty of obtaining accurate night photos under floodlit foreground conditions (see Section 3.4.3.4.12). In addition, vehicles crossing the bridge cause vibrations that reduce the clarity of the long timed exposures required at night. Oncoming headlights from traffic would also interfere with the photographic representation and therefore reduce the accuracy of the simulation. While the night lighting of the WTGs would likely be visible to viewers on the bridges and along the Canal, the relatively high levels of ambient night lighting from the floodlighting on the bridges, along the sides of the Canal and nearby roadways, would help to minimize the contrast of Project lighting to the existing night viewscape.

The Sagamore Bridge viewpoint includes a number of existing built features already in the landscape, including the blades of an artificial windmill at the Christmas Tree Shop at the base of the Bridge (see lower left on Figure 3-53), tall lights that illuminate the Sagamore Bridge, buildings around the busy Route 6 access ramps at the southern end of the Sagamore Bridge, and the nearby Cape Cod Outlet Mall (out of photograph to the right). Also in the panorama outside the photograph are other built features such as electric transmission lines, cell towers, busy transportation corridors and an oil fired power plant stack. The addition of WTGs into the viewscape, while visible, does not seem out of character for this area, where infrastructure converges to serve Cape Cod as a whole.

Nantucket Sound Alternative

Historic properties that could be affected by Project activities are presented for each Nantucket Sound sub-site, below. The Wind Park at each of the Nantucket Sound sub-sites would be visible from a number of designated historic districts and structures near or at the shorefront along the south side of Cape Cod, the northeast side of Martha's Vineyard, and the north side of Nantucket. The greatest Project visibility and visual contrast generally occur at distances of less than 8 miles (12.9 km), as discussed in Section 5.10. Beyond this distance, Project structures become more obscure and certain components, such as rotor blades, become difficult to see. Generally, within 8 miles (12.9 km) all the WTGs will be visible within the field of view.

Locations of shoreline historic properties with open views toward the Nantucket Sound Alternative sub-sites are listed in Table 3-21; locations are shown on Figure 3-32.

Horseshoe Shoal Sub-site

Construction and Decommissioning

No submerged historic properties or archaeological resources have been identified and no wrecks recorded within this sub-site. The archaeological sensitivity for this sub-site is anticipated to be high for Euro-American submerged cultural resources, because of the general area of Nantucket Sound's documented vessel losses, navigational hazards (submerged shoals) and relatively close proximity to modern and historic period shipping routes. The archaeological sensitivity for ancient Native American submerged cultural resources is also anticipated to be high, because of the potential presence of archaeologically sensitive intact buried paleosols within the sub-site, areas of variable bathymetry, and its somewhat protected location from the ocean (see PAL report in Appendix 3-I).

Due to this predictive sensitivity, if this sub-site is selected, the area of physical disturbance associated with Project construction and operation would be subjected to further archaeological evaluation, to confirm the presence or absence of potentially significant archaeological resources.

Construction and decommissioning equipment and vessels will be visible from shoreline historic properties with open views toward the Alternative. These visual impacts will be temporary. Permanent visual effects due to Project operation/maintenance are discussed in the section below.

As mentioned in the MMR discussion, none of the construction sound levels, whether above water or below, are expected to be able to physically damage or affect historic structures, if any are found in the area. These findings are applicable for all offshore Alternative Sites.

Operation and Maintenance

The view of the Project from the closest historic property to this Alternative, the Wianno Historic District in the Town of Barnstable, was selected for photo rendering (see Figures 3-54 and 3-55). The WTGs are at distances of 5.67 to 12.63 miles (9.1-20.3 km) from the viewer, with 91 percent of the 130 proposed WTGs visible in this rendering. The regular row pattern of the turbine layout is apparent.

This rendering represents visibility of this proposed Alternative sub-site from approximately Cotuit east to Yarmouth, including historic districts and properties at Cotuit and Hyannis Port, home of the Kennedy Compound, a National Historic Landmark. This rendering is also similar to potential visual effects from northern Cape Poge on Martha's Vineyard.

At night, the flashing red FAA-required lights will be visible to the viewer at the shore in this area (see Figure 3-55). The amber USCG-required lights, designed to be visible only within 2 miles (3.2 km), should not be seen onshore. The Project's flashing lights and comparatively low ambient light conditions will create a visual change to the existing relatively unbroken night time view under clear sky conditions.

Monomoy Handkerchief Shoal Sub-site

Construction and Decommissioning

No submerged historic properties or archaeological resources have been identified and no wrecks recorded within this sub-site. The archaeological sensitivity for this sub-site is anticipated to be moderate for Euro-American submerged cultural resources, because of the area's documented vessel losses and relatively close proximity to the shipping route between Hyannis and Nantucket Harbors. The archaeological sensitivity for ancient Native American submerged cultural resources is also anticipated to be moderate, because of the Alternative sub-site's proximity to previously identified potentially archaeologically sensitive areas within the nearby Horseshoe Shoal sub-site, areas of variable bathymetry, and protected location from the ocean.

If this sub-site is selected, the area of physical disturbance associated with Project construction and operation would be subjected to further archaeological evaluation, as described for the Horseshoe Shoal Sub-site.

Construction and decommissioning equipment and vessels will be visible from shoreline historic properties with open views toward the Alternative. These visual impacts will be temporary. Permanent visual effects due to Project operation/maintenance are discussed below.

Operation and Maintenance

The closest historic property to this sub-site is the NRHP-listed Monomoy Lighthouse at the southern end of Monomoy Island. Day and night photo renderings were prepared at the proposed distances from this historic property (see Figures 3-56 and 3-57). In the day time rendering, the turbines are from 6.4 to 11 miles (10.3-17.7 km) away, and 83 percent of the 130 proposed turbines are visible in the rendering. At these distances, the grid layout of the turbines is discernable.

The day and night photo renderings are generally representative of what would be seen from Cape Cod shoreline areas in Chatham, Harwich, Dennis, Yarmouth and eastern Hyannis, including the Kennedy Compound and Hyannis Port. There are no designated historic properties designated along the shoreline between Chatham west to Yarmouth (see Table 3-21 and Figure 3-32).

At night, the red FAA-required lights will be visible to the viewer at the shore in this area (see Figure 3-57). The amber USCG-required lights are designed to be visible only within 2 miles (3.2 km) and therefore should not be seen from the shore. The Wind Park's flashing lights and comparatively low ambient light conditions at Monomoy Light will create a visual change to the existing relatively unbroken night time view under clear sky conditions.

Tuckernuck Shoal Sub-site

Construction and Decommissioning

No submerged historic properties or archaeological resources have been identified and no wrecks recorded within this sub-site. The archaeological sensitivity for this sub-site is anticipated to be high for Euro-American submerged cultural resources, because of the area's navigation hazards, relatively close proximity to the Main Channel, charted shipwrecks (2) and large number of documented shipwrecks in the vicinity (85). The archaeological sensitivity for ancient Native American submerged cultural resources is also anticipated to be high, because of the sub-site's variable bathymetry, proximity to the Main and Muskeget channels (potential former river beds) and somewhat protected location from the ocean.

To confirm the presence or absence of potentially significant archaeological resources, the area of physical disturbance associated with the Project at this sub-site would be subjected to further archaeological evaluation.

Construction and decommissioning equipment and vessels will be visible from shoreline historic properties with open views toward the sub-site. These visual impacts will be temporary. Permanent visual effects due to Project operation/maintenance are discussed below.

Operation and Maintenance

The closest historic property to this sub-site is the NRHP-listed Cape Poge Lighthouse on Martha's Vineyard. Day time and night time renderings were prepared at distances from this historic property to this layout, as shown on Figures 3-58 and 3-59). In the day time rendering, the turbines are from 3.9 to 15.2 miles (6.3-24.4 km) away. Approximately 99 percent of the turbines are visible in the photo rendering. The grid pattern of the layout is easily discernable, as are the rotor blades and nacelles on the turbines. This rendering shows similar views to what would be experienced from the northwest side of Nantucket. This sub-site would be barely visible from the south coast of Cape Cod.

The flashing red FAA-required lights will be visible to the viewer at the shore in this area (see Figure 3-59). However, the USCG-required lights will not, as discussed with regard to the Monomoy Handkerchief Shoal sub-site. With the addition of each WTGs lights, a visual change to the existing relatively unbroken night time view is anticipated under clear sky conditions.

South of Tuckernuck Island Alternative

Construction and Decommissioning

No submerged historic properties or archaeological resources have been identified and no wrecks recorded within this Alternative. A low archaeological sensitivity has been assigned for potential Euro-American submerged cultural resources, because of its distance from charted channels, ports and navigation hazards, as well as the small number of documented shipwrecks (1) reported in the vicinity. A low archaeological sensitivity for ancient Native American submerged cultural resources has also been assigned, due to the area's homogenous bathymetry and largely unprotected ocean location.

Construction and decommissioning equipment and vessels will be visible from shoreline historic properties with open views toward the Alternative. These visual impacts will be temporary. Permanent visual effects due to Project operation/maintenance are discussed below.

Operation and Maintenance

The closest historic property to this Alternative is Madaket Beach along the southwest side of Nantucket. The beach is considered a historic property because the entire island of Nantucket is a National Historic Landmark. Day time and night time photo renderings were prepared at distances from this historic property to the wind turbine array (see Figures 3-60 and 3-61). In the day time rendering (Figure 3-60), the turbines are from 3.8 to 12.3 miles (6.1-19.8 km) from the viewer. Approximately 47 percent of the turbines are visible in the photo rendering. The grid layout, nacelles and access platforms are discernable to the viewer at this location.

This view is similar to what would be experienced from other areas in southwestern Nantucket, and from Cape Poge on Martha's Vineyard. These properties are listed in Table 3-22; locations are shown on Figure 3-33. This Alternative would not be visible from Cape Cod.

Figure 3-61 depicts the flashing red FAA-required lights visible to the viewer at the shore in this area. As the USCG-required lights are designed to be only visible for 2 miles, they should not be seen onshore. The Project's flashing lights, however, and low ambient light conditions at Madaket Beach and vicinity will create a visual change to the existing night time conditions under clear skies.

New Bedford / Reduced Horseshoe Shoal Alternative

Construction and Decommissioning

New Bedford Sub-site: Because one historic shipwreck archaeological site has been identified within the southwest corner of the Alternative, additional investigation will be required prior to ground disturbance to evaluate the extent and potential National Register eligibility of this scatter site. A high archaeological sensitivity has been assigned for potential Euro-American submerged cultural resources, due to the area's documented vessel losses, maritime activity and navigational hazards. Additionally, a moderate archaeological sensitivity for ancient Native American submerged cultural resources has been assigned because of the area's proximity to the archaeologically sensitive Acushnet River area, somewhat variable bathymetry and waters protected from the open Atlantic Ocean.

Prior to construction, a marine archaeological reconnaissance survey within the offshore Project APE would likely be required to locate targets that have potential to be submerged cultural resources. This would consist of additional background research, geophysical and geotechnical survey.

Reduced Horseshoe Shoal Sub-site: For potential impacts to archaeological sites, please refer to the previous description for the 130 turbine proposed Horseshoe Shoal Alternative sub-site under the Nantucket Sound Alternative. Construction and decommissioning equipment and vessels will be visible from shoreline historic properties with open views toward the Alternative. These visual impacts will be temporary. Permanent visual effects due to Project operation/maintenance are discussed below.

Operation and Maintenance

New Bedford Sub-site: The closest historic property to the New Bedford sub-site is the shoreline area of the Padanaram Historic District in South Dartmouth, which is from 0.9 to 4.58 miles (1.4-7.4 km) away from the offshore WTGs. This historic district is the closest historic property to proposed turbines of any of the Alternatives, and as a result was selected for day time and night time renderings (see Figures 3-64 and 3-65). Approximately 96 percent of the turbines are in view within the day time rendering (Figure 3-64). Turbine components such as the rotor blades, nacelles and access platforms are easy to discern on the closest structures. Other shoreline historic properties with views toward this Alternative are, at increasing distances, New Bedford, Fairhaven, Mattappoisett, Marion, Bourne and Falmouth. These are listed in Table 3-23; locations are shown on Figure 3-34.

Although offshore New Bedford and Buzzards Bay may offer higher levels of ambient night time light (not shown on generic nightscape used for the night time photo rendering), the closeness of the structures will make the

flashing FAA-required lights very visible (see Figure 3-65). In addition, the amber USCG-required lights will also be visible to viewers within 2 miles (3.2 km).

Reduced Horseshoe Shoal Sub-site: This sub-site omits 16 of the 18 closest foreground turbines proposed for the 130-turbine Alternative to the southern Cape Cod shoreline, making the closest turbines 0.5 mile (0.8 km) more distant than the full 130 WTG Horseshoe Shoal Alternative. Turbines in this reduced array are from 6.24 to 12.63 miles (10-20.3 km) from the onshore viewer. Approximately 91 percent of the turbines are visible in the day time rendering (see Figure 3-62). The day and night renderings (Figures 3-62 and 3-63) can be compared to those for the Horseshoe Shoal sub-site (Figures 3-54 and 3-55).

Because the closest structures are perceived as the largest from the perspective of the onshore viewer, the omission reduces the day time visual impact to a limited degree (see Figure 3-62). At night, some of the higher intensity FAA-required lights on the foreground turbines are also omitted from the viewscape, again lessening the visual impact to a limited degree (see Figure 3-63). Nonetheless, the day and night renderings for this reduced Alternative appear very similar to views shown for the 130-turbine Horseshoe Shoal Alternative.

The Wind Park's flashing lights and somewhat low ambient light conditions from the Wianno Historic District and vicinity will create a visual change to the existing relatively unbroken night time view under clear sky conditions.

Comparative Summary of Impacts

Two historic properties (structures associated with Camp Edwards military activities) are located within the MMR Alternative. No other known historic properties are located within the layout of the other Alternatives. None of the Alternatives will result in a direct physical disturbance of known historic or archaeological sites, but there is the possibility that unidentified sites are present.

Visual contrast of the proposed built Wind Park with the existing land/seascape is greatest at all the offshore Alternatives (Figures 3-54 and 3-58), which provide largely natural seascapes. The exception is the New Bedford Alternative (Figures 3-64 and 3-65)where the existing views encompass the activity and development typical at the entrance to a busy urban port city and the entrance to Buzzards Bay and the Cape Cod Canal. The visual contrast at the onshore MMR Alternative (Figure 3-53) is also less than the offshore Alternatives, as this viewscape contains existing high structures and other built features.

This visual contrast is expected for both day and night views, as the relatively low ambient light of the more remote offshore Alternatives renders the night lighting more visible than in more developed viewscapes such as New Bedford and MMR. Because a generic nightscape was used for the night photo renderings, actual ambient light is not represented on the night time figures.

However, the proposed WTG array at the New Bedford Alternative is the closest to any onshore historic property of the offshore Alternatives under consideration, with the nearest turbine located 0.9 mile (1.4 km) from the shoreline at the Padanaram Historic District in South Dartmouth. The closest WTGs at the MMR Alternative are 0.81 mile (1.3 km) from the Sagamore Bridge, which has been evaluated eligible for listing on the NRHP (as has the Bourne Bridge).

The Horseshoe Shoal (Figures 3-54, 3-55, 3-62, and 3-63) and Tuckernuck Shoal (Figures 3-58 and 3-59) sub-sites in Nantucket Sound are within the viewshed of the largest number of historic properties of the Alternatives. These are located along the south side of Cape Cod, northeast Martha's Vineyard and northern Nantucket. The Monomoy Handkerchief Shoal sub-site (Figures 3-56 and 3-57) has the least historic properties in the viewshed. With the exception of Monomoy Light, there are no designated historic properties designated along the shoreline between Chatham west to Yarmouth.

3.4.3.4.12 Aesthetic/Landscape/Visual

This section describes the visual studies conducted to prepare day time and night time photo renderings of expected views of the proposed WTG arrays at the Alternatives under consideration. The purpose of the visual studies was to show the anticipated visual changes using high resolution computer-enhanced image processing to

create realistic photo renderings of views to the built turbines from the selected locations. Seven layouts at six sites were evaluated as part of this process. The locations selected for visual modeling were generally the onshore historic property closest to each Alternative with an open unobstructed view of the layout. These selected locations are also representative of nearby recreational resources in the viewshed, such as beaches and conservation areas.

For purposes of this screening analysis, the onshore viewshed for offshore Alternatives is considered to be shoreline areas oriented to experience open unobstructed views of the built WTGs, extending 300 feet (91.4 m) landward from the shoreline. Due to the foreground screening typically provided away from the immediate shoreline by mature vegetation, intervening structures and topography, this area adequately represents the viewshed for each offshore Alternative. The viewshed for the MMR Alternative is considered to be areas within 300 feet (91.4 m) of the MMR Alternative, as well as more distant areas along the Cape Cod Canal, areas adjacent to and including the bluffs along the north side of the Canal to the east and west, and the northwest portion of Sandwich. Historic properties and recreational resources within these viewshed areas were identified, as described in Sections 3.4.3.2.11 and 3.4.3.2.13, respectively. For purposes of this screening analysis, areas to the west, south and east of the MMR Site were considered visually screened by foreground mature vegetation and intervening topography.

The visual methodology used to create the photo renderings of the built Alternatives is described in the Appendix 3-K, entitled “Photo Rendering Methodology” prepared by EDR, PC. The methodology specific to the onshore MMR Alternative is summarized in the section below. The methodology common to all the photo renderings of the offshore Alternatives follows. The day time and night time photo renderings are shown in Figures 3-53 through 3-65.

The visual contrast of the aboveground turbines at each of the Alternatives to the character of the existing landscape or seascape is described in this section. Visual impacts to historic properties and recreational resources are described in Sections 3.4.3.4.11 and 3.4.3.4.13, respectively.

Massachusetts Military Reservation

Construction and Decommissioning

Construction and decommissioning equipment will be visible under clear sky conditions from onshore and offshore locations with open views toward the MMR Alternative. These visual impacts will be temporary. Given the vegetation screening and topographic features, the visual affects are less than those associated with the offshore Alternatives.

Operation and Maintenance

The view toward the MMR Alternative from the Sagamore Bridge was selected for day and night photo renderings representative of the visual change that would result from the built Project as seen from nearby historic and recreational resources, including the Bourne Bridge and the Cape Cod Canal area. A day time visual photo rendering was prepared for the MMR Alternative, showing the expected view of the array as it would appear to southbound travelers coming onto the Cape from the Sagamore Bridge (see Figure 3-53). Both bridges have been evaluated as eligible for listing on the NRHP; the Canal is a National Historic Civil Engineering Landmark. The photo rendering from the Sagamore Bridge was considered as being representative of area visual resources.

To produce the renderings, day time color photographs of the existing viewscape toward the proposed MMR array were taken on January 23, 2004 from three viewpoint locations on the sidewalk along the east side of the Sagamore Bridge. At each of these viewpoints, the exact location of a tripod-mounted camera was determined using GPS survey equipment. Bearings of each sequential photograph of the viewscape south of the Canal were measured using a compass. Locations of other known features in the view were also determined using field GPS and aerial photographs. Color photographs were taken with a 35 mm Olympus OM-10 SLR camera using a 50 mm setting, to simulate normal human eyesight relative to scale. Field conditions were clear, cold and sunny.

After reviewing the Sagamore Bridge photos, one viewpoint out of the three was selected because it offered the most open, unobstructed publicly-accessible view toward the MMR Site, and therefore represented a worst-case view of the MMR array as it would be seen from the Bridge. Visibility to either side of the Bridge is obscured in the other two higher viewpoints, due to densely-gridded safety fencing that is in place along the upper elevations of the Bridge.

At this point, methodology for the onshore and offshore renderings (which used a generic seascape rather than a site-specific photograph) coincides. The photographs and locational information were imported into an AutoCAD 2000r drawing of the MMR layout plan. The two-dimensional AutoCAD data was imported into 3D Studio Max 6.0. The 3D layout was superimposed over the photographs, and minor changes were made to align all known reference points, to ensure that, to the extent possible, Project elements and locations, scale and perspective are accurate and true to the proposed design and scale. Additional information on the methodology is included in Appendix 3-K.

The day rendering for the MMR Alternative was prepared using photographs of 1.5 MW built turbines, which are operational at the Fenner Project in New York State. These turbines are similar in size, design and nacelle shape to the proposed upland turbines. For specifics on the dimensions and lighting of the turbines used in the rendering, please see Appendix 3-K.

The photo rendering of the MMR Alternative shows that 50 percent of the proposed turbines are visible in the field of view from the Sagamore Bridge viewpoint. The turbines range from 0.81 to 6.25 miles (1.3-10 km) from the viewer. The bases of the turbines are screened from view, due to topography and mature vegetation. Note that additional WTGs are located outside the photograph to either side, and would be visible to the viewer.

The existing Sagamore Bridge viewpoint (see Figure 3-36) includes a number of existing built features already in the landscape, including the blades of an artificial windmill at the Christmas Tree Shop at the base of the Sagamore Bridge (see lower left on figure), the busy Route 6 on and off ramps, adjacent commercial buildings, and the tall lights that illuminate the Sagamore Bridge and the nearby Cape Cod Outlet Mall and parking areas. In the panorama outside the photograph are other built features such as electric transmission lines, cell towers, other busy transportation corridors and a power plant stack. The addition of WTGs into the viewscape, while clearly visible, does not seem out of character for this area, where infrastructure converges to serve Cape Cod and the Islands as a whole.

It was determined that usable night time photographs to accurately model what the human eye can perceive were not obtainable from the viewpoint location, due to the high foreground ambient light on the Bridge, which is floodlit, midground lighting from area buildings and roads, and bridge vibrations and headlight interference from passing vehicles. Although the lighted turbines would likely be clearly visible to the southbound traveler over the Sagamore Bridge and Bourne Bridge, the high levels of existing ambient light would minimize the visual contrast at night. Again, the lighted turbines would be an addition to a viewscape that already contains significant artificial light.

The following section contains the methodology employed to prepare the photo renderings for all the offshore Alternatives. Photo renderings from one onshore viewpoint closest to each of the three Nantucket Sound sub-sites were prepared, and are described in the appropriate sections below. The visual contrast of the aboveground turbines at each of the Alternatives to the character of the existing landscape or seascape is described in this section.

Methodology for Visual Modeling of Offshore Alternatives

Although a site-specific photograph was used to model views toward the MMR Alternative, photo renderings of the alternate offshore sites/layouts were prepared using a generic seascape photograph as the background for each offshore rendering. The generic photograph (see Figure 3-35) shows a section of beach, an expanse of open water, and a horizon line that essentially could represent an open unobstructed shoreline view from any of the selected locations. However, the distance and direction of views from each viewpoint location reflects the correct distance to and orientation of the layout as it would be visible from that location (even though the photo was not obtained from those locations). The onshore historic properties selected to illustrate views of the proposed offshore Alternatives are provided below in Table 3-53.

The preparation of photo renderings from these locations adequately illustrates potential visibility and visual impact of Project Alternatives from Cape Cod, Nantucket, Martha's Vineyard and the New Bedford area. Figures 3-54 through 3-65 show the day and night time photo renderings produced for the offshore Alternatives.

The model incorporated the visible components of the structures and lighting proposed for the offshore Alternatives. Input parameters included the appropriate number of 3.6 MW GE wind turbines, each mounted on 246 foot (75 m)-tall tubular steel monopole towers. The 3-bladed rotors have a diameter of approximately 341 feet (104 m) and will reach a maximum height of approximately 417 feet (127 m) above sea level. Each tower has a service platform located approximately 30 feet (10 m) above the water surface. The turbines are arranged in a grid pattern with an approximate separation distance of 0.34 to 0.54 nautical miles (629-1,000 meters). All built components of the offshore structures are proposed to be a marine gray color.

A consistent day time natural lighting scenario was used for all the renderings, to allow for direct comparison of the Alternatives. At distances of more than 3 to 4 miles (4.8 to 6.4 km) from the viewer at sea level, the curvature of the earth would begin to obscure the bases of the turbines from all of the selected locations (except at the New Bedford Alternative sub-site, which is closer to South Dartmouth). However, because the degree of screening cannot be accurately determined, in views where the turbines are over 3 miles (4.8 km) from the viewer, the renderings were created by placing the turbines on the visible horizon (again a worst case presentation of views).

For the purposes of this study it was assumed that every other offshore perimeter wind turbine would be illuminated at night with dual aviation warning lights (white strobes [FAA L865] during the day and flashing medium intensity red lights [FAA L864] at night) mounted on the nacelle. The remaining perimeter turbines would be marked day and night with two flashing low intensity red lights (FAA L810). Interior turbines would each have two flashing low intensity red lights (L810) at night and during the day time. USCG amber navigation warning lights will be installed on each tower approximately 35 feet (1.2 m) above the water's surface.

This data was used to construct to-scale computer models of the alternate arrays evaluated in this analysis. All visible facilities were modeled to scale and in the proper geographic location and elevation using 3D Studio Max 6.0® software. Details about the modeling process that created the photo renderings are included in the Appendix 3-K.

Night time renderings were also prepared using a generic night time photograph. To allow for a worst case evaluation, a dark photo was chosen, which may not accurately illustrate any existing light sources that could be visible from the selected location and in the direction of view. Because the FAA warning lights will be flashing, the proposed flashing rate (20 FPM) was used to animate the computer model lights, with each interior turbine flashing randomly (rather than synchronized). Each simulation is essentially a snap shot that shows the Project at one moment in time (i.e. 1/30th of a second) with some portion (in the range of 50-65 percent) of the interior lights on. All of the perimeter lights are illuminated, as the flashing of these lights is proposed to be synchronized. Due to the effects of distance, no visible lighting from the USCG navigation warning lights was shown in the night time renderings, except in the view of the New Bedford sub-site from South Dartmouth.

Based upon a review of the day and night photo renderings for each Alternative, changes to the existing landscape or seascape character are described below.

Nantucket Sound Alternative

Construction and Decommissioning

Construction and decommissioning equipment and vessels will be visible under clear sky conditions from onshore and offshore locations with open views toward each Alternative. These visual impacts will be temporary. The visual effects of construction and decommissioning activities described above are the same for all locations and are not repeated in the discussion of the Alternatives below. Permanent visual changes to the seascape expected due to Project operation at each of the Alternatives follows.

Horseshoe Shoal Sub-site

Operation and Maintenance

The existing Nantucket Sound seascape in the vicinity of this offshore Alternative sub-site contains a large expanse of open water, rimmed by the low-lying landforms of the Cape and the Islands. The character of the viewscape is not fragmented, and is consistent with a natural unified nearshore southern New England seascape. Activity is currently limited to recreational and fishing boats, ferries, navigational aids, and aircraft flying overhead.

Under clear sky conditions, viewers within approximately 6 miles (9.7 km) of this Alternative will experience views similar to that shown on the day time photo rendering for the Horseshoe Shoal sub-site, representing expected views from the Wianno Historic District (see Figure 3-54). The full horizon is in view and there is no visual screening from topography or intervening vegetation available. At this distance and direction, approximately 91 percent of the 130 turbines are visible. The grid layout is visible, as are individual structural components such as rotor blades.

The size and perspective of the turbine array will be a function of the viewer's location and orientation at sea level. Turbines will appear darker or lighter against the sky, based upon the position of the sun and shadows cast at different times of the day. The Project will add a built element to existing views of the seascape, and cause a change in day time views of the Horseshoe Shoal area as presently experienced by viewers of the existing seascape.

As shown on the night time photo rendering representing expected views from the Wianno Historic District (Figure 3-55), under clear sky conditions the FAA-required aviation warning lights mounted on each turbine will be visible. The flashing lights will create a visual change to the existing relatively unbroken night time view under clear sky conditions.

The greatest visibility and visual contrast will occur at undeveloped or lightly developed sites with dark skies, such as in offshore waters and on Cape Poge or Tuckernuck Island. Ambient light in more developed areas significantly reduces the visibility and contrast of the lights against the night sky. Note that because a dark generic seascape with virtually no ambient lighting was used for the photo renderings to represent a worst case, slight differences in site-specific ambient light are not represented on the photo renderings. Depending on background features of the viewshed some sites differ relative to existing night time light sources, into which the WTG lights will merge.

Monomoy-Handkerchief Shoal Sub-site

Operation and Maintenance

The general seascape description for the Horseshoe Shoal sub-site above also applies to the potential visual changes from Monomoy Island. Under clear sky conditions, viewers within approximately 6 miles (9.7 km) of the WTG array (such as south-facing shoreline viewers in Chatham, Harwich, Dennis and Yarmouth and visitors to the Monomoy National Wildlife Refuge on Monomoy Island) will experience day time views similar to those on the Handkerchief Shoal sub-site rendering representing expected views from Monomoy Lighthouse (see Figure 3-56). At this remote natural area, the full horizon is in view and there is no visual screening from topography or intervening vegetation available. At this distance and direction, approximately 83 percent of the 130 turbines are visible in the rendering, at distances ranging from 6.4 to 11 miles (10.3-17.7 km). The grid layout is visible, as are individual structural components such as rotor blades, nacelles and access platforms.

As shown on the night time photo rendering representing expected views from Monomoy Lighthouse (Figure 3-57), under clear sky conditions the FAA-required aviation warning lights mounted on each turbine will be visible from this location. The flashing lights will create a visual change to the existing relatively unbroken night time view, which has low ambient light, under clear sky conditions.

Tuckernuck Shoal Sub-site

Operation and Maintenance

The general seascape description for the first two sub-sites also applies to the potential visual changes as seen from Cape Poge and the north side of Nantucket for the Tuckernuck Shoal sub-site. The full horizon is in view and there is no visual screening from topography or intervening vegetation available. At this distance and direction from remote Cape Poge Lighthouse, approximately 99 percent of the 130 proposed turbines are visible in the day time photo rendering (see Figure 3-58), at distances ranging from 3.9 to 15.2 miles (6.3-24.5 km). The grid layout is apparent, as are individual structural components such as rotor blades, nacelles and access platforms.

As shown on the night time photo rendering from Cape Poge Lighthouse (Figure 3-59), the FAA-required aviation warning lights on each WTG will be visible under clear sky conditions. Compared with the existing relatively unbroken dark night time view from this location, which has low ambient light, under clear sky conditions, the flashing lights will create a visual change.

South of Tuckernuck Island Alternative

Operation and Maintenance

The existing seascape toward the South of Tuckernuck Island Alternative contains open ocean (again, not shown in the generic photograph used for the rendering). The character of the viewscape is not fragmented, and is consistent with a natural unified southern New England ocean view. Tankers, freighters and other large commercial ships, as well as large recreational vessels, transit the area to the south of the Islands.

In the day time photo rendering for this location (see Figure 3-60), the full horizon is in view and there is no visual screening from topography or intervening vegetation available. At this distance and direction from Madaket Beach, approximately 47 percent of the turbines are visible in the rendering, although additional turbines in the layout would be visible to the viewer to the right and left outside of the photograph. Distances of the turbines from the beach range from 3.8 to 12.3 miles (6.1-19.8 km). The grid layout is apparent, as are individual structural components such as rotor blades, nacelles and access platforms.

Figure 3-61 shows the night time photo rendering under clear sky conditions. FAA-required aviation warning lights mounted on each turbine will be visible and create a visual difference to the existing night time view from this location, which has low ambient light, under clear sky conditions.

New Bedford/Reduced Horseshoe Shoal Alternative

Operation and Maintenance

New Bedford Sub-site: The existing viewscape in the vicinity of the New Bedford sub-site includes developed shoreline and headlands, overlooking the outer New Bedford Harbor, a busy fishing and industrial port. The seascape in Buzzards Bay also reflects commerce and maritime use of the area, with large vessels transiting Buzzards Bay and the Cape Cod Canal year-round, fishing boats, and numerous recreational boats in the warmer months. Nonetheless, the closeness of the proposed turbines (0.9 to 4.58 miles (1.4-7.4 km)) to the shoreline at the day time photo rendering for this location (see Padanaram Historic District shoreline on Figure 3-64) results in a visual contrast during both day and night conditions. At night, USCG amber lights will also be visible at locations less than 2 miles (3.2 km), as shown on the night rendering (see Figure 3-65).

Reduced Horseshoe Shoal Sub-site: At the Horseshoe Shoal sub-site in Nantucket Sound, 16 of the 18 closest foreground turbines proposed for the 130-turbine Alternative were omitted for the reduced sub-site. These structures are perceived as the largest from the perspective of the onshore viewer, and the omission reduces the day time visual impact to a limited degree (see Figure 3-62 representing views from the Wianno Historic District). At night, some of the higher intensity FAA-required lights on the foreground turbines are also omitted from the viewscape, again lessening the visual impact to a limited degree (see Figure 3-63, Wianno

Historic District). Nonetheless, the day and night renderings for this reduced sub-site appear very similar to views shown for the 130-turbine Horseshoe Shoal sub-site.

Comparative Summary of Impacts

For purposes of comparison, all the day photo renderings were produced using the same lighting conditions.

The MMR Alternative is the only one of the Alternatives that offers partial visual screening due to mature vegetation and topography (see Figure 3-53). The existing built features already in the viewshed result in less visual contrast when the turbines are added to the landscape than for the offshore Alternatives. As described in the sections below, a night time photo rendering from the Sagamore Bridge toward the MMR Alternative was not produced due to interference from high levels of ambient light and other factors, which prevented an accurate portrayal of the background landscape at night. Nonetheless, although the FAA-required lights would likely be clearly visible to the southbound traveler over the Sagamore Bridge (and the Bourne Bridge), the high levels of existing ambient light in those areas would serve to minimize the visual contrast at night. Again, the lighted turbines at the MMR Alternative would be an addition to a viewscape that already contains significant artificial light.

The existing seascapes in the vicinity of the offshore Alternatives contain large expanses of open water. In the cases of the Nantucket Sound sub-sites, the water is rimmed by the low-lying landforms of the Cape and the Islands. The South of Tuckernuck Island Alternative is located in open ocean. At all the offshore Alternatives except for the New Bedford sub-site, where more regional screening is available due to headlands and embayments, the full horizon is in view.

As discussed in Section 5.10, the greatest Project visibility and visual contrast is expected to occur at distances of less than 8 miles (12.9 km), within which all the WTGs will be visible within the field of view. Beyond this distance, Project structures become more obscure and certain components, such as rotor blades, become difficult to see. The grid pattern of the turbine layout will also be visible within this distance. Turbines will appear darker or lighter against the sky, based upon the position of the sun and shadows cast at different times of the day.

The Project will add a built element to existing views of the natural seascape, and cause changes in day time views of the largely natural offshore Alternatives. At night under clear sky conditions, the flashing lights of the offshore Alternatives will create a visual change to the existing relatively unbroken night time views, especially at remote locations with low levels of ambient light under clear sky conditions. The Monomoy-Handkerchief Shoal sub-site would have the greatest visual impact to the Monomoy National Wildlife Refuge on nearby Monomoy Island.

The seascape in Buzzards Bay reflects both commercial and recreational maritime use of the area, with large vessels transiting Buzzards Bay and the Cape Cod Canal year-round, and fishing boats, and numerous recreational boats in the warmer months. Nonetheless, the closeness of the proposed turbines (0.9 to 4.58 miles (1.4-7.4 km)) to the shoreline at the photo rendering location (see Figure 3-64) results in a visual contrast during both day and night conditions. At night, USCG amber lights will be visible at onshore locations less than 2 miles (3.2 km) (see Figure 3-65).

At the Horseshoe Shoal sub-site in Nantucket Sound, 16 of the 18 closest foreground turbines proposed for the 130-turbine Alternative were omitted for the combined New Bedford/Horseshoe Shoal Alternative (see Figures 3-62 and 3-63). These structures are perceived as the largest from the perspective of the onshore viewer, and the omission reduces the visual impact to a limited degree. At night, because some of the closest WTGs to the shoreline have been dropped from the reduced array, their associated FAA-required lights are also omitted. Because these foreground lights would appear brighter than FAA lights on more distant WTGs due to their relative nearness to the shoreline viewer, their omission would lessen the visual impact to a limited degree.

3.4.3.4.13 Recreation

This section describes potential impacts to onshore and offshore recreational resources, including users of recreational resources, for each Alternative Site under consideration. Potential impacts include direct physical

effects and visual effects of construction/decommissioning and operation/maintenance of the Wind Park at each Alternative Site. Potential impacts to recreational fishing are described in Section 3.4.3.4.5.

Massachusetts Military Reservation

Construction and Decommissioning

Physical Impacts
Because the upland MMR Alternative Site is within the MMR facility, a restricted-access military base, there will be no direct physical impacts to onshore public recreational resources due to the Project. No recreational resources available to users of MMR within the Alternative Site have been identified at this time (see Figure 3-37 and Table 3-24).

Visual Impacts
During clear days and nights, users of nearby onshore recreational resources and boaters in the Cape Cod Canal area will experience partially screened views of the upper parts of northernmost WTG structures, and associated heavy equipment such as cranes (see Figure 3-53 for a representative view from the Sagamore Bridge). The most open views of construction operations will be experienced by boaters transiting the Canal, and users of the bike path and associated recreational areas especially along the north side of the Canal. The turbines will also be visible from the Bourne Bridge and nearby vantage points with open views to the southeast. Although the Shawme-Crowell State Forest is generally well vegetated with mature forests, some open views of the WTGs may be available to campers, hikers and bird watchers. Recreational resources in these areas are shown on Figure 3-37 and Table 3-24.

Due to the mature vegetation and variable topography, widespread open visibility toward the MMR Alternative Site is not expected from onshore recreational resources to the west, south and southeast of the site, although intermittent visibility may be available.

Operation and Maintenance

Physical Impacts
No physical impacts are anticipated during operation and maintenance of the Wind Park at the MMR Alternative, as described above.

Visual Impacts
Recreational onshore users and boaters in the Cape Cod Canal area will experience partially screened views of the visible components of the upper parts of northernmost WTG structures during clear days and nights. Due to the hummocky topography of the upland and the mature vegetation, a number of the WTG structures will not be fully visible to area recreational users. However, turbines will be visible to the east and west beyond the limits of the photo rendering (compare Figure 3-53 and Figure3-44). The most open views of Project operation will be experienced by boaters transiting the Canal, and users of the bike path and associated recreational areas primarily along the north side of the Canal. Most of these recreational resources are operated by the USACE. Although the Shawme-Crowell State Forest is generally well vegetated with mature forests, some open views of the turbines may be available to campers, hikers and bird watchers.

The Project will add an additional built element to existing day time views presently experienced by recreational boaters and onshore recreational users. Existing views toward the MMR Site presently contain built structures, including cell and electric transmission line towers, the bridges over the Cape Cod Canal, and the stack at the Mirant Canal electric power plant.

At night under clear sky conditions from areas with project visibility, FAA-required aviation warning lights mounted on each turbine will be visible. No USCG lights will be required on these onshore WTGs. Although these lights will be visible, significant ambient light is present along the Canal, from lighting on the bridges and at the Cape Cod Outlet Mall off the Sagamore rotary, as well as ambient light from Sandwich, the Route 28 corridor and MMR itself. The ambient lighting from these developed areas will significantly reduce the visibility and

contrast of the WTG lights against the night sky from this Alternative Site. No night time rendering has been prepared for the MMR Alternative Site (see Section 3.4.3.4.12).

Nantucket Sound

Cape Cod, Martha's Vineyard, and Nantucket support a summer tourism industry that includes a variety of land based and water based recreational opportunities. Seasonal visitors to these areas, while driving, boating, swimming or otherwise recreating outdoors will be subject to an altered view of Nantucket Sound. Impacts are discussed in detail below.

Construction and Decommissioning

Physical Impacts

There will be no physical impacts to onshore recreational resources due to construction of the Project at this Alternative Site. Existing onshore recreational uses will continue undisturbed.

Nantucket Sound is a popular area for recreational boating (including fishing and diving). Some temporary physical impacts are anticipated to navigation by recreational boaters in the immediate vicinity of ongoing construction and decommissioning operations, to protect the safety of mariners. These measures, more fully described in Section 3.4.3.4.10 (Navigation), may include temporary vessel or channel access restrictions in the immediate vicinity of construction operations. Marine construction operations will be implemented in close coordination with the USCG and local Harbor Pilots. Construction activities will require that mariners be more attentive to their vessel's position and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the work areas. Other recreational activities such as diving, windsurfing, water skiing and jet skiing also occur within the Sound, but generally at locations closer to shore than any of the three sub-sites for this Alternative.

Visual Impacts

As shown on Figure 3-38 and Tables 3-25 through 3-27, there are many recreational resources located within 300 feet (91.4 m) of shoreline areas expected to have open and unobstructed views toward the Nantucket Sound Alternative sub-sites. Recreational users at shorefront locations and offshore boaters oriented toward the offshore Alternative Sites will experience open views of the visible components of the Wind Park during construction, including heavy equipment. No topographic or vegetative screening is feasible. A more detailed description is presented below.

Operation and Maintenance

Physical Impacts

As with the construction phase, there will be no physical impacts to onshore recreational resources due to operation of the Project at this Alternative Site. Existing onshore recreational uses will continue undisturbed.

Operation and maintenance of the Wind Park at each of the Nantucket Sound sub-site alternatives is expected to present minimal operational limitations to recreational vessel navigation in the vicinity. During periods of low visibility, light and sound signals mounted on offshore Project structures will serve as aids-to-navigation for recreational boaters in and around the Wind Park, as discussed in Navigation (Section 3.4.3.4.10). Those vessels not physically restricted from anchoring or operating in the areas of the offshore sub-site alternatives due to existing physical water depth limitations will still be able to use the waters. The spacing between the WTGs, in combination with NOAA chart revisions and establishment of private aids-to-navigation, will provide adequate watersheet area for unrestricted and safe navigational access in and around the Wind Park at each Alternative for recreational vessels (including fishermen and divers). However, the presence of the Wind Park will require that mariners be more attentive to their vessel's position and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the Wind Park.

Visual Impacts

The day and night photo renderings for the Horseshoe Shoal sub-site, the Monomoy Handkerchief Shoal sub-site (figure titled Handkerchief Shoal Alternative) and the Tuckernuck Shoal sub-site are presented as Figures 3-54

through 5-59, respectively. These renderings represent views as they would appear to users of recreational resources at the associated distances reported in the captions.

Recreational users at shorefront locations and offshore boaters oriented toward the Nantucket Sound sub-sites will experience open views of the visible components of the Wind Park during clear days and nights. No topographic or vegetative screening is feasible. The size and perspective of the turbine array will be a function of the viewer's location and orientation at sea level. As shown on Figure 3-38 and Tables 3-25 through 3-27, there are many recreational resources located within 300 feet (91.4 m) of shoreline areas expected to have open and unobstructed views toward the Nantucket Sound Alternative.

During clear day time conditions from a boat or shoreline recreational areas such as beaches oriented toward the sites, the full horizon is in view. No visual screening from topography or intervening vegetation is available. As discussed in Section 5.10, the greatest Project visibility and visual contrast is expected to occur at distances of less than 8 miles (12.9 km). Beyond this distance, Project structures become more obscure and certain components, such as rotor blades, become difficult to see. Generally, within 8 miles (12.9 km) all the WTGs and the ESP will be visible within the field of view. The grid pattern of the turbine layout will also be visible. Turbines will appear darker or lighter against the sky, based upon the position of the sun and shadows cast at different times of the day.

The project will add a built element to existing views of the seascape, and change day time views presently experienced by recreational users and boaters in Nantucket Sound.

At night under clear sky conditions within the viewshed, FAA-required aviation warning lights mounted on each turbine will be visible from recreational resources in the viewshed of the three Nantucket Sound sub-sites (see Figures 3-55, 3-57, and 3-59). These include two medium-intensity red flashing lights mounted on the nacelle of every other perimeter turbine, and two low-intensity red lights on each of the remaining turbines. Amber USCG-required navigation lights will be installed on each turbine at about 35 feet above the water. The amber lights on perimeter WTGs are designed to only be visible to viewers within 2 miles (3.2 km); the amber lights on interior WTGs are designed to be visible to viewers within 0.5 nautical miles (0.9 km). The flashing lights will create a visual change to the existing relatively unbroken night time view under clear sky conditions.

Greatest visibility and visual contrast will occur at undeveloped or lightly developed sites with dark skies, such as on Cape Poge, Monomoy Island or Tuckernuck Island. Ambient light in developed areas, such as within shorefront towns and villages, significantly reduces the visibility and contrast of the lights against the night sky. Ambient light is not shown on the generic nightscape used for the night time photo renderings.

South of Tuckernuck Island

Construction and Decommissioning

Physical Impacts

There will be no physical impacts to onshore recreational resources due to construction of the Project at this Alternative Site. Existing onshore recreational uses will continue undisturbed.

Fewer recreational boaters are expected within this Alternative Site (as compared to the other two offshore alternatives) due to the more open ocean conditions. Few, if any, windsurfers, waterskiers, divers or jet skiers are expected at this site, due to open ocean conditions.

Visual Impacts

Visual impacts at this Alternative are similar to the Nantucket Sound Alternative as described above.

Operation and Maintenance

Physical Impacts

Existing onshore recreational uses will continue undisturbed, as no physical impacts to onshore recreational resources will occur due to operation of the Project at this Alternative Site.

Potential physical impacts to offshore recreation are similar to the Nantucket Sound Alternative as described above.

Visual Impacts
The day time photo rendering for the South of Tuckernuck Island Alternative (see Figure 3-60) shows expected views of this Alternative from recreational resources along the southwest side of Nantucket and the southeast side of Martha's Vineyard, as well as offshore boaters oriented toward the site. These viewers will be able to see the WTGs at this Alternative Site during clear days and night. No topographic or vegetative screening is feasible. The size and perspective of the turbine array will be a function of the viewer's location and orientation at sea level. Recreational resources in these viewshed areas are shown on Figure 3-39 and Table 3-28. In general, compared to the Nantucket Sound Alternative Site, fewer individuals will be affected by the altered viewshed, since the two nearby islands do not support, either year-round or seasonally, the number of people as Cape Cod.

At night, the greatest visual contrast will occur at undeveloped or lightly developed sites with dark skies, such as from onshore locations within the viewshed of this Alternative Site (see Figure 3-61). Few recreational boaters would be expected at night in the vicinity of this site due to open ocean conditions.

Additional details on day and night visibility also relevant to this Alternative Site are presented in the appropriate Nantucket Sound Alternative section above.

New Bedford / Reduced Horseshoe Shoal

This discussion is broken into the two respective components since the Horseshoe Shoal component is altered under this alternative scenario compared to the Horseshoe Shoal sub-site of the Nantucket Sound Alternative.

New Bedford Sub-site

Construction and Decommissioning

Physical Impacts
As is the case for the other offshore Alternatives, no physical impacts to onshore recreational resources due to construction of the Project are anticipated at this Alternative Site. Existing onshore recreational uses will continue undisturbed.

The vicinity of the New Bedford offshore Alternative Site within Buzzards Bay is a popular area for recreational boating. See applicable section discussed for Nantucket Sound navigation, above. Due to the nearshore location of this Alternative Site, more water skiers, windsurfers, divers and jet skiers could be expected to utilize these waters. Construction activities may temporarily limit use of construction work areas, for safety reasons.

Visual Impacts
During construction and decommissioning, visual impacts will be similar to those outlined in the Nantucket Sound Alternative above.

Operation and Maintenance

Physical Impacts
Existing onshore recreational uses will continue undisturbed. There will be no physical impacts to onshore recreational resources due to operation of the Project at this Alternative Site.

Potential physical impacts to offshore recreation are similar to the Nantucket Sound Alternative as described above. Due to the nearshore location of this Alternative Site, more water skiers, windsurfers, divers and jet skiers could be expected to utilize these waters. However, operation of the Project should not significantly interfere with these activities, as long as users remain aware of their locations relative to project structures. During periods of low visibility, light and sound signals mounted on offshore project structures will serve as aids-

to-navigation for recreational boaters in and around the Wind Park, as discussed in Navigation (Section 3.4.3.4.10).

Visual Impacts

The day time photo rendering entitled the New Bedford Alternative (see Figure 3-64) presents expected views of this Alternative Site from recreational resources in the South Dartmouth area. Onshore users of recreational resources along the eastern shorefront of South Dartmouth, and shoreline surrounding outer New Bedford Harbor in New Bedford and Dartmouth, as well as offshore boaters in Buzzards Bay oriented toward the site, will be able to see the WTGs at this Alternative Site during clear days and night. The night time photo rendering is presented as Figure 3-65). No vegetative screening is feasible. Because the shoreline contains more embayment and headlands than the open shorelines of the Cape and Islands, topography will help to screen views from shoreline areas not directly oriented toward the Alternative Site.

Recreational resources in these viewshed areas are shown on Figure 3-40 and listed on Table 3-29.

Reduced Horseshoe Shoal Sub-site

Potential physical impacts during construction and operation and visual impacts during construction are expected to be similar to the Nantucket Sound Alternative as described above.

Operation and Maintenance

Physical Impacts

The previous discussion of the Nantucket Sound Alternative remains relevant since the removal of 16 turbines for the Reduced Horseshoe Shoal sub-site does not represent a substantial change in the physical presence of the turbines in the Wind Park.

Visual Impacts

At Horseshoe Shoal in Nantucket Sound, 16 of the 18 closest turbines to Cape Cod proposed for the 130-turbine Alternative were omitted for the Reduced Alternative. These structures are perceived as the largest from the perspective of the onshore Cape Cod viewer, and the omission reduces the day time visual impact to a limited degree (see Figure 3-62). At night, some of the higher intensity FAA-required lights on the foreground turbines are also omitted from the viewscape, again lessening the visual impact to a limited degree (see Figure 3-63). Nonetheless, the day and night renderings for this Reduced Alternative appear very similar to views shown for the 130-turbine Horseshoe Shoal sub-site.

Comparative Summary of Impacts

Large vessels necessary for construction of the Wind Park at the offshore Alternative Sites may temporarily limit maritime recreational uses within the locally active construction areas, such as recreational boating. Construction of the New Bedford Alternative Site, which is closest to shore of all the offshore alternatives (less than one mile (1.6 km)), may temporarily limit use of the watersheet by water skiers, jet skiers and divers. The other Alternative Sites are sufficiently offshore to have more limited recreational activities. Additionally, the sandy substrates of the Nantucket Sound and South of Tuckernuck Island Alternative Sites are not generally of interest to recreational divers, but which could be enhanced by the presence of the turbines.

Operation of the Wind Park at all of the proposed Alternative Sites is expected to result in minimal limits to the use of, or physically affect the, recreational resources in or around the Wind Park. No recreational resources have been identified within the upland MMR Alternative Site, which is not accessible to the public. With respect to recreational boating, those vessels not physically restricted from anchoring or operating in the areas of the offshore proposed Alternatives due to existing physical depth limitations will still be able to use the waters at each offshore Alternative Site. Jet skiers, windsurfers and water skiers will still be able to conduct these activities within the offshore Alternative Sites, although all except for New Bedford are relatively distant from the shore.

At the offshore Alternative Sites, the presence of the Wind Park will require that mariners be more attentive to their vessel's position and the proximity of the WTGs and other vessels in and around the Wind Park. Each WTG

will be marked on NOAA charts, and together with associated light and sound signals, will add to the existing network of aids-to-navigation, which will assist recreational boaters, especially during times of poor visibility (see Section 3.4.3.4.10).

With respect to visual impacts to users of onshore recreational resources, shoreline areas with open unobstructed views toward the Nantucket Sound Alternative have more recreational resources identified by GIS in the viewshed than the other Alternative Sites under consideration. Shoreline recreation sites exist on Cape Cod, Martha's Vineyard and Nantucket that will all be visually affected by the presence of the wind park in their viewsheds.

Existing views of the seascape in the vicinity of all offshore sites except New Bedford generally contain large expanses of water, rimmed by low-lying landscape. The seascape in the vicinity of the New Bedford site contains more built features, consistent with the entrance to a busy port. The most altered viewshed will be the South of Tuckernuck Island Alternative Site, since no objects or land masses occur on the horizon to the south and no other permanent sources of light exist to the south. However, the Nantucket Sound Alternative Site has the potential to alter views for the greatest number of people, particularly during the summer tourism season. New Bedford has the potential for the least alteration of the viewshed of any offshore site, however, its impacts must be considered cumulatively with the Reduced Horseshoe Shoal sub-site impacts.

During Project construction and operation, recreational users at shorefront locations and offshore boaters oriented toward the offshore Alternative Sites will experience open views of the visible components of the Wind Park during clear days and nights. The Project at any of the offshore Alternative Sites will add a built element to existing views of the seascape. No topographic or vegetative screening is feasible.

The MMR Alternative is largely screened from recreational resources by variable topography and mature upland vegetation. The bases of the WTGs will be screened in areas of visibility, with the upper parts of the northernmost WTGs visible from the Cape Cod Canal area (see Figure 3-53)). The greatest visibility will be experienced by boaters transiting the Cape Cod Canal and onshore users of bikepaths and parks along the Canal, particularly along its north side. As shown on the MMR photo rendering from the Sagamore Bridge, the bases of a number of the visible WTGs are screened. The existing view toward the MMR Site contains built features, such as transmission and cell phone towers, the Mirant Canal stack and the bridges.

Night time visibility of the lighted WTGs will offer the most contrast from existing views at relatively dark undeveloped areas with low ambient light, such as sparsely populated onshore areas facing the Nantucket Sound sites and the South of Tuckernuck Island site. The MMR and New Bedford alternative sites are expected to have the most ambient light, which will decrease the visibility of Wind Park lighting, although the New Bedford Alternative is closest to land of the offshore Alternatives. Note that a generic nightscape was used to produce the night time photo rendering, as discussed in the previous section, so ambient lighting is not represented and therefore represents a worst-case scenario

3.4.3.4.14 Noise

This section describes the potential impacts of underwater and above water sound from the construction and operation of the proposed Wind Park at each of the four Alternative Sites under consideration. The existing sound level results from three representative coastal sites are provided in Table 3-31. The applicant performed acoustic modeling of above water sound in order to assess and compare relative sound levels resulting from the operation of the proposed WTG array at each Alternative Site. The analysis of sound effects for the Project utilized baseline sound level monitoring and acoustic modeling both above water (airborne sound) and underwater according to the methods outlined in Section 5.11 of this DEIS. The extent of acoustical impact is governed by both the sound to be generated by construction or operation activities and the existing baseline underwater or above water sound conditions in the area.

Underwater Sound

In general the construction-related sound to be generated at each of the offshore Alternatives is expected to be similar in duration and intensity and the underwater operational sound generated by the WTGs is expected to be the same at all of the offshore Alternative Sites under the design wind conditions. To determine the impact of these sound levels, a comparison to baseline sound levels was made. By comparing ocean current, wind, surface

waves and vessel traffic characteristics at each of the offshore Alternative Sites, it was determined (Tech Environmental, 2004) that the measured baseline sound levels at Nantucket Sound are applicable to the other two offshore Alternative Sites, as described in more detail below.

Baseline underwater sound levels originate from many sources both natural and man-made, including turbulence in ocean currents, wind, surface waves and vessel traffic. For a light wind condition, baseline underwater sound levels at the Alternative Sites depend primarily on tidal ocean currents. While tidal currents for the three Nantucket Sound Alternative sub-sites and the South of Tuckernuck Island Alternative Site are generally comparable, those in New Bedford Harbor at the New Bedford/Horseshoe Shoal Alternative are lower (see section 3.4.3.2.3). Offsetting this effect at the New Bedford Alternative Site, however, is the heavy volume of vessel traffic in the harbor by large commercial ships as well as fishing and recreational vessels (see section 3.4.3.2.10).

At the design wind condition for which the acoustic modeling for impacts of underwater operational sound was performed, wind and wave noise become important and this baseline sound source would be the same at all Alternative Sites under the design wind condition. The same baseline underwater sound levels were also applied to the analysis of impacts from underwater sound during construction.

Above Water Sound

For above water sound, the modeling methodology outlined in Section 5.11.1.4 was followed. The only exception was that smaller 1.5 MW GE wind turbine generators were assumed for the MMR Alternative Site.

Massachusetts Military Reservation

Construction and Decommissioning

For the MMR Alternative, the sounds from construction and decommissioning activities will be similar to the off-shore sites (with trucking sounds replacing barge sounds and pile driving sounds replaced by sounds from foundation excavation and pouring), but these sounds will have much greater impacts because of the closer proximity of residences, commercial and retail areas of population to the construction activities on the MMR Alternative Site (for comparative examples of noise levels please refer to Table 2 of Appendix 5.11-A). The greater population density and proximity of the MMR Site to potential noise receptors tends to increase the potential for effects from this Alternative Site. However, this potential is offset by higher existing nearby noise levels. In particular, military activities on the MMR already result in sporadic loud noise from plane and helicopter flights and ground-based training maneuvers involving small-arms and artillery firing. The best, and most appropriate, quantification that can be provided in this alternatives analysis is the data presented below in Table 3-54. This table offers a comparison of projected operating sound levels at each of the Alternative Sites under consideration. The table allows the evaluator to understand the relative difference between the potential noise effects of the Project at each Alternative.

Operation and Maintenance

Acoustic modeling for the MMR Alternative was performed to predict the above-water, broadband continuous sound level L_{eq} (dBA) at the closest sensitive receptors outside the boundaries of the MMR for this Alternative. The worst case was assumed with the Wind Park operating at its design wind speed and wind directions corresponding to downwind conditions for the sensitive receptors. The upland Alternative will utilize the smaller 1.5 MW GE wind turbine generators, and sound power data for that WTG was used in the calculations.

The nearby receptors used for the MMR Alternative in the acoustic modeling are Shawme-Crowell State Forest, Bournedale, and Peebles School in Bourne. The maximum predicted sound level for the MMR Alternative is 47.1 dBA. As with the noise effects resulting from construction activities, the effects of operational noise from the Wind Park will be in an environment that includes substantial noise from ongoing nearby military operations. Wildlife will acclimate to the Wind Park noise during operation as these will be at levels well below noise generated on a routine basis due to MMR military activities.

Nantucket Sound

Construction and Decommissioning

For off-shore Alternative Sites, the sound effects of construction will be temporary and are associated with the diesel engines powering cranes and barges and the impact sound from pile driving of the monopiles into the sea bed. The diesel engine sounds are likely to be less noticeable than the pile driving sounds. The droning sounds of boat engines are part of the offshore mix (together with the sounds of wind and waves) of noise that exists in Nantucket Sound. The primary sound resulting in effects at both on-shore and offshore receptors would be the sharp, repetitive sound from pile driving. Pile driving sounds are more likely to be noticeable above the steadier background noise levels. Decommissioning sound effects will be similar to those for construction except that there will be no pile driving sound. A discussion of the above water sound effects from these activities is given in Section 5.11.1.6. Based on underwater sound measurements described in Section 5.11.2.3 and underwater sound measurements conducted for comparable projects (Section 2.3 of Appendix 5.11-A), predicted maximum underwater sound levels during construction of this Project at a distance of 1,640 feet (500 m) will be below the 180 dBL threshold for preventing injury to marine mammals and sea turtles set by the National Marine Fisheries Service (NMFS)[67]. A more detailed discussion of underwater sound effects is given in Section 5.11.2.

Operation and Maintenance

Underwater Sound Levels During Operation

Acoustic modeling of underwater operational sound was performed for the design wind condition using sound source data provided by GE Wind Energy as discussed in Section 5.11.2.4. Based on acoustical modeling described in Section 5.11.2.4, baseline underwater sound levels under the design condition are 107.2 dBL. The total level of baseline plus Project sound falls from 109.1 dBL at 65.6 feet (20 m) to 107.5 dBL at 164 feet (50 m) to 107.2 dBL at feet 360.9 feet (110 m). Thus, underwater levels fall to the baseline level within a relatively short distance (360.9 feet/110 m) of each monopile, which is far less than the spacing between WTG monopiles. These levels are unlikely to have a significant impact on marine life, and one that diminishes with distance from each monopile.

Above Water Sound Levels During Operation

Acoustic modeling for the Nantucket Sound Alternative sub-sites was performed to predict the above-water, broadband continuous sound level L_{eq} (dBA) at the closest sensitive onshore receptors for the three Alternatives. The worst case was assumed with the Wind Park operating at its design wind speed and wind directions corresponding to onshore conditions for the sensitive receptors. The offshore Alternative Sites utilize a 3.6 MW GE wind turbine generator and sound power data for that WTG was used in the calculations.

The three Nantucket Sound sub-sites, and the receptors used in the acoustic modeling, are as follows:

- Horseshoe Shoal Sub-site Receptor: Point Gammon
- Tuckernuck Shoal Sub-site Receptor: Cape Poge
- Monomoy-Handkerchief Shoal Sub-site Receptors: Monomoy Point, Point Gammon, Dennis Port, Parkers Neck

The maximum predicted sound levels for the Horseshoe Shoal sub-site is 25.9 dBA; for the Monomoy-Handkerchief Shoal Sub-site it is 26.8 dBA, and for the Tuckernuck Shoal Sub-site the maximum predicted sound level is 27.4 dBA. The type of sound generated by the operating WTGs is likely to be less noticeable at receptor locations than the sharp, repetitive sounds caused by pile driving during construction. Given the relatively low noise levels during operation, it is likely that no receptors on shore will be able to detect the WTGs. Similarly, the low level of sound during operation is likely to result in acclimation by avian receptors that are found within the Wind Park. Depending upon a number of variables, (among them wind speed, wind direction, distance from the WTG, type of vessel (sail or motor), direction of vessel travel), boaters may or may not be able to detect WTG sound when in close proximity to the Wind Park (less than 500 meters away). However (as discussed in Appendix 5.11-A) the audibility of any WTG sound will rapidly diminish with distance.

[67] NMFS Correspondence to USACE (Kurkul June 27, 2002)

South of Tuckernuck Island

Construction and Decommissioning

The potential impacts from above water and underwater sound related to construction and decommissioning activities at the South of Tuckernuck Island Alternative Site will be equivalent to the impacts from these activities at the Nantucket Sound Alternative. However, due to the greater number of foundation supports with larger diameters and the greater distance that this site is located offshore, the South of Tuckernuck Island Site may require a longer construction timeframe, thereby resulting in greater acoustical impacts during construction and decommissioning compared to the other offshore alternative sites.

Operation and Maintenance

Underwater Sound Levels During Operation

The potential impacts from underwater sound related to operation of the WTGs at the South of Tuckernuck Island Alternative Site will be equivalent to the impacts from these activities at the Nantucket Sound Alternative.

Above Water Sound Levels During Operation

Acoustic modeling for the South of Tuckernuck Alternative was performed to predict the above-water, broadband continuous sound level L_{eq} (dBA) at the closest sensitive onshore receptors for this alternative. As with the other Alternatives, the worst case was assumed with the Wind Park operating at its design wind speed and wind directions corresponding to onshore conditions for the sensitive receptors and sound data for a 3.6 MW GE WTG was used in the calculations.

The onshore receptor used for the South of Tuckernuck Alternative in the acoustic modeling is Madaket Beach on Nantucket. The maximum predicted sound level for the South of Tuckernuck Alternative is 29.6 dBA. As discussed above with respect to the Nantucket Sound Alternative, operational noise South of Tuckernuck Island is less likely to be noticeable than the pile driving noise during construction. As discussed above, wildlife and human receptors are expected to acclimate to the low noise levels and are not likely to be adversely affected.

New Bedford / Horseshoe Shoal

Construction and Decommissioning

The potential impacts from underwater sound related to construction and decommissioning at the New Bedford/Horseshoe Shoal Alternative will be equivalent to the impacts from these activities at the Nantucket Sound Alternative. However, for the New Bedford portion of this combined Alternative Site, the impacts from above water construction and decommissioning sounds are expected to be noticeably greater than from the Horseshoe Shoal activities, given the closer proximity of the WTG array at New Bedford to on-land recreational and residential receptors. As with the other offshore sites discussed above, it is the pile driving activity that is likely to be most noticeable at these locations and given the proximity to shore are likely to be more easily detected than the other offshore sites.

Operation and Maintenance

Underwater Sound Levels During Operation

The potential impacts from underwater sound related to operation of the WTGs at the New Bedford/Horseshoe Shoal Alternative will be equivalent to the impacts from these activities at the Nantucket Sound Alternative.

Above Water Sound Levels During Operation

Acoustic modeling for the New Bedford/Horseshoe Shoal Alternative was performed to predict the above-water, broadband continuous sound level L_{eq} (dBA) at the closest sensitive onshore receptors for this combination Alternative. The worst case was assumed with the Wind Park operating at its design wind speed and wind directions corresponding to onshore conditions for the sensitive receptors. All offshore Alternative Sites utilize 3.6 MW GE WTGs and sound power data for that WTG was used in the calculations.

The onshore receptors used for the New Bedford/Horseshoe Shoal Alternative in the acoustic modeling are Point Gammon, Smith Neck, South Dartmouth, and Clark's Point. The maximum predicted sound level for the New Bedford/Horseshoe Shoal Alternative is 39.4 dBA. As discussed above with respect to the Nantucket Sound Alternative, operational noise at the New Bedford site is less likely to be noticeable than the pile driving noise during construction. As discussed above, wildlife and human receptors are expected to acclimate to the low noise levels and are not likely to be adversely affected. However, the New Bedford/Horseshoe Shoal Alternative does result in the highest sound levels to sensitive onshore receptors of any of the offshore sites.

Comparative Summary of Impacts

The impacts from underwater sound during both construction/decommissioning and operation is expected to be similar at all three of the offshore Alternative Sites. There are likely to be some differences in the type of sounds that might result in negative effects at the offshore sites as compared to the on-shore site at MMR. At the MMR, construction activities will generate the types of noise that traditional land-based construction projects generate. Noises from land clearing, earthworks, foundation installation and tower erection using mechanized equipment will be noticeably different from the pile driving sounds that will dominate the construction noise generated at the offshore sites. For underwater sound from wind farm operation, there is no difference between the offshore Alternatives, and the results discussed later in Sections 5.11.2.5 and 5.11.2.6 apply equally to each Alternative.

The maximum predicted above water sound levels at onshore receptors for each Alternative Site (the Nantucket Sound Alternative has three sub-sites that have been assessed individually relative to projected sound levels) are summarized in Table 3-54 along with the predicted maximum level of 25.9 dBA at Point Gammon for the Horseshoe Shoal sub-site.

The results show that the Alternative on Horseshoe Shoal would result in less sound energy at onshore sensitive receptors than the other Alternative Sites under consideration. Maximum sound levels at the other Alternative Sites would range from 1 to 21 dBA higher than at the Horseshoe Shoal sub-site, representing sound energy that is in the range of 1.2 to 132 times greater than that resulting for operation of the WTG at Horseshoe Shoal. The one on-land alternative (MMR) has the highest predicted sound levels, 21 dBA higher than those for the Horseshoe Shoal Alternative sub-site.

3.4.3.4.15 Water Quality and Water Resources

This section describes impacts to water resources, including wetlands, at the four Alternative Sites under consideration: MMR, Nantucket Sound, South of Tuckernuck Island, and New Bedford/Horseshoe Shoal. No long-term impacts to water quality are anticipated with any of the Alternatives. While limited short-term, localized impacts are anticipated during construction, measures would be implemented to prevent and minimize these impacts. These measures include using state-of-the-art hydraulic jet plow for submarine cable installation (see Section 4.0) and post-construction monitoring to document habitat disturbance and recovery (see Section 6.0). Potential impacts to water quality related to Project construction, operation, and decommissioning are discussed in greater detail below.

Massachusetts Military Reservation

This section describes potential impacts to water quality, wetlands, and groundwater resources within the MMR Alternative Site.

Construction and Decommissioning

Potential impacts to surface water quality and waterbodies at the MMR Alternative during Project construction and decommissioning could result from vegetation clearing and land disturbance associated with the construction/decommissioning of the towers, installation/removal of inner-array cables, and the clearing of ROWs.

Soil disturbance, in addition to vegetation removal, may potentially increase erosion throughout the Project layout. Underground trenching may undermine slope stability in areas with varying (steep) topography. Storm water runoff associated with the addition of impervious surfaces from the towers may also increase erosion

throughout the Project layout. Decommissioning the Wind Park by removing towers and the cables would result in similar soil disturbances, which could impact surface water quality. Soils disturbance during land clearing and restoration would be minimized using appropriate erosion and sedimentation controls.

The Wind Park would be located in the vicinity of Donnely Pond, Cranberry Bog, Bailey's Pond, Monument Swamp, Gibbs Pond, Raccoon Swamp, and Spruce Swamp and may be near vernal pools. WTG GR18 appears to be located in or near Raccoon Swamp. This may result in direct wetland impact if the layout cannot be adjusted to avoid this area. Although Raccoon Swamp has not been certified, vernal pool indicator species have been observed using this wetland system (Commonwealth of Mass Military Division, 1996). Activities in this area may impact the ability of this wetland to function as a vernal pool. Vegetation removal adjacent to waterbodies increases insolation of water surfaces that can result in increased water temperatures, increased algal growth, and reduced dissolved oxygen levels under some circumstances. Vegetation removal can also lead to increased erosion of nearby soils and sedimentation of the waterbody if stormwater is not properly managed.

Spills and releases (hydraulic hose bursting, refueling spill, etc.) can occur during construction. Such spills and releases, if not addressed appropriately, can result in impacts to surface water and groundwater as material percolates downward through the soil. Spill and release contingency measures can be addressed in the SWPPPs as well as in erosion and sedimentation control plans.

Groundwater

As discussed in Section 3.4.3.2.15, the surficial geology of MMR is comprised of unconsolidated glacial outwash sediments and glacial moraines, and the MMR is located entirely within the Cape Cod Aquifer. The MMR is a Superfund site, and plumes of groundwater contamination have been identified beneath the MMR, primarily to the south and east of the alternative site. However, an explosives plume above USEPA health advisory levels is mapped under the Site (Air Force Center for Environmental Excellence, 2004).

Because the turbines would need to be constructed on concrete pads excavated to depths of approximately 9 feet (2.7 m) below ground level, with the inner array cables buried to approximately 4 feet (1.2 m), groundwater is not expected to be encountered during construction. The potential for encountering previously unknown contamination exists but is unlikely, as groundwater is not expected in the shallow excavations that would be required for Project construction.

Operation and Maintenance

Potential impacts to the existing water resources from operation and maintenance activities would be limited to soil disturbance, erosion, and accidental spills. Disturbed areas would be stabilized after construction to avoid impacts to wetland and water resources. Operation and maintenance activities that may potentially affect water quality include routine mowing and trench work associated with periodic cable replacement/inspection.

Each WTG would utilize lubricating oil, cooling liquids, and grease, all of which would be located in the nacelle or hub (the hub houses the blade pitching system). In order to minimize and mitigate any minor spill incidents that may pose a threat to groundwater, each WTG would be configured to contain any fluid leakage and prevent discharges (see Section 4.6.1). In addition, waste collection systems would be installed on board each WTG. The waste would be separated (i.e., used oil, coolant liquids, filters, paper/rags, etc.) for proper disposal.

Spills and releases can occur during maintenance and change out of cooling and lubricating fluids and oils. Such spills and releases, if not addressed appropriately, can result in impacts to ground water and nearby surface waters and wetlands. Spill and release contingency measures can be addressed in the SWPPPs as well as in erosion and sedimentation control plans.

Nantucket Sound

This section describes potential impacts to water quality within the Nantucket Sound Alternative Site.

Construction and Decommissioning

Potential impacts to water quality associated with construction and operation of a Wind Park and the inner-array cables at the Nantucket Sound Site are expected to be short-term and localized. Inner-array cables would be installed using low impact hydraulic jet plow equipment and submarine foundation structures would be minimized through use of a monopile system (see Section 4.3). Potential water quality impacts would be limited to temporary localized sediment disturbance along the cable corridors and at monopile locations.

Due to the predominance of fine to coarse-grained sand in Nantucket Sound, localized elevated TSS concentrations associated with monopile foundation and inner-array cable installation or removal is expected to be minimal and localized to the area immediately surrounding the monopiles or inner-array cables. Turbidity levels are expected to return to ambient levels within a relatively short time after sediment disturbance (typically one to two tidal cycles). Chemical analysis results indicate that constituents of concern present in sediment samples from Nantucket Sound are at concentrations below the levels that would cause either chronic or long-term biological impacts and should pose little or no risk to water quality (see Section 5.1.3).

Water quality impacts related to sediment disturbance from installation would be comparable to disturbance already occurring within Nantucket Sound from natural events and fishing gear. The volume and extent of sediment disturbance as well as the biological impacts associated with the jet plow are less than those associated with both one tidal cycle and commercial trawling. In addition, it is important to note that use of the jet plow is an isolated event whereas commercial trawling takes place routinely over large areas during the fishing season and two tidal cycles generally occur each and every day. The near bottom suspended sediment concentrations associated with the jet plow are within the range of natural variability resulting from tidal currents, waves, storms, trawling, and vessel propulsion, and as a result are low compared to concentration associated with other natural and man-made occurrences in Nantucket Sound. (CWA, 2003) Potential impacts to surface water resources would be minimized to the greatest extent practicable through the use of jet plowing methodology, and by limiting the area of seabed disturbance. Therefore, minimal short-term and no long-term impacts are anticipated.

Spills and releases (hydraulic hose bursting, refueling spill, etc.) can occur during construction. Such spills and releases, if not addressed appropriately, can result in impacts to water quality. Spill and release contingency measures can be addressed in SWPPPs as well as in erosion and sedimentation control plans. Response measures may include use of zero-discharge vessels and deployment of sorbent booms or other spill recovery equipment.

All work vessel bilge and wastewater would be disposed of properly outside the Project area as per applicable requirements and would not adversely affect water quality.

Operation and Maintenance

Potential impacts to surface waterbodies associated with Wind Park operation would be limited to minor changes in magnetic fields that may be associated with inner-array cable operation (see Section 3.4.3.4.16). The cable system would generate a limited amount of heat that is absorbed by, and dissipated into, the surrounding environment. This loss of heat to the sediments is essential for proper operation of cables. Any changes in thermal gradients are expected to be negligible. These disturbances would be minimized by burial of the cable to a depth of approximately 6 feet (1.8 m). These types of disturbances would not result in impacts to surface waters or biota in the vicinity of the Project. Spills and releases can occur during maintenance and change out of cooling and lubricating fluids and oils. Such spills and releases, if not addressed appropriately, could result in impacts to surface waters. Spill and release contingency measures would be addressed in the SWPPPs.

The welded steel monopile foundations are the only components of the Project that would come in regular contact with seawater during Project operation and therefore be subject to interactions between water, encrusting organisms, and sediment. The transition piece of the WTGs, which will be located on top of the

monopile at the water line / splash zone, will be coated with a product equal or similar to Interzone® 954[65]. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower (above the transition piece), will be coated with an epoxy-polyamide. In addition, cathodic protection utilizing sacrificial anodes made of pure aluminum would be utilized on the piles. The limited area of contact between the coated transition piece and seawater, and the protective anodes on the monopile would minimize the potential for undesirable interactions between water, encrusting organisms, and sediment. The selected coating is not anticipated to degrade substantially or leach materials into the water column over the life of the Project, as evidenced by its wide spread use in marine applications (i.e. hulls, bridge structures, etc.). Therefore, no measurable change in these interactions is expected after Project installation.

South of Tuckernuck Island

Potential impacts to water quality within the South of Tuckernuck Island Alternative Site are anticipated to be similar to those of the Nantucket Sound Alternative discussed above, however due to rougher sea conditions and longer construction duration the potential for spills from vessels is greater than the Nantucket Sound Alternative.

New Bedford / Horseshoe Shoal

Potential impacts to water quality within the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative are anticipated to be somewhat similar to those of the Nantucket Sound and the South of Tuckernuck Island Site. However, notable differences in sediment quality conditions at New Bedford Harbor as compared to the other two offshore Alternative Sites and the potential impacts of contaminated sediments on water quality are discussed below. Potential water quality impacts at the Horseshoe Shoal component of this Alternative are discussed under the Nantucket Sound Site section presented earlier.

There is evidence of chemical contamination in the sediments in New Bedford sub-site (PCBs and other sediment contamination) (see Section 3.4.3.2.2). As discussed under Section 3.4.3.2.15, Outer New Bedford Harbor is listed on the Massachusetts Year 2000 Integrated List of Waters (formerly known as the Section 303(d) List of Impaired Waters) as a Category 5 Water requiring a pollutant loading assessment (i.e., TMDL) for priority organics, non-priority organics, metals, organic enrichment/low dissolved oxygen, and pathogens (MADEP, 2002). In addition, Outer New Bedford Harbor is dominated by fine sands, silts, and clays, so sediment suspension may occur over a larger area for a longer period of time compared to the other two alternative sites that contain coarser-grained sediments. Therefore, the re-suspension of the sediments at New Bedford Harbor during foundation placement and cable embedment may adversely impact marine water quality and aquatic biota.

As discussed under Section 3.4.3.2.15, Paul et al., (1999) and MADEP (1996) report moderate hypoxia (dissolved oxygen below 5 ppm) in the waters of Outer New Bedford Harbor. In addition, algal blooms are a major concern in New Bedford Harbor due to the limited flushing of the Harbor and the nutrient loading attributed to storm water runoff and point-source pollution discharges (MADEP, 1996). Therefore, sediment disturbance in this area may exacerbate already poor water quality conditions at this Alternative.

As with the other two offshore sites, the only components of the Project that would come in regular contact with seawater during Project operation and be subject to interactions between water, encrusting organisms, and sediment are the welded steel monopile foundations. The monopiles have cathodic protection utilizing sacrificial anodes made of pure aluminum to protect them from corrosion. As described above the selected coating on the transition piece splash zone is not anticipated to degrade substantially or leach materials into the water column over the life of the Project. Therefore, no measurable change in these interactions is expected after Project installation.

[65] A two component, low VOC, modified epoxy barrier coat designed to give long-term protection in seawater. Continues to cure when immersed in water, and has been used extensively in the offshore sector for over 25 years. (International Protective Coatings/ Akzo Nobel) www.international-pc.com

Comparative Summary of Impacts

Due to documented sediment contamination, hypoxia, and algal blooms related to water column nutrient concentrations at the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, sediment disturbance in this area would have the potential to exacerbate the existing water quality conditions at this Alternative. Sediment quality at the Nantucket Sound and South of Tuckernuck Island Alternatives reflects a lack of contamination so neither chronic nor long-term biological impacts are expected from project construction or operation activities that result in resuspenion of sediments. Further, resuspended sediments will result only in temporary and localized increases in turbidity during construction, primarily of the inner-array cables. Accidental or incidental releases of potential contaminants such as fuel, lubricants, and oil have the potential to affect water quality, which would be common to all offshore sites and could be a minor concern during construction and operational periods.

The MMR Alternative was the only inland/terrestrial site evaluated. Since there are no large streams, floodplains or lakes at the MMR Alternative, potential impacts would be limited to wetlands and groundwater, primarily either through erosion and sedimentation or through accidental spills. The MMR Wind Park layout would avoid impacts to wetlands and other inland surface waters in the vicinity to the greatest extent possible and groundwater levels are substantially deeper than the foundation and cable installation depths.

3.4.3.4.16 Electrical and Magnetic Fields

This section describes the potential impacts on electric and magnetic fields that may result from the construction and operation of a Wind Park at four Alternative Sites under consideration. Low frequency EMF will be present anywhere electricity is generated, distributed or used and therefore these fields are a common occurrence where electric power facilities exist or power is used. The WTGs, interconnecting power cables and other associated electrical equipment at the Alternative Sites will operate at power frequencies (60 Hz) and therefore have potential EMF impacts onshore and offshore.

Massachusetts Military Reservation

Operation and Maintenance

Approximately 130 – 1.5 MW WTGs would be installed at the MMR Alternative Site. The hub height of the WTGs would be approximately 279 feet (85 m) above ground level. Solid dielectric 34.5 kV cable will connect each WTG to an inner array cable of the same voltage. Each inner array cable will service anywhere from 6 to 20 WTGs. It is anticipated that there would be several inner array cables and the current carried by each will vary depending on the location within the Wind Park, number of WTGs and output of the WTGs. The inner array cables will ultimately tie in at a new substation located in the vicinity of the NSTAR Bourne switching station. This substation will contain a control building, circuit breakers and step up transformers to increase the voltage from 34.5 kV to 115 kV, which will then be tied into the bus at the Bourne switching station for interconnection with the New England grid.

The inner array cables will run predominantly along existing roads or electric transmission ROWs. Frank Perkins Road and Orchard Road run generally north-south along the eastern edge of the western array of WTGs. Three overhead 115 kV transmission lines run from the Bourne switching station along existing ROWs in proximity to the WTGs. One 115 kV line runs south from the station in a ROW along the western edge of the western WTG array, generally paralleling Route 28 into Falmouth. Two 115 kV line lines run generally southeast in a common ROW in the proximity of the northern and easterly WTG arrays.

Typical cable installation will be direct burial at a depth of approximately 4 feet (1.2 m) below grade. Cables connecting individual turbines will also be buried at an approximate depth of four feet below grade.

Electric fields will be effectively contained within the body of the new underground cables by a grounded metallic shield and therefore, no external electric fields would be present. As a result, upon completion of the WTG installation and the individual WTG cables and inner array cables, there will be no new electric fields from the installation and therefore electric fields are anticipated to be approximately the same as the existing condition.

Potential EMF Exposure

Magnetic fields produced by the generator located in the wind turbine nacelle would be greatly attenuated by the above ground height and therefore are anticipated to be minimal at ground level. The individual WTG cables and the inner array cables will introduce a source of magnetic fields within the area of MMR occupied by the Wind Park. Magnetic field strength will be proportionate to the current being carried, which is a function of the power generated by the WTGs. In areas where WTGs will be located along ROWs, such as Orchard Road and Frank Perkins Road, where there are minimal or no power distribution lines, a new magnetic field will result. The inner array cables running in electric transmission ROWs will be an additional source of magnetic fields to those already existing from the overhead transmission facilities. The magnetic fields in these areas are expected to be at levels comparable to other developed areas containing electric transmission substations, high voltage electric transmission lines and lower voltage electric distribution lines. Magnetic field levels will be reduced through burial of the cables at an approximate depth of 4 feet (1.2 m) and by bringing the phases in close proximity to each other to capitalize on cancellation effects. Therefore, fields will be present directly above the cables, but drop off rapidly (well within 15-20 feet) with distance from the line.

The new substation where the inner array cables come together to be transformed to the high voltage required to be tied into the NSTAR system (115 kV) will also be a new source of magnetic fields. However, it will be in close proximity to the existing switching station where magnetic fields already exist from the station equipment and overhead high voltage transmission lines.

Magnetic fields and therefore potential for exposure will occur over a small area, and decrease rapidly within a few feet from a given location. As a result, any exposure will have a short duration because potentially exposed individuals will more likely transit across the area and not spend a lot of time in any one location. Human exposure to magnetic fields is anticipated to be limited to workers and military personnel as the MMR has controlled access and the general public would not be allowed in the Wind Park. Any potential human exposure will typically be small as compared to the other sources of exposure normally encountered during the day (i.e. home appliances, workplace exposure such as office and manufacturing settings, normal house wiring etc.) (see Appendix 5.13-A).

Ecological (plant and wildlife) exposure to magnetic fields from the Project is anticipated to be typical of that experienced on existing ROWs containing electric transmission or distribution facilities. In general, this level of exposure has not been shown to result in measurable changes to species populations, or growth and survival of plants and animals.

Nantucket Sound, South of Tuckernuck Island and New Bedford / Horseshoe Shoal

Operation and Maintenance

The EMF attributable to the offshore Alternatives are anticipated to be similar to each other. The Nantucket Sound Alternative has three sub-sites with differing 3.6 MW WTG arrays, Horseshoe Shoal and Tuckernuck Island layouts with 130 WTGs and the Monomoy-Handkerchief Shoal layout that would contain 92 WTGs. The South of Tuckernuck Island alternative would have 130 WTGs and the New Bedford / Horseshoe Shoal alternative would have 114 WTGs off of Horseshoe Shoal and 25 WTGs off of New Bedford all of the 3.6 MW design. The hub height of the WTG nacelle will be approximately 246 feet (75 m) above water. Up to 10 WTGs will be connected to an inner array cable operating at 33 kV. With the exception of the New Bedford offshore location, the inner array cables will ultimately tie in at an offshore Electric Service Platform (ESP) where transformers will step up the voltage from 33 kV to 115 kV and then transmit to shore via 115 kV submarine transmission lines. The inner array cables will be solid dielectric design and will be buried approximately six feet below the sea bottom using jet plow techniques.

In the immediate vicinity of the ESP, the cables become more closely spaced as they converge on the ESP. In the immediate vicinity of the ESP, the cables will be buried approximately 2 feet (0.6 m) deep under the scour control mats and will rise vertically from the sea floor to the ESP in conduits secured to the ESP support structure. Therefore, the higher magnetic fields are most likely to occur in the limited area around the ESP (See Appendix 5.13-A).

Electric fields will be effectively contained within the body of each cable by its grounded metallic shield and therefore, no external electric fields would be present. As a result, upon completion of the WTG installation and the individual WTG cables and inner turbine array cables, there will be no new electric fields from the installation. Likewise, because the ESP electrical equipment is effectively contained in grounded metal enclosures, no external electric field is produced. Magnetic fields produced by the electrical equipment on the ESP can be expected to be comparable to or less than those found in conventional land based substations (estimated to range anywhere from 2- 80 milligauss depending upon where the measurement is taken and the configuration of the substation). The principal sources of magnetic fields in a substation are the high voltage buses and connections (the magnetic field of a transformer is largely contained within the transformer). In the compact gas-insulated design proposed for the ESP, the bus bars are more closely spaced than in an outdoor air insulated substation, so the magnetic field intensity is expected to be less. Moreover, any fields experienced on the ESP would be attenuated by the distance to sea level (mean low water is 40 feet (12 m) below the ESP deck).

Magnetic field strength around a cable is proportional to the electrical current flow in the cable and therefore the field strength associated with the 33 kV inner-array cables will vary depending on the location of the cable segment within a string of turbines and on the power output of the turbines. Magnetic field strength will be mitigated by burial of the cables below the sea floor and the use of three-conductor cable that reduces the spacing between phases, minimizing fields.

Potential EMF Exposure

There are no known sources of power line frequency fields currently in the vicinity of the offshore Alternatives and therefore no existing electric or magnetic power frequency fields. Magnetic fields produced by the generator located in the wind turbine nacelle would be greatly attenuated by the above water height and therefore are anticipated to be minimal at the water surface.

The potential for EMF to result in any impact to either humans or wildlife would be substantially similar for any of the offshore Alternative Sites under consideration. Magnetic field exposure scenarios for humans are expected to be limited to those involving boaters in the proximity of the ESP or divers on the sea floor in the vicinity of the buried cables or in the vicinity of cables that rise from the sea floor to the ESP. Surface vessels could possibly traverse over the area where the WTGs and buried inner array cables are located. However, because of the depth of cable burial below the seabed and the depth of water, and the distance vessels would be from the ESP, magnetic field strengths are anticipated to be minimal if present at all. Therefore, due to the low field strengths and the extremely short duration a vessel would be over the area, exposure to this group is minimal to none.

Potential exposure to divers occurs over a small area where the cables are buried or in the vicinity of the ESP. Magnetic field strengths directly over the cables and in the vicinity of the ESP drop off rapidly with lateral and vertical distance from the cable and with distance from the ESP. Given the small area occupied by the cables and ESP and because divers would likely not spend a large amount of time directly over the cables, exposure to magnetic fields would be minimal.

Potential exposures for marine organisms would be similar to that of divers. Mobile marine species would likely not spend a large amount of time directly over the cables and therefore exposure to magnetic fields would be minimal. Larger marine species that may frequent the area around the ESP would be mobile and therefore their exposure would vary depending on the amount of time they were in the vicinity of the ESP and distance from the ESP. Overall only a very small fraction of the available habitat will have potential exposure to the higher fields in the vicinity of the ESP for infaunal species.

Comparative Summary of Impacts

Potential EMF impacts for the four Alternative Sites are generally similar. In all cases, because of the use of shielded and grounded electric cable and other equipment, minimal electric fields will be present at any of the four sites from the proposed Wind Park installation. In the case of the offshore Alternatives, the installation of the Wind Park will introduce a source of power frequency magnetic fields where there are none presently. However, all of the offshore Alternatives will be similar with respect to the magnetic fields introduced.

The upland Alternative will result in magnetic fields that are very similar to those present at existing electric transmission and distribution facilities throughout Massachusetts and the United States. Electric facilities installed where none currently exist will introduce a new source of magnetic fields. In areas where there are existing facilities such as transmission line ROWs, the new facilities will introduce another source of magnetic fields to those already existing.

Magnetic fields and the likely potential for exposure for all four of the Alternative Sites under consideration would occur over a small area, and decrease rapidly within a few feet from a given location. Consequently, any exposure is anticipated to be of short duration and impacts would not be significant. Also, magnetic fields will be minimized by prudent and economically viable actions such as the use of three-conductor cable, which minimizes spacing between phases and lowers fields and by burial of the cables.

Given the use of typical heavy construction equipment and tools, construction and decommissioning activities will not result in any appreciable EMF impacts.

3.4.3.4.17 Air and Climate

This section describes the potential impacts to air quality and climate from the construction and operation of a Wind Park at the four alternative sites under consideration. The proposed Wind Park will not result in the generation of air emissions when operating at any of the alternative sites. There is the potential for beneficial air quality impacts to occur as the need to generate electricity and the resultant air emissions from existing fossil-fuel fired generating stations in the area will be reduced by the operation of the Wind Park. The level of emissions that would be offset or reduced from existing generating facilities is proportional to the net power output of the Wind Park constructed at any of the alternative sites along with the age and fuel type(s) of the displaced generating facilities. As stated in the project description in Section 4.0, the installed capacity and the anticipated annual average generating rate of the proposed wind park are 468 MW and 170 MW, respectively. While the specific facilities that would be displaced will vary from day to day and under different load and ambient weather conditions, a Wind Park at any of the alternative sites under consideration would result in substantial emissions reductions. The land-based alternative at MMR would result in approximately 60% lower power generation and emissions offsets due to the limited space available in comparison to the offshore alternative sites. However, as the same generating facilities are likely to be displaced on any given day, independent of the selected alternative location, it is unlikely that development of the project at any of the alternative sites would result in appreciably different air quality benefits in the project area.

The activities associated with construction and decommissioning of a Wind Park at any of the alternative locations will result in some level of air emissions due to the use of fossil fuel fired mobile sources (e.g., ships, trucks, construction equipment, etc.). In addition, the construction of a Wind Park at MMR will generate fugitive particulate emissions resulting from land alteration activities (e.g., grading, excavation, etc.). Other construction activities, such as welding, cleaning and degreasing, painting, etc. may also result in air emissions. These emissions will be short term, temporary in nature, and unlikely to result in any significant or appreciably different air quality impacts at any of the alternative locations.

Climate

A proposed Wind Park at any of the alternative sites will have no direct impact on the climate. However, the generation of electrical power using a zero emission, renewable technology, will result in an equivalent decrease in electrical power generation and an associated decrease in carbon dioxide emissions from existing fossil fuel fired units.

Carbon dioxide has been identified as a “greenhouse gas” and is linked to climate change. Reductions in greenhouse gas emissions may have farther-reaching beneficial global climate impacts.

In addition, the displacement of electrical power now generated by existing fossil fuel fired units will also yield some reductions on a regional scale of pollutants, such as nitrogen oxides, sulfur dioxide, and fine particulates, which contribute to acid rain, ozone formation, and visibility degradation.

3.4.3.4.18 Safety

This section describes the potential impacts to safety related to the construction and operation of a Wind Park at the four Alternatives under consideration. Specifically, this section addresses the safety concerns applicable to both contractors that would construct, operate, maintain and decommission the Wind Park, as well as the safety of the general public that may visit the vicinity. Additional information regarding safety as it relates to aviation and navigation activities is provided in Sections 3.4.3.4.8 and 3.4.3.4.10, respectively. Presented first are the safety concerns that are common to all of the Alternatives and then site-specific safety issues for each of the Alternatives.

Construction and Decommissioning

Contractor Safety

During construction and decommissioning activities, various pieces of construction equipment, machinery, and hand and power tools will be in use, creating potential safety and occupational health risks. Appropriate measures will be provided in order to minimize the risk of impacts on construction personnel's occupational health and safety, including:

- Providing appropriate personal protection equipment (PPE) during construction work in hazardous areas; such as hard hats/safety helmets, gloves, eye protection, safety boots, etc.
- Maintaining all equipment and machinery in good condition. Unsafe equipment will be taken out of service and repaired to working condition, in conformance with accepted industry standards.
- Installing adequate warning signs in dangerous zones, such as areas under the high voltage transmission lines, in accordance with industry specifications.

During the development and construction phase of the project, personnel will be subject to applicable safety regulations, including, but not limited to, the OSHA Safety and Health Regulations for Construction (29 CFR 1926). In addition, construction personnel will be required to comply with OSHA's General Duty Clause, which requires that sites must be free from recognized hazards that are likely to cause death or serious physical harm. Potential hazards that may be encountered and applicable safety regulations are summarized in Table 3-55.

Public Safety

The construction phase may also create public safety issues, in addition to the occupational health and safety concerns listed above. Because of the potential danger, particularly during erection of towers and blades, public access will be restricted from the immediate active construction area, using temporary fencing on land or site control personnel who are responsible for keeping the public at a distance for the offshore Alternatives. Maintaining controlled access to the area while construction or decommissioning activities are occurring will minimize the potential impacts to public safety.

While many of the potential safety hazards and public safety issues identified are common to all areas, individual Alternative locations may create unique hazards. Other specific health and safety concerns that may apply to the Alternatives under consideration have been summarized below.

Operation and Maintenance

Contractor Safety

Operational wind farms pose potential safety hazards to personnel working on or around the wind turbines, as well as the general public if they enter restricted areas. While working on or around operational wind turbines, personnel will be subject to applicable safety regulations, including, but are not limited to, the OSHA Safety and Health Standards (29 CFR 1910). In addition, personnel will comply with OSHA's General Duty Clause. Potential hazards at the Wind Park during operation and applicable safety regulations are summarized in Table 3-56.

Public Health and Safety

Potential public health and safety issues resulting from wind turbine operation may include blade throws, falling ice, lightning strikes, shadow flicker, and stray voltage.

A rarely encountered health and safety issue is potential failure due to extreme events such as earthquakes, extreme wind loadings, or ship impacts. The possibility of extreme events is not expected to vary greatly between the Alternatives. Proper design and construction practices will be employed to minimize or eliminate these risks.

Each wind turbine will contain a small amount of dielectric fluid and/or lubricating oil (approximately 190 gallons). In addition, transformers, capacitors, etc. constructed as a result of the project may contain similar types of fluid(s). Although these units are sealed, the potential exists for any of these components to leak. Units which are constructed over or near water pose a greater risk because discharged material has the potential to travel a greater distance in water and pose a greater challenge to contain/remediate.

Massachusetts Military Reservation

Construction and Decommissioning

Contractor Safety

In addition to the potential hazards listed above, there is the potential that unexploded ordnance (UXO) may be present, as a result of past military training operations, where the WTGs are to be sited. The presence of heavy equipment or excavation/construction activities may result in detonation of UXO, creating the potential for serious injury or death to construction personnel. Contractors will comply with established military standards when working at the facility, including immediately ceasing all construction activities and clearing personnel from the area in the event UXO is encountered. If UXO is encountered (or suspected), military personnel will be immediately contacted to safely handle and dispose of the object.

In addition to UXO, other hazardous materials may be present in the soil, including organic compounds and metals. To minimize exposure to these hazardous materials, an appropriate level of PPE will be worn by personnel working in an area where exposure may be possible. Prior to the commencement of construction activities, sampling may be performed to characterize the soil. Periodic monitoring during construction activities may also be performed in the event previously undiscovered hazardous materials are encountered. All sampling and monitoring will conform with OSHA and military regulations.

Public Safety

Since the Wind Park at the MMR Alternative would be located in an exposed area, there is the potential for temporary dust nuisance due to the movement of construction equipment, transportation of materials and construction activities. It is also believed that some portion of the existing soil may be impacted with hazardous materials. Transportation of materials, excavation for foundations, and construction of the wind turbines may generate dust that could contain hazardous materials to which the personnel at MMR may be exposed. It is unlikely that dust would extend beyond the boundaries of MMR where it could become a public concern.

Operation and Maintenance

Public Safety

The public health and safety issues resulting from wind turbine operation (e.g., noise generation, shadow flicker, blade throws, and falling ice) are not unique to a particular location, but they are more likely to impact public health and safety if the units are located in close proximity to the public (i.e., land based units are generally more likely to create adverse impacts). Although the potential impacts are minimal, they are more likely to affect public health if the units are operated at the MMR Alternative because the WTGs are located closer to the general public.

An active airfield is operated at MMR, posing an increased risk to departing and incoming aircraft as discussed in Aviation (Section 3.4.3.4.8)

The wind turbines will likely be visible from major roadways, such as Route 6 (see Figure 3-53). The presence of the turbines within the drivers' field of view may create a distraction, increasing the potential for an accident or collision. Drivers will need to be more attentive, especially as they cross the Sagamore Bridge onto the Cape, in order to avoid distraction.

Nantucket Sound, South of Tuckernuck Island and New Bedford / Horseshoe Shoal

Construction and Decommissioning

Contractor Safety

Working over or near the water during the construction of an offshore wind farm creates potential hazards in addition to those applicable on land. These hazards are summarized in Table 3-55.

Public Safety

For the marine Alternatives, a local Notice to Mariners will be filed with the USCG, describing the work area and required limited safety buffers from work vessels. Furthermore, site control personnel in boats will assist in temporarily keeping the public at a safe distance from the individual offshore construction sites. Maintaining temporary controlled access to the limited areas while active construction or decommissioning activities are occurring will minimize the potential impacts to public safety.

Operation and Maintenance

Public Safety

The proposed WTGs will be placed in navigable waters. Impacts to navigation have been addressed in a Navigational Risk Assessment for the Horseshoe Shoal Alternative Sub-site (see Appendix 5.12-A). The USCG reviewed the Navigational Risk Assessment and determined that its findings are generally applicable to all of the offshore alternative site locations, provided the construction specifications and WTG array spacing remain the same at each site (See Section 3.4.3.4.10).

The risks associated with fouling of, or damage to, underwater power cables are considered to be low as these would be adequately buried under the sea floor (minimum of 6 feet (1.8 m) burial depth) and marked on the appropriate navigational charts.

Although the specific dielectric fluid to be used in the Electrical Service Platform transformers has not yet been selected, the typical fluids available for this application provide good dielectric properties and low potential for environmental effects. Due to its relatively low volatility (compared to most industrial solvents) and low toxicity, workers are not typically required to wear respiratory protection equipment when working with these materials, and adverse dermal effects typically only occur under prolonged exposure. Given these considerations, health and safety risks are expected to be minimal.

The Wind Park will be required to prepare a SPCC Plan that will detail the means to prevent, control and mitigate releases to the environment. In the event of a release, clean up measures will be employed to minimize impacts to the environment and assure the protection of any people in the immediate area. As the materials do not persist in open water and can be cleaned up from land, it is unlikely that any lasting impacts to the environment or recreational resources will occur.

Comparative Summary of Impacts

The consideration of safety is important for all four of the Alternatives. Potential safety issues for the three offshore Alternatives would be nearly identical. However, due to its closer proximity to land and a busy commercial harbor, it is reasonable to expect that there would be a greater likelihood of a safety issue arising in the vicinity of the WTG array at the New Bedford sub-site.

Safety issues at the MMR Alternative would be expected to be somewhat different than those for the offshore Alternatives. On one hand, contractor safety issues during construction or maintenance activities may be heightened due to the necessity to work on an active military base. On the other hand, the restricted access status of the MMR because of its military operations, would be expected to reduce public exposure to potential safety hazards associated with a Wind Park.

3.4.3.4.19 Socio-Economic Impacts

This section describes the potential economic and fiscal impacts at each of the four Alternatives under consideration. The predominant socioeconomic effects at the local level from the four Alternatives are expected to be located near the onshore facilities associated with each Alternative. The onshore facilities for the Nantucket Sound and South of Tuckernuck Island Alternatives and the entire MMR Alternative are located in Barnstable County, while the Buzzards Bay portion of the New Bedford/Reduced Horseshoe Shoals Alternative is located in Bristol County. There will be no direct use of the islands of Martha's Vineyard or Nantucket during facility construction or operation. Thus, no direct socio-economic effects to tourism in Dukes County or Nantucket County from items such as occupancy of lodging accommodations or overcrowding of restaurants due to construction workers has been considered in this alternatives analysis.

Global Insight conducted a simulation of its Barnstable County model and its Massachusetts state model to assess the economic impact of the Project. The assessments described and reported in the Global Insight Analysis (see Appendix 5.16-A) were used to provide the estimates of the value of economic and fiscal effects of the manufacturing/assembly (M/A), construction/installation (C/I), and the operation and maintenance (O/M) of the Wind Park. These estimates are the basis for the discussion of potential impacts provided in this section.

There are a number of positive economic and fiscal impacts that would accrue to the Commonwealth of Massachusetts (the Commonwealth) and beyond. These impacts include significant increases in direct, indirect and induced full-time jobs; personal and corporate income tax revenues; total state economic output and value added; a moderate increase in sales tax revenue; as well as substantial net-positive economic impacts from projected annual savings in wholesale electric power costs for the New England region. These state-wide (or broader) benefits would be similar, regardless of which of the four Alternatives is developed; although, because the MMR Alternative would be located entirely within the Commonwealth's boundaries, state tax revenues for this Alternative would be somewhat greater than for the offshore Alternatives. In most cases these state and regional impacts would also result in some benefit to the municipality(ies) in which the Project is located that again would be similar regardless of which Alternative is utilized.

As a result, the common impacts on the Commonwealth and New England are not discussed further in this section. A detailed discussion of these broader economic and fiscal impacts is provided in Section 5.16. The remainder of this section focuses on those economic and fiscal impacts that are more localized among the four Alternatives.

Massachusetts Military Reservation, Nantucket Sound, and South of Tuckernuck Island

Since predominant socioeconomic affects at the local level from these Alternatives are expected to occur in Barnstable County, and the activities proposed for the construction and operation of the Wind Park will be generally similar, it is reasonable to assume that the range of socio-economic impacts at these Alternatives will be similar to one another. (It should be noted that the possibility cannot be precluded that occasionally a boat from one of the offshore WTG arrays may land in a harbor on Nantucket or Martha's Vineyard (Nantucket and Dukes Counties, respectively) to supplement food or other supplies for C/I or O/M personnel or to provide temporary shelter for workers during unexpected severe weather; however, such occurrences are expected to be rare and the socioeconomic impact of these isolated events is expected to be negligible.) The following is a description of the potential economic and fiscal impacts on Barnstable County.

Based upon the Global Insight Analysis (Appendix 5.16-A), there would be a number of economic and fiscal impacts on the mainland cities and towns located in Barnstable County, especially Barnstable and Yarmouth or Bourne and Sandwich, resulting from the construction and operation of the Wind Park proposed by Cape Wind Associates.

M/A and C/I Phase Impact Summary

There would be a number of positive economic and fiscal impacts during the 27-month M/A and C/I phase of the Project. The range of these positive effects would apply generally for each of the Alternatives in Barnstable County and can be summarized as follows:

1. Between 597 and 1,013 direct, indirect, and induced full-time jobs would be created in the region, some portion of which would be filled by local people.
2. Of this 597-1,013 range, 391 direct M/A and C/I jobs are created (not all in Mass).
3. A portion of the regional increase in labor income of between $32 million and $52 million annually would accrue to local residents and be spent in the Barnstable County area.
4. Other property income, comprised of rent, dividends and interest, and corporate profits, would increase by between $9.2 million and $14.8 million annually.
5. Employment would increase by up to approximately 75 construction jobs, of this, 75 percent, or 56 construction jobs will be created for Barnstable County.
6. Barnstable and Yarmouth, or Bourne and Sandwich if the MMR Alternative is built, would receive one-time building permit fees during the M/A and C/I phase.

O/M Phase Impact Summary

The positive economic and fiscal impacts associated with the Project would extend beyond the M/A and C/I phase. During the operation phase, the range of these positive effects would apply generally for each of the Alternatives in Barnstable County and can be summarized as follows:

1. There would be an annual permanent employment increase of 154 direct, indirect, and inducted jobs created beginning in 2007, many of which are expected to be concentrated in the ROI. Of these, 50 O/M jobs are directly created by the Project.
2. A portion of the regional increase in labor income of $6.9 million annually would accrue to local residents and be spent in the Barnstable County area.
3. Barnstable would receive $62,510 in annual property tax revenues, and Yarmouth would receive $217,168 in annual property tax revenues.
4. Or, the Towns of Bourne and Sandwich would receive between $1,958,411 (based on the Bourne taxation rate and $2,398,939 (based on the Sandwich taxation rate) in annual property tax revenues, depending on how much of the value of the project would be sited in each town.
5. In the long run, there should be no appreciable increase in the demand for locally or state provided government services.

The detailed results of the economic and fiscal analysis are summarized below.

Economic Impacts During the M/A and C/I Phase

The direct economic impacts in the ROI (and Massachusetts) during M/A and C/I would consist of the hiring of M/A and C/I workers and the purchase of non-labor goods and services. It is expected that most of the specialized components of the WTGs such as the nacelles (i.e., the portion of the WTGs that contain the drive train and the electromotive generating systems), and the rotors will be purchased outside the ROI and very likely outside of Massachusetts. Some non-labor goods and services will be purchased in the Barnstable County area. The temporary increase in economic activity during the M/A and C/I phase will be the sum of the: 1) direct economic impacts — hiring of M/A and C/I workers and purchases of non-labor goods and services; 2) indirect effects — the additional demands for inputs from the businesses that sell non-labor goods and services directly to the Project; and 3) induced effects — the increases in employment, income, etc. generated by the expenditure of disposable income of the newly hired M/A and C/I workers. The size of the temporary increase in economic activity in the ROI during M/A and C/I and operation will depend on the proportion of direct expenditures that take place within the local area. Once the Wind Park begins operating, the direct, indirect and induced economic effects would be permanent changes to ROI (and state) economies.

There will be two types of activities during the 27-month M/A and C/I phase:

- Manufacture and assembly of the blades and other WTG components in southern New England before being transported to the Project site.

- Construction and installation of the WTGs includes the installation of the foundations that will support the WTGs, the on-site assembly of the WTGs; the construction of the offshore electric service platform (ESP) for the offshore Alternatives; and installation of the offshore and onshore components of the transmission line that convey the Project's electric power to the region's existing electric transmission and distribution system.

According to the applicant, about 20 percent of the labor inputs required during the M/A and C/I phase will be needed for construction and installation activities. Some portion of these workers is expected to come from the ROI.

The impact assessment presented below addresses both the manufacture and assembly activities conducted onshore and the construction and installation activities that will occur either onshore or offshore and along the transmission line right-of-way. Based on the applicant's estimate of total person-months of M/A and C/I-phase labor required, it is estimated that a total of 880 person-years of labor will be required during the M/A and C/I phase, 711 for M/A operations and 169 for C/I activities. This translates into an annual average of 391 full-time jobs during the 27-month period, consisting of 316 for M/A activities, and 75 for C/I activities. However, in actuality the M/A and C/I activities will not be evenly distributed across the M/A and C/I phase, but will instead peak during year 2 when the maximum employment at the two locations at one time will be about 600 workers. Given the size of the regional M/A and C/I labor market, and proximity of M/A and C/I phase operations to both the Boston and Providence metropolitan areas, it is reasonable to assume that 75 percent of the C/I workers will be from Massachusetts (and potentially Barnstable County), and 25 percent of the M/A workers will be from Massachusetts. The latter proportion could rise if some or all of the M/A operations are conducted in Fall River, or another location in southeastern Massachusetts. It is estimated that total payments of wages and salaries to Massachusetts' residents hired during the M/A and C/I phase will be about $17.2 million.

Estimates have been prepared that determined that about 20 percent of the Project's total capital cost of $700 million will be needed for labor inputs, while 80 percent will be required for non-labor goods and services, including the WTG components; electric equipment including transmission lines; environmental studies and licensing costs; materials; legal service; construction materials such as steel; and transportation services. The 80 percent share for non-labor costs means that the temporary increase in economic activity in the ROI (and Massachusetts and even in New England) during the M/A and C/I phase will depend primarily on the value of non- labor items purchased within the region. Based on the location of likely suppliers for the WTG components as identified by the applicant, it is estimated that between $150 million and $250 million in purchases on non-labor inputs will occur in Massachusetts during the M/A and C/I phase.

In order to estimate the temporary increase in economic activity during the M/A and C/I phase, the analysis used the IMPLAN input/output (I/O) model for Massachusetts. The IMPLAN model produces multipliers for the total statewide increases in employment, output, value added, and income. Global Insight obtained the year 2000 structural matrices for Massachusetts, and then used the I/O model to derive the appropriate multiplier impacts at the state level. The multiplier effects within the ROI will be lower than at the state level due to the leakage of expenditures from the local economy, and because most of $150 million to $250 million in purchases of non-labor goods and services will be made outside the ROI such as in the Boston area.

Since the total purchases of labor and non-labor inputs will occur over a three-year period, Global Insight performed three separate simulations with the I/O model and allocated the probable purchases of both labor and non-labor inputs to each year based on the labor schedule prepared by the applicant. Global Insight averaged the model results, recognizing that at any point in time during the M/A and C/I phase the actual total economic impacts would be higher or lower. Global Insight estimates the following average annual changes in Massachusetts during the M/A and C/I phase of the Wind Park:

- Between 597 and 1,013 direct, indirect and inducted full-time jobs will be created in Massachusetts, with the range of the increase varying based on the value of non-labor purchases of goods and services made in Massachusetts. Of these, 391 direct jobs will be created.
- Total labor income (consisting of wages and salaries, and income to sole proprietors) will increase by an average of between $32.1 million and $52.0 million annually.
- Other property income, comprised of rent, dividends & interest, and corporate profits, would rise by between $9.2 million and $14.8 million annually.

Tourism

Cape Cod, Nantucket and Martha's Vineyard Islands are well-known vacation and tourist destinations, particularly in the warm weather months. Construction activities would be visible from many locations irrespective of which Alternative is selected. However, other than the visual change, construction of the Wind Park would not limit the

opportunities tourists currently enjoy such as shopping, eating at restaurants or overnight stays at inns, hotels and motels. This is especially true of the onshore MMR Alternative. Offshore boaters would need to exercise additional care, especially during periods of reduced visibility, when traveling near or within an offshore array. Nevertheless, it is reasonable to expect that the majority of tourists that would select the area for a destination will continue to do so during (and after) construction. The presence of the Wind Park could, in fact, be an attraction for some tourists. Impacts on tourism are not expected to be significant for the offshore Alternatives and would be negligible for the MMR Alternative since the Project would not preclude existing recreational uses in the vicinity of any of the four Alternatives under consideration (for additional information please refer to Appendix 5.16-A).

Economic Impacts During O/M Phase

Once the Wind Park begins operation, the applicant estimates that the annual O/M purchases would be approximately $16 million, including $2.644 million for wages and salaries paid to the 50 workers required to maintain the facility. The 50 O/M workers would earn, on average, $52,880 in annual salary and wages. The annual purchase of O/M services would generate additional permanent increases in economic activity in the ROI and Massachusetts. Global Insight assumed that 90 percent of the O/M workers would be residents of Massachusetts. The combination of the direct, indirect and induced effects as described above would generate the following permanent increases in Massachusetts, most of which would be concentrated in the ROI:

- Annual permanent increases, starting in 2007, of 154 direct, indirect, and induced jobs which includes 50 direct O/M jobs, $21.8 million in output, $10.2 million in value added, and $6.93 million in labor income.
- The multiplier effects in the ROI during the operations phase would be larger than during the M/A and C/I phase for two reasons: 1) a higher share of the O/M workers would likely be residents of the ROI; and 2) experience at other energy facility sites shows that over time local vendors develop the expertise, and add the required product lines, to provide an increasing share of the specialized goods and services required to operate and maintain new facilities, thus increasing the local permanent economic impacts. Overall, the Applicant forecasts that the operation and maintenance of the Cape Wind Energy Project would have a positive effect on the economy of both Barnstable County and the Commonwealth.
- O/M of any of the offshore Alternatives would result in a noticeable change to the offshore visual experience for tourists and require that offshore boaters exercise additional care, especially during periods of reduced visibility, when traveling near or within an offshore array. As is the case during construction, however, impacts on tourism are expected to be insignificant for the offshore Alternatives and negligible for the MMR Alternative.

Fiscal Impacts During the M/A and C/I Phase

This section describes the net fiscal impacts that would occur in Barnstable County municipalities during the M/A and C/I phase. Net fiscal impacts are the difference between the additional increases in annual local tax revenues and the demand for additional public services generated by the M/A and C/I workers. Potential demands for locally provided government services are discussed in order to define the potential net fiscal impacts on the affected local governments.

Based on the proximity of the Project to the Boston and Providence metropolitan areas, all of the M/A and C/I phase labor inputs will be obtainable from within a daily commuting distance, indicating that no M/A and C/I workers will have to relocate to either the Barnstable County area or to the onshore M/A sites in Fall River or Quonset Point. Depending on the location of the prime contractor, there may be a small number of management and supervisory personnel who would be required to relocate to the ROI for the M/A and C/I phase. Barnstable County municipalities would experience minimal, temporary increases in demand for local government services during the M/A and C/I phase for police and traffic control due to likely daily commuting by M/A and C/I workers. Since the Applicant does not foresee any significant permanent in-migration by M/A and C/I workers and their dependents to the ROI during the M/A and C/I phase, there would be no corresponding increase in the demand for locally provided government services. Therefore, there is likely to be a minimal net fiscal impact on Barnstable County municipalities during M/A and C/I. Yarmouth and Barnstable would receive some one-time building permit fees during the M/A and C/I phase for the approximately $20 million in on-shore facilities that would be constructed in those two jurisdictions, if either of the offshore Alternatives were built. Bourne and Sandwich would receive a similar one-time building permit fees during the M/A and C/I phase for on-shore facilities that would be constructed in those two jurisdictions, if the onshore MMR Alternative were built.

Public Services and Housing
As previously discussed the increase in the number of local workers to fill the requirements of the M/A and C/I phase of the Project will be modest: approximately 79 M/A jobs (25 percent of 316) and 56 C/I jobs (75 percent of 75). It is unlikely that this level of employment would require migration of workers from outside of the ROI. Even if these workers were to relocate to Barnstable County from outside the area, there would be an insignificant additional burden on publicly provided services. The influx of approximately 135 workers is likely to be easily absorbed by the public service infrastructure already serving a population of almost 226,000.

As shown in the existing conditions discussion, the Barnstable County communities of Barnstable and Yarmouth had over 10,000 vacant housing units shown in the year 2000. Bourne and Sandwich had approximately 3,622 vacant housing units in the same year. Even considering that 89 percent of those vacant units are considered to be seasonal or recreational in nature, there would still be approximately 1,200 housing units in Barnstable/Yarmouth. Approximately 84 percent of vacant housing units in Bourne/Sandwich are seasonal or recreational leaving 600 available to those that may choose to migrate to the area.

Fiscal Impacts During Operation
As noted above, the $26,250,000 of onshore improvements associated with the offshore Alternatives in Nantucket Sound and South of Tuckernuck Island would generate annual increases in real property tax revenues of $62,510 in Barnstable and $217,168 in Yarmouth. The value of onshore improvements at the MMR Alternative would be substantially higher than for the offshore Alternatives. The total value of the Wind Park $228,253,000 would be considered as improvements subject to property taxes in the Towns of Bourne and Sandwich. As a result, operation of the MMR Alternative would generate a combined annual increase in real property tax revenues of $195,841 in Bourne and Sandwich.

There would be a minimal increase, if any, in the demand for locally provided government services or housing in Barnstable County once the Project begins operations, primarily because there would be no permanent in-migration of O/M workers. As noted above, the Applicant has assumed that 90 percent of the 50 permanent employees would be residents of Massachusetts and reside within daily commuting distance of the Project. Since the O/M workers for the offshore Alternatives would commute daily to an on-shore support base, possibly located on Cape Cod, before being transported to the offshore WTGs, there would be only a minimal net increase in demand for new, locally provided, public services. For the onshore MMR Alternative, workers would commute using existing land-based transportation systems. Finally, there would not be any significant increase in demand for government services or housing in adjacent municipalities.

<u>New Bedford/Reduced Horseshoe Shoal</u>

Economic Impacts During M/A and C/I Phase
Given that this Alternative combines WTGs in New Bedford and others located on Horseshoe Shoal in Nantucket Sound, the economic and fiscal effects of this Alternative can be factored between the two locations by the proportion of WTGs constructed in each part of the combination Alternative. The New Bedford portion represents roughly 18 percent of the total Alternative layout (25 of 139 total WTGs), with the balance of the WTGs located at Horseshoe Shoal.

During the M/A and C/I phase, it is estimated that approximately 800 full-time jobs will be created (the midpoint of 597 to 1,013 range of jobs presented earlier), which includes direct jobs created during the M/A and C/I phase as well as direct and indirect effects. Based upon the employment impacts, it is estimated that these 800 full-time jobs will generate roughly $7.2 million in labor income (from 18 percent of the jobs) to the residents of Bristol County with the remaining $32.8 million (from 82 percent of the jobs) expected to benefit Barnstable County residents. Assuming that $32 million of the $40 million total will be spent and a 1.5 spending multiplier attributable to direct, indirect, and induced effects, it is estimated that over $8.6 million of spending will be added to the New Bedford/Bristol County economy during the M/A and C/A phase

Economic Impacts During O/M Phase
There will be a permanent increase of 139 jobs starting in 2007 when full operation begins, assuming 90 percent of 154 jobs will be in Massachusetts. The distribution of these jobs among industries will be the same as it would

be for Barnstable County. The 139 jobs created will generate approximately $7 million in total labor income. Assuming that $6 million of the $7 million will be spent (based on 80 percent consumption rate previously mentioned) and a 1.5 spending multiplier attributable to direct, indirect, and induced effects, it is estimated that over $1.6 million (from 18 percent of the workers) of spending will be added to the New Bedford/Bristol County economy and roughly $7.4 million (from 82 percent of the workers) will be added in Barnstable County during the O/M phase.

Fiscal Impacts

As with the host towns for the other Alternatives, the City of New Bedford would receive one-time building permit fees during the M/A and C/I phase for the approximately $177.5 million in facilities constructed in its jurisdiction. Yarmouth and Barnstable would receive one-time building permit fees during the M/A and C/I phase for the approximately $26.25 million in on-shore facilities that would be constructed in those two jurisdictions for the reduced Horseshoe Shoal array. The on-land improvements of the facilities located in New Bedford would have an assessed value of approximately $177.5 million and would generate approximately $5.5 million in property tax revenues for New Bedford. The on-land improvements for the reduced Horseshoe Shoal portion of this combination alternative would be unchanged from the full Horseshoe Shoal Alternative, as the interconnection and transmission improvements would have essentially the same value.

Public Services and Housing

As discussed for the MMR, Nantucket Sound and South of Tuckernuck Island Alternatives, approximately 135 workers would be added to local employment to fill the requirements of the M/A and C/I phase of the Project. Approximately 18 percent (24) of these M/A and C/I jobs would be needed for the New Bedford portion of the New Bedford/Reduced Horseshoe Shoal Alternative. Approximately 25 (18 percent 154 X 0.9) new permanent employees are expected in the New Bedford/Bristol County area. It is unlikely that this level of new employment would require migration of workers from outside of the ROI. Even if these workers were to relocate to Bristol County from outside the area, there would be an insignificant additional burden on publicly provided services. The influx of less than 30 workers during construction and approximately 25 during operation is likely to be easily absorbed by the public service infrastructure already serving a population of almost 540,000.

As previously shown in the existing conditions discussion, the City of New Bedford had over 3,000 vacant housing units shown in the year 2000. Only 1 percent of those vacant units are considered to be seasonal or recreational in nature, thus there would still be over 3,000 housing units available to those that may choose to migrate to the area.

The number of new employees or need for additional housing in Barnstable County would be less than for the other Alternatives, so the potential impacts on public services and housing from development of the combination Alternative would be even less than previously described for Barnstable County.

Tourism

Tourism is not as important to the Bristol County economy as it is to Barnstable County and the Islands and even less important to the New Bedford economy. As a result, construction and operation and operation of the New Bedford/Reduced Horseshoe Shoal Alternative is not expected to have any significant impact on tourism.

Environmental Justice

As illustrated in Section 3.4.3.2.19, of the municipalities surrounding each of the Alternatives, the City of New Bedford was identified as having the highest percentage of minorities in its population as well as the greatest number of people living below the poverty level. However, environmental burdens associated with the Project in no way unfairly burden New Bedford over any other Alternative community. Air quality impacts on the communities surrounding the Alternatives are not a concern as there will be minimal air emissions released during Project construction and negligible impacts during operation. There are no foreseen health concerns resulting from the Wind Park as proposed. Environmental burdens to the general population are limited to permanent visual impacts, changes to existing navigation patterns, etc. and would be shared equally by the communities surrounding the Alternatives, irrespective of race or economic class. Therefore, in conclusion, the Project has no significant impact in terms of Environmental Justice with respect to any of the four Alternatives or their surrounding communities.

Comparative Summary of Impacts

The potential socio-economic impacts that could result from the construction and operation of the Wind Park at any of the four Alternatives under consideration will be positive and generally similar for all. There will be a greater contribution to state and local tax revenues from a Project at the MMR Alternative because all of the improvements will be onshore whereas the bulk of improvements installed for the offshore Alternatives will be outside of state and local taxing jurisdictions. Tourism activities would continue on Cape Cod and the Islands (as well as in the Bristol County/New Bedford area) irrespective of the Alternative locations for the Project, although any impact on tourism is expected to be less from development of the MMR Alternative or the New Bedford portion of the combination Alternative.

However, these tax revenue differences and the insignificant potential decrease in tourism revenues are a small fraction of the potential economic and fiscal benefits that would accrue from the Project at any of the Alternatives under consideration. Because the New Bedford/Reduced Horseshoe Shoal Alternative splits the Wind Park with 25 WTGs in New Bedford and the remaining 114 WTGs at Horseshoe Shoal, it can be assumed that roughly 18 percent of the economic benefit would accrue to the residents of New Bedford and Bristol County, while the remaining 88 percent would remain with residents of Barnstable County.

3.4.3.5 Summary of Detailed Analysis of Alternatives

Existing Resources

In order to summarize the range of information presented for the 19 resource topics for all four Alternatives, the resource characterization information presented in Section 3.4.3.2 was reviewed to select, for each resource topic, potentially differentiating factors (see Table 3-57). An “X” indicates the relevance of each characteristic for each site. This summary assessment is not intended to result in a “ranking” of the Alternatives, since the weighting of individual factors is not considered. This table provides an illustration of the relative number and types of resource characteristics associated with each alternative. Since it is not the objective of this summary to determine the viability of the Alternative Sites, the material presented in Table 3-57 is provided merely as a concise summation of resource characteristics for the alternative sites associated with the hypothetical construction and operation of a Wind Park under the four (4) Alternatives assessed in Section 3.4.3.

As is evident from Table 3-57, a broad range of characteristics has been considered for each Alternative and no one Alternative exists for which no significant characteristics were identified. It is also evident that the evaluation frameworks for the upland Alternative and the three off-shore Alternatives involve differing factors that are not directly comparable, but must be considered within each appropriate context.

Impact Analysis

Section 3.4.3 impacts were reviewed for the four Alternatives to identify the impacts of concern for each of the 19 resource topics. Presented by resource topic below is a summary of the more important impacts that are helpful in obtaining an understanding of the similarities and differences between the Alternatives under wind park construction and operation scenarios.

Protected Avian Species and Avian Resources

- Waterbirds (e.g., bay ducks, shorebirds) that are rarely found at offshore Alternatives such as Nantucket Sound and South of Tuckernuck Island are common at the New Bedford component of the New Bedford/Horseshoe Shoal Alternative and thus may be more impacted during construction and operation.
- The long-tailed duck, which is more prevalent at the South of Tuckernuck Island Alternative than at the other two offshore Alternatives, may be more affected by construction activities at this Alternative due to an anticipated longer construction period.
- The South of Tuckernuck Island Alternative may have a somewhat lower species density than the other two offshore Alternatives due to its distance from the mainland but a somewhat higher density of pelagic species (e.g., shearwaters, jaegers, and fulmars), therefore pelagic species are likely to be more affected at this Alternative during construction and operation.

- The MMR Alternative has the greatest potential to affect land birds, including woodland species such as warblers, raptors, and state listed grassland species, during construction and operation.
- In total, MMR has the potential to adversely affect the most number of state listed species during project construction and operation.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to avian resources would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Geology and Soils/Sediments

- Contamination exists in association with soils/sediments at the MMR and New Bedford portion of the combination Alternative that could be disturbed during construction, thereby potentially increasing exposure to humans and biota.
- Sediment or soil having physical characteristics (i.e. small grain size) that make them more susceptible to mobility due to construction disturbance is present at the New Bedford Component of the combination Alternative.
- The New Bedford portion of the New Bedford/Horseshoe Shoal Alternative may require blasting and more seabed/sediment disturbance during construction than the other offshore Alternatives due to more rock outcrops.
- The South of Tuckernuck Island Alternative would result in more temporary and permanent seabed impacts associated with Project operation than the other Alternatives, due to its location in relatively deep water, which requires larger foundation supports for the WTGs.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to geology and soils/sediments would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Oceanography

- There may be somewhat more wave reflection and/or diffraction in the immediate vicinity of the WTGs located in the South of Tuckernuck Island Alternative during operation than at the other two offshore Alternatives as a result of the need for grouped-pile foundation systems (quad-caisson) at the South of Tuckernuck Island Alternative.
- Small eddies may result for the duration of the facility operation at all offshore Alternatives, which would only remain in the general vicinity of each tower.
- Seabed modification as a result of construction activities will occur more with the South of Tuckernuck Island Alternative compared to the other alternatives because of the greater disturbance and, the New Bedford component of the combination Alternative if blasting is required.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to oceanography would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Protected Marine Species

- The Monomoy and Tuckernuck Shoal sub-sites are in closer proximity to seal haul-out and breeding sites and therefore Project development at these sites has a greater potential to impact seals both during construction and operation.
- There is greater potential to impact whales at the South of Tuckernuck Island Alternative primarily during construction since the site is proximate to historical sightings of these mammals.
- The South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to Federal protected marine species during construction, although if blasting is required at the New Bedford sub-site then it also could impact protected marine species.
- During construction, elevated TSS levels at the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative have the potential to occur over a wider area for a longer period of time compared to the other offshore Alternatives due to smaller grain size, which could affect foraging.
- The New Bedford Harbor portion of the New Bedford/Horseshoe Shoal Alternative contains contaminated sediments and therefore poses a greater bioaccumulation risk to protected marine species during construction compared to the other offshore Alternatives, which have no evidence of contaminated sediments.

- The South of Tuckernuck Island Alternative may have more potential to attract seals or other marine mammals by offering a new prey base throughout operation of the Wind Park since it results in the greatest increase in hard substrate habitat.
- There is a potential for greater impact to prey species at the South of Tuckernuck Island Alternative compared to the other Alternatives given the greater potential benthic habitat disturbance at this Alternative and anticipated longer construction duration.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to protected marine species would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Fisheries

- Once in operation, all offshore alternatives will provide surface area for potential fish aggregations, however the South of Tuckernuck Island Alternative offers a greater surface area for potential fish aggregations compared to the other Alternatives.
- The South of Tuckernuck Island Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance, resulting in greater impacts to fisheries from sediment disturbance compared to the other offshore Alternatives.
- The New Bedford portion of the New Bedford/Horseshoe Shoal Alternative has documented sediment contamination and therefore poses a greater bioaccumulation risk to finfish throughout construction/decommissioning compared to the other Alternatives that have no evidence of contamination.
- The South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to finfish compared to the other offshore Alternatives, since that Alternative would likely require a longer construction/decommissioning timeframe. The New Bedford portion would impact fish if blasting were required.
- Localized finfish displacement and mortality is a construction/decommissioning phase impact associated with development at all offshore Alternatives.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to fisheries would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Benthos

- It is possible that the risk of spills impacting benthic habitat from oil, fuel, hydraulic fluid, or other fuels and lubricants associated with the construction machinery would be somewhat greater at the South of Tuckernuck Island Alternative since more time would be required to construct the quad-caisson WTG foundations. In addition, maintenance activities will be more challenging to complete at the South of Tuckernuck Island Alternative because of the more severe sea conditions.
- The additional pilings, cross-braces, and scour protection required at the South of Tuckernuck Island Alternative substantially increase (by more than 10 times) the vertical habitat structure available for colonization by benthos for the life of the Wind Park.
- Anchoring impacts associated with construction/decommissioning would be similar for the New Bedford/Horseshoe Shoal and Nantucket Sound Alternatives, approximately 75 percent less area disturbed compared to the anchoring impacts anticipated for the South of Tuckernuck Island Alternative.
- The benthic community at the New Bedford component of the New Bedford/Horseshoe Shoal alternative is reported to be slightly more diverse than that at both the South of Tuckernuck Island and the Nantucket Sound Alternatives, which may mean that impacts to the benthic community from jet plowing and other construction activities would be slightly greater at the New Bedford component of this Alternative.
- The area of direct impact at the South of Tuckernuck Island Alternative would be nearly twice that of the Nantucket Sound Alternative, likely resulting in greater overall impact to benthos at the South of Tuckernuck Island Alternative.
- The New Bedford Alternative has the greatest number of marked rocky reefs that would be affected should anchoring or anchor cables occur on these reefs during construction/decommissioning.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to benthos would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Upland

- MMR has the potential for extensive terrestrial resource impacts, including impacts to vegetation, wildlife, bats, and invertebrates that are not present at the offshore Wind Park Alternatives.
- Temporary as well as permanent habitat loss and habitat fragmentation will occur at the MMR Alternative.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to upland resources would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Aviation

- Each of the offshore alternatives have received a "Determination of No Hazard to Air Navigation" by the FAA as a result of their aeronautical studies (Appendix 5.12-C).
- MMR appears to have the greatest impact to air navigation, effectively eliminating all military flight training and operations involving helicopters or low altitude fixed wing aircraft, and as an emergency-landing site for the NASA Space Shuttle.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to aviation would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Telecommunications

- The three offshore Alternatives were determined to have no adverse impacts to telecommunication, however a number of WTG locations for the terrestrial Alternative on MMR could likely interfere with microwave signals.
- The siting of WTGs on MMR would negatively impact military communications and the operation of the PAVE/PAWS radar system.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to telecommunications would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Navigation

- With the addition of WTG structures at any of the offshore Alternatives, mariners (including recreational boaters) may need to be more attentive to navigation in the Wind Park area.
- With the CWA commitment to provide private ATONs within the Wind Park, mariners will have new ATONs when navigating in and around the WTGs for all offshore Alternatives.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to navigation at MMR would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development, However offshore locations would not benefit from additional ATONs, but would otherwise remain as-is.

Cultural

- None of the Alternatives will result in a direct physical disturbance of known historic or archaeological sites during construction, but there is the possibility that unidentified sites are present.
- The Nantucket Sound Alternative is considered to have a higher predicted archaeological sensitivity for ancient Native American submerged cultural resources than the other alternatives.
- The visual contrast at the onshore MMR Alternative is less than the offshore Alternatives, as this viewscape contains existing high structures and other built features.
- The Horseshoe Shoal and Tuckernuck Shoal sub-sites in Nantucket Sound are within the viewshed of the greatest number of historic properties of any Alternative. These are located along the south side of Cape Cod, northeast Martha's Vineyard and northern Nantucket.
- The Monomoy Handkerchief Shoal sub-site has the least historic properties in the viewshed. With the exception of Monomoy Light, there are no designated historic properties designated along the shoreline between Chatham west to Yarmouth.
- Required flashing lights will be most highly visible on the WTGs during Project operation at onshore historical properties associated with the New Bedford/Horseshoe Shoal Alternative.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to cultural resources would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Aesthetics / Landscape / Visual

- The MMR Alternative is the only one of the Alternatives that offers partial visual screening due to mature vegetation and topography.
- FAA lighting will be a required Project feature for all four Alternatives.
- All offshore Alternatives will also have USCG required lighting.
- The Project will add a built element to existing views of the natural seascape, with day time views of the offshore Alternatives. At night under clear sky conditions, the flashing lights of the offshore Alternatives will create a visual change to the existing relatively unbroken night time views, especially at remote locations with low levels of ambient light under clear sky conditions. The South of Tuckernuck Alternative would affect the fewest number of viewers.
- The MMR site and New Bedford portion are expected to have the most ambient light, which will decrease the visibility of Wind Park lighting during operation, although the New Bedford sub-site is closest to land of any offshore Alternative.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to aesthetics / landscape / and visual resources would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Recreation

- Construction at the New Bedford Alternative sub-site, which is closest to shore of all the offshore Alternatives (less than one mile (1.6 km)), may temporarily limit use of the watersheet by water skiers, jet skiers and divers. The other Alternative Sites are sufficiently offshore to have more limited recreational activities.
- The sandy substrates of the Nantucket Sound and South of Tuckernuck Island Alternatives are not generally of interest to recreational divers, but which could be enhanced by the presence of the WTGs.
- No recreational resources have been identified within the upland MMR Alternative Site, which is not accessible to the public.
- Each offshore WTG will be marked on NOAA charts, and together with associated light and sound signals, will add to the existing network of aids-to-navigation, which will assist recreational boaters, especially during times of poor visibility.
- With the addition of WTG structures at any of the offshore Alternatives recreational boaters may need to be more attentive to navigation in the Wind Park area.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to recreation would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Noise and Vibration

- At the MMR, construction activities will generate traditional land-based construction noises. Noises from land clearing, earthworks, foundation installation and tower erection using mechanized equipment will be noticeably different from the pile driving sounds that will dominate the construction noise generated at the offshore sites, and will occur closer to residences.
- For underwater sound from Wind Park operation, there is no difference between the offshore Alternatives, although the South of Tuckernuck Island Alternative will likely have a longer construction period.
- Maximum sound levels at the other Alternatives and sub-sites would range from 1 to 21 dBA higher than at the Horseshoe Shoal sub-site, representing sound energy that is in the range of 1.2 to 132 times greater than that resulting for operation of the WTG at Horseshoe Shoal because of either different WTG types, proximity to sensitive receptors, or wind speeds.
- MMR has the highest predicted sound levels, 21 dBA higher than those for the Horseshoe Shoal Alternative sub-site because of the different WTGs required compared to the offshore alternatives and proximity to sensitive receptors.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to noise and vibration would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Water Quality and Resources

- Due to documented sediment contamination, hypoxia, and algal blooms related to water column nutrient concentrations at the New Bedford portion of the New Bedford/Horseshoe Shoal Alternative, sediment disturbance in this area could be expected to exacerbate the existing water quality conditions.
- Sediment quality at the Nantucket Sound and South of Tuckernuck Island Alternatives reflects a lack of contamination so neither chronic nor long-term biological impacts are expected from Project construction or operation activities that result in resuspension of sediments.
- Accidental or incidental releases of potential contaminants such as fuel, lubricants, and oil have the potential to affect water quality, which would be common to all offshore Alternatives and could be a minor concern during construction and operational periods.
- At the MMR Alternative, potential impacts would be limited to wetlands and groundwater, primarily either through erosion and sedimentation or through accidental spills. The MMR Wind Park layout would avoid impacts to wetlands and other inland surface waters in the vicinity to the greatest extent possible and groundwater levels are substantially deeper than the foundation and cable installation depths.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to water quality and resources would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

EMF

- In the case of the offshore Alternatives, the installation of the Wind Park will introduce a source of power frequency magnetic fields where there are none presently.
- The upland Alternative will result in magnetic fields that are very similar to those present at existing electric transmission and distribution facilities throughout Massachusetts. Along cable routes within new rights-of-ways or rights-of-way that are not proximate to existing electricity sources, will introduce a new source of magnetic fields. In areas where there are existing facilities such as transmission line ROWs, the new WTGs or inter-array cables will introduce another source of magnetic fields to those already existing.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to EMF would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Air and Climate

- Fossil fuel electrical generation emissions will be reduced by all alternatives.
- Emissions from mobile sources during construction, operation (maintenance activities) and decommissioning will be greatest at the South of Tuckernuck Alternative given the distance vessels need to travel, as well as the duration of construction.
- Fugitive particulate emissions are likely at MMR during ground disturbing construction activities.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to air and climate would be expected to worsen as increasing demand for electricity would likely be met by continued use of traditional fossil-fuel generation.

Safety

- Due to its closer proximity to land and a busy commercial harbor, it is reasonable to expect that there would be a greater likelihood of a safety issue arising in the vicinity of the WTG array at the New Bedford sub-site.
- Contractor safety issues during construction or maintenance activities will be heightened at MMR due to the necessity to work on an active military base which has UXO and hazardous material on-site.
- The restricted access status of the MMR because of its military operations, would be expected to reduce public exposure to potential safety hazards associated with a Wind Park, such as falling ice, blade throws, lightning strikes, shadow flicker, and stray voltage.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to safety would be expected to remain as-is with neither a positive nor negative impact or effect from the proposed development.

Socioeconomics

- There will be a greater contribution to state and local tax revenues from a Project at the MMR Alternative because all of the improvements will be onshore whereas the bulk of improvements installed for the offshore Alternatives will be outside of state and local taxing jurisdictions.

- Tourism activities would continue on Cape Cod and the Islands (as well as in the Bristol County/New Bedford area) irrespective of the Alternative locations for the Project, although any potential for negative impact on tourism is expected to be less from development of the MMR Alternative or the New Bedford portion of the combination Alternative.
- Under the No-Action alternative, or in the event of permit denial, the existing conditions with respect to socioeconomics would be expected to remain as-is. The positive effect on local, state and regional economies estimated to result from the construction and operation of the proposed project would not be realized.

Cumulative Impacts

In addition to the proposed Project as discussed above at any of the alternatives, other activities in the past, present or future which may contribute to cumulative impacts would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY), as well as upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

Secondary Impacts

The secondary impacts associated with construction staging/laydown activities at Quonset are expected to be positive. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

3.4.4 Comparison of Nantucket Sound Alternatives

3.4.4.1 Nantucket Sound Project Design Siting Criteria

Three locations within Nantucket Sound have been considered by the project proponent. Siting analysis was conducted to evaluate these specific locations within the Sound using the following Project design siting criteria:

- Average water depths between 12 and 50 feet below the mean lower low water (MLLW) datum;
- Adequate water sheet area (approximately 24 square miles) for installation of up to 130 WTGs capable of delivering approximately 454 MW of wind-generated energy;
- Geological conditions suitable for installation of pile-type foundation systems for the WTGs;
- Configuration that allows for optimum siting of WTGs to provide maximum wind power density and duration for efficient wind generating capacity;
- Proximity to suitable landfalls and interconnection points to the NSTAR electric transmission system on Cape Cod;
- Reasonable distance from shore to minimize potential visual impacts but facilitate submarine cable interconnections;
- Minimal potential for conflict with established shipping channels and navigational fairways;
- Minimal potential for conflict with general aviation and established Federal Aviation Administration (FAA) – Instrument Flight Rules (IFR) flight paths;
- Minimal potential for conflict with commercial fishing;
- Minimal potential for conflict with established commercial passenger ferry routes;
- Minimal potential for impact to the marine environment;
- Avoidance of existing submarine cable and pipeline areas; and
- Avoidance of known or documented marine archaeological resources.

As shown in Figure 3-66, three geographic areas within Nantucket Sound were identified that met the preliminary siting criteria for the Wind Park. Each of these geographic areas were evaluated using the Project design siting criteria. All three areas were determined to be generally feasible for siting of a Wind Park at the desired size and scale; however, each site had its own positive and negative attributes relative to the design needs of the Project.

3.4.4.2 Monomoy / Handkerchief Shoal

The Monomoy / Handkerchief Shoal area in eastern Nantucket Sound was evaluated using the Project design criteria. This geographic area was determined to be technically, environmentally, and economically constrained for the following reasons:

- Several federally-listed and designated threatened or endangered species are known to utilize this area of Nantucket Sound for life-cycle, migratory, or breeding habitat. It is well documented that the area of eastern Nantucket Sound and the Monomoy Islands serves as significant and unique habitat and refuge for protected shorebirds as well as migratory pathways for protected marine mammals. In addition, Waring (2001) reports that Monomoy Island is a principal harbor seal and/or gray seal winter haulout location;
- This area of Nantucket Sound does not contain adequate water sheet area for installation of up to 130 WTGs capable of delivering approximately 454 MW of wind-generated energy;
- This area of Nantucket Sound has higher observed commercial fishing activities than the other two alternative sites in Nantucket Sound; and
- This area of Nantucket Sound presents very limited options for a technically and economically feasible submarine cable interconnection with the existing NSTAR electric transmission system. The closest point of interconnection is the Outer Cape; however, this geographic area east of Yarmouth is primarily served by low voltage transmission lines. Interconnection points for a 115 kV transmission line are extremely limited and likely to require significant infrastructure upgrades by NSTAR to efficiently transmit their power to the regional transmission grid.

3.4.4.3 Tuckernuck Shoal

The Hawes and Tuckernuck Shoals area in southern Nantucket Sound were evaluated using the Project design siting criteria. This geographic area was determined to be technically, environmentally and economically constrained for the following reasons:

- Several federally-listed and designated threatened or endangered species are known to utilize this area of Nantucket Sound for life-cycle, migratory, or breeding habitat. It is well documented that the area of southern Nantucket Sound and Tuckernuck Island serves as significant and unique habitat and refuge for birds. In addition, Waring (2001) reports that Muskeget/Tuckernuck Islands are principal harbor seal and/or gray seal winter haulout locations. Muskeget Island is one of only two U.S. breeding locations for the gray seal;
- Siting of WTGs and cables in this area of Nantucket Sound is constrained by commercial navigation since it is in an area of defined navigation channels serving as an offshore entry point to Nantucket Sound (Muskeget Channel) and nearby commercial and recreational ports (Nantucket, Vineyard Haven, and Edgartown Harbors);
- This area of Nantucket Sound presents the most limited options for feasible submarine cable interconnections to the existing NSTAR electric transmission system on Cape Cod. This area is more than 20 nautical miles south of Cape Cod, which makes a HVAC submarine cable interconnection to Cape Cod technically infeasible for the Project. In addition, connection to existing NSTAR submarine cable interconnections with the Islands of Martha's Vineyard and Nantucket that are interconnected to the mainland grid were also determined to be infeasible. This is because these are low voltage lines (26 kV and 46 kV) that cannot easily interconnect with the higher voltage (115 kV) transmission lines of the Wind Park. To do so would require major and significant infrastructure upgrades to the NSTAR electric transmission systems presently servicing the Island load centers;
- This area has higher observed commercial fishing activities than Horseshoe Shoal; and
- Location of the Wind Park in this area of Nantucket Sound would present greater visual impacts to the Islands of Martha's Vineyard and Nantucket than the other sites due to the proximity of these islands.

3.4.4.4 Horseshoe Shoal

The Horseshoe Shoal area in central Nantucket Sound was evaluated using the Project design siting criteria. This geographic area met all of the Project design siting criteria and, therefore, was determined to be a technically, environmentally and economically feasible alternative for the following reasons:

- Horseshoe Shoal provides adequate watersheet area to allow for optimum siting of the 130 WTGs;

- The location minimizes visual impacts associated with the Project from shoreline locations while maintaining a feasible distance offshore for submarine cable interconnections to the NSTAR grid;
- Horseshoe Shoal is located outside established navigation channels and fairways, and established aviation FAA-IFR corridors. The Shoal has very shallow water depths (averaging 10 to 20 feet). Ferries and larger commercial and recreational vessels with deep drafts do not cross this area;
- Horseshoe Shoal provides the closest location for submarine cable interconnections to the existing NSTAR electric transmission system on Cape Cod and is a central location in Nantucket Sound with the most options for interconnection with the existing transmission grid;
- Horseshoe Shoal has subsurface geological conditions ideal for structural stability and relative ease of installation for a pile-type foundation system for the WTGs. This type of foundation system is the most cost-effective and environmentally sensitive design alternative;
- Horseshoe Shoal is not a unique habitat in Nantucket Sound and is not a significant habitat, refuge or migratory pathway for marine mammals. There are no reported harbor seal or gray seal winter haulout locations (Waring 2001) in close proximity to Horseshoe Shoal;
- The Horseshoe Shoal location avoids existing submarine cable and pipeline areas and known or documented archaeological resources; and
- Based on state and federal fisheries data and telephone/dock surveys, Horseshoe Shoal has less commercial fishing activity than the other Nantucket Sound sites (see Section 5.4 for details).

3.4.4.5 Summary of Findings and Comparison of Nantucket Sound Alternatives

As summarized in Table 3-58, the Wind Park siting analysis for Nantucket Sound clearly demonstrates that Horseshoe Shoal is technically, environmentally, and economically preferable to the other two Nantucket Sound alternatives for the proposed Wind Park energy generation facility using the Project's established siting criteria.

3.5 Submarine and Upland Cable Routes for the Applicants Proposed Site

3.5.1 Introduction

The following section presents a detailed alternatives analysis for the submarine and upland cable routes for the transmission system that will transmit the power generated offshore, (from the Applicant's proposed site at HSS) onshore to the established New England power grid. The information contained in this section has been summarized from Cape Wind Associates, LLC's (and Commonwealth Electric Company d/b/a NSTAR Electric's) petition to the Commonwealth of Massachusetts Energy Facilities Siting Board (EFSB) and Department of Telecommunications and Energy (Docket number EFSB 02-2/D.T.E. 02-53). In the July 2, 2004 Tentative Decision, the EFSB determined that the Applicant's preferred cable route alternative (see Alternative #1 below) "would be preferable to the alternative route with respect to providing a reliable energy supply to the Commonwealth with a minimum impact on the environment at the lowest possible cost" (EFSB, 2004).

The Applicant has evaluated a reasonable range of practical routing alternatives for the proposed transmission line, as presented below. These routes were sited and locations selected to minimize environmental and community impacts and installation costs while maintaining the reliability of the electric transmission system. In order to evaluate the proposed alternative routes, a variety of criteria was developed to assess environmental and community impacts, installation and maintenance impacts and costs, while still maintaining reliability of the power transmission system.

The following sections describe the development and application of threshold criteria to define the possibilities for the transmission line routes and to identify the best route alternatives within those possibilities for further consideration. In addition, the sections will describe the screening criteria used to identify alternatives that would ensure that a clearly superior alternative to the proposed transmission line route was not overlooked or eliminated.

3.5.2 Siting Criteria

Initially, a number of transmission line approaches were considered that could meet the need of interconnecting the output of the wind farm with the New England and local electric grid. The preferred approach was identified

as an interconnection with NSTAR's Barnstable Switching Station. The following criteria were then used to evaluate alternative submarine and upland transmission line routes for interconnecting to this point:

Land Use / Community Impacts Siting Criteria

- Utilize landfall locations that are in close proximity to the existing NSTAR Electric Barnstable Switching Station;
- Utilize 115kV interconnection locations to match the transmission voltage level of the Project and minimize the amount of transmission infrastructure upgrades that would be required to reach the Barnstable Switching Station and associated construction impacts such as expanded easements;
- Utilize underground construction methodologies for the upland transmission line to the maximum extent feasible in order to avoid or minimize potential adverse impacts to local neighborhoods, roadway systems, and utility infrastructure, and avoid unnecessary direct disturbance of land surfaces and natural resources;
- Utilize sites that have already been developed and disturbed by previous activities to minimize use of undeveloped land or natural resource areas; minimize impacts to parkland and open space areas; and avoid disruption of community or neighborhood services. Using developed sites also reduces impacts on surrounding land use patterns and sensitive receptors;
- Utilize existing developed waterfront shorelines and nearshore areas to the maximum extent feasible for the submarine transmission line landfall and transition to reduce direct disturbance of natural terrestrial, wetland, and sensitive coastal habitats, and avoid associated habitat restoration or ecosystem impacts;
- Utilize existing ROWs with workspace available for transmission line installation and maintenance to minimize impacts to existing public and private utilities and infrastructure;
- Utilize existing ROWs that minimize the number of bends or turns required in an effort to reduce the quantity of splicing vaults and minimize larger excavation areas; and
- Utilize roadway widths, sidewalks, and shoulder areas in an effort to maintain travel access for vehicles and pedestrians at all times.

Environmental Protection Siting Criteria

- Select a linear route that has direct routing between the ESP and the landfall location;
- Select a linear route that avoids or minimizes surface or subsurface disturbance of existing terrestrial, wetland, and aquatic resources to avoid or minimize construction or encroachment into wetland resource areas, streams, sensitive habitat areas, or natural shoreline areas to the greatest extent practicable;
- Select a linear route that utilizes existing developed land and waterfront areas to the greatest extent practicable, and avoid routes that encroach on undeveloped or natural land use or shoreline conditions to avoid or minimize disturbance in more environmentally sensitive land, parklands, open space areas, and shoreline areas, while focusing construction in areas that have been previously developed for transportation or waterfront uses;
- Select a linear route that minimizes potential construction and operational impacts to regional land-based and waterborne commerce or transportation networks to avoid or minimize potential project impacts to roadway transportation infrastructure, commercial shipping and navigation, and recreational boating;
- Select a linear route with conditions suitable for submarine transmission line installation and construction methodologies that avoid or minimize impacts to aquatic resources, water quality, seabed conditions, and benthic habitat. Use construction methodologies that minimize bottom disturbance, particularly in nearshore areas, and the resuspension and transport of sediment during periods of sensitive life-cycle stages of fish and other aquatic life. Consider using HDD construction methods for the submarine transmission line landfalls, and the use of jet plow embedment methods for the submarine transmission line burial in the seabed; and
- Select a submarine transmission line installation methodology and cable bundle configuration that would minimize the number of submarine transmission line trenches to complete the AC circuitry for Wind Park interconnection. Evaluate potential construction and operational impacts of submarine transmission line bundling to reduce the number of required cable seabed trenches, and stacking configurations, which would reduce the width of the trench.

3.5.3 Description of Route Selection

The Applicant identified six alternative transmission line routes, including submarine and upland transmission components that appeared reasonable, to provide the necessary interconnection between the ESP and the

Barnstable Switching Station (Figure 3-67). These landfalls and routes were evaluated using the established siting criteria as discussed above and represent a geographically diverse analysis. Table 3-59 summarizes each of the alternative routes.

3.5.3.1 Alternative Route #1 – Yarmouth – New Hampshire Avenue Landfall and Transmission Line Route

The following route has been found to be the preferred route by the EFSB in their tentative ruling of July 2, 2004 (EFSB, 2004).

The Alternative Route #1 submarine transmission line makes landfall at New Hampshire Avenue in Yarmouth and ends at the interconnection with the Barnstable Switching Station (Figure 3-68). The submarine transmission line would travel northerly through Lewis Bay to be installed along the easterly property line, then transition to upland solid dielectric cable via a transition splicing vault situated at the end of New Hampshire Avenue. The submarine transmission line would be buried in Lewis Bay via jet plow embedment; transition of the submarine transmission line to the upland transmission line would be accomplished using HDD methodologies. Four 18-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 200 feet long. For this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location would be approximately 12.2 miles in length (6.6 miles within the Massachusetts three-mile territorial line).

The preferred landfall location, New Hampshire Avenue, is owned and maintained by the Town of Yarmouth. New Hampshire Avenue extends to an existing concrete sea wall at the water's edge; beach and riprap are located along the seaward perimeter of the seawall. The New Hampshire Avenue landfall is abutted to the east and west by residential properties. The house on the property to the east is set back from the water's edge by a small sandy beach area. There are no trees or vegetation located around the landfall that would be impacted by installation of the transmission line. The transition vault would be located approximately 50 feet upland within New Hampshire Avenue.

From the landfall, the upland transmission line route would run northeasterly along the east side of New Hampshire Avenue for approximately 0.1 miles. New Hampshire Avenue is approximately 22 feet wide with light underground utilities. New Hampshire Avenue is a residential development area with approximately eight homes located on both sides. In addition, there are a lodge and town beach with parking located to the east of the upland transmission line route.

At the end of New Hampshire Avenue, the upland transmission line would intersect Berry Avenue, cross to the west side, then turn and run due north within the road for approximately 0.7 miles. Berry Avenue is a two-lane road, approximately 22 feet wide with a moderate density of underground utility infrastructure. Berry Avenue is a residential neighborhood with houses on both sides of the road and a business located at its intersection with Route 28. At the north end of Berry Avenue, the upland transmission line would cross Route 28 via trenchless technology and come out in the easterly side of Higgins Crowell Road. The underground crossing of Route 28 would be approximately 700 feet long.

The upland transmission line would run within the east side of Higgins Crowell Road in a northerly direction for approximately 1.0 mile, then cross to the west side and continue running northerly, then along a bend in the road in a westerly direction all the way to Willow Street. Thus, the total transmission line run within Higgins Crowell Road would be approximately 2.6 miles.

Higgins Crowell Road is a two-lane road, approximately 24 feet wide with ample shoulders and light to moderate underground utility infrastructure. At the intersection of Higgins Crowell Road and Route 28, there are two businesses located on the west side of the road. Continuing north on Higgins Crowell Road to the intersection of Buck Island Road, the transmission line route is bordered by residential properties. Buck Island Road is an intersection that is heavily traveled and was recently repaved by the Town.

From Buck Island Road to Lavender Street, there are approximately six residential homes on either side. After passing Lavender Street, the left and right sides of Higgins Crowell Road are undeveloped conservation land with trails and public access. The upland transmission line would not be located within the conservation land. The

police station and three houses are located on the east side of the route after the conservation land. In addition, there are two public schools located on the east side of the road, Mattacheese School and Marguerite Elementary School. Higgins Crowell Road then continues with residential developments, a church, and businesses separated with undeveloped forestland. There are three potable wellfields located within this portion of the route.

Once reaching Willow Street, the upland transmission line would travel along the east side and run north again within Willow Street for approximately 0.5 miles. Willow Street is a heavily traveled two-lane roadway that is approximately 30 feet wide with moderate underground utility infrastructure. The transmission line would travel past several businesses on the northern side of the Route 6 underpass. The upland transmission line would continue its northerly route, crossing beneath and perpendicular to the east bound and west bound overpasses of Route 6 via trenchless technology. The route then turns west and intersects with the existing NSTAR Electric ROW. The NSTAR Electric ROW is an undeveloped existing maintained transmission line ROW that has an herbaceous understory present within a corridor approximately 180 feet wide. The perimeter of the corridor consists of a variety of trees that provide canopy coverage with residential properties setback approximately 50 feet.

The total length of the upland transmission line route to the intersection with the NSTAR Electric ROW at Willow Street is approximately 4.0 miles, which would be installed entirely below grade within public roadways.

The transmission line at the intersection of Willow Street and the existing NSTAR Electric ROW currently has two 115 kV transmission line circuits, which originate at the NSTAR Electric Barnstable Switching Station.

The interconnection to the Barnstable Switching Station from Willow Street will be continuing in a westerly direction underground within the ROW for approximately 1.4 miles and then turning in a southerly direction for approximately 0.5 miles to the Barnstable Switching Station. This would involve the construction of two new underground transmission lines in the existing NSTAR Electric ROW approximately 1.9 miles in length and running from the point where the new upland transmission line intersects the existing ROW in Yarmouth to the Barnstable Switching Station. The two transmission lines together within the NSTAR Electric ROW would consist of 12 (two circuits x two conductor/phase x three phases) cables. A third bay would be added at the Barnstable Switching Station to allow for the installation of three new circuit breakers and shunt reactors.

Advantages to Alternative #1:

- The entire length of the upland transmission line will be below grade within existing public roadways and electric transmission ROWs to the Barnstable Switching Station;
- On a qualitative basis, this route ranked as one of three routes judged to be a more reliable interconnection to the electric transmission system;
- There would be no direct impact to any rare and endangered plant or wildlife species and habitat as designated by Massachusetts Natural Heritage Endangered Species Program (MNHESP);
- There are no identified historical properties and archaeological sites within the upland transmission line route of physical disturbance to the intersection of the NSTAR Electric ROW; and
- This route is relatively straight and direct with relatively wide streets.

Disadvantages to Alternative #1:

- There is the potential for temporary traffic flow disturbances;
- The route crosses under an active rail line, and
- There are relatively high numbers of manholes/vaults as compared to other routes.

3.5.3.2 Alternative Route #2 – Mashpee – Mashpee Neck Road Town Landing and Transmission Line Route

Alternative #2 would require the submarine transmission line to be horizontally directional drilled approximately 1,000 feet under Popponesset Beach in order to avoid impacting the barrier beach. The submarine transmission line would then travel in a northerly direction through Popponesset Bay and make landfall at the Mashpee Neck Road Town Landing, utilized as a public boat ramp (Figure 3-69 and 3-69a). The submarine transmission line would be buried in the bay via jet plow embedment and transition to the upland would be accomplished by HDD methods. The submarine transmission line would travel up through Popponesset Bay to be installed on the west

side of the concrete boat ramp, then transition to upland solid dielectric cable via a transition splicing vault located in a grassy undeveloped area on the west side of the ramp. Four 18-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 500 feet long for the land to water HDD. Under this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location is approximately 10.0 miles in length (5.2 miles within the Massachusetts three-mile territorial line).

Popponesset Bay is a shallow, narrow embayment with the potential to make the submarine transmission line installation challenging. The installation vessel for the submarine transmission line would most likely be unable to enter Popponesset Bay due to the relatively shallow and narrow characteristics of the Bay and the barrier beach located at the mouth of Popponesset Bay. Two different HDD installations (one land-to-water and one water-to-water) would be required in order to avoid impacting Popponesset Beach (a barrier beach) at the entrance of Popponesset Bay. From the Town Landing Landfall location to just past the south side of Popponesset Beach is a distance of approximately 8,000 feet. An HDD operation would need to be performed on the upland at the landfall out approximately 500 feet into Popponesset Bay and then a second HDD operation, approximately 1,000 feet long, would need to be performed using a jack-up barge to directionally drill under the spit of the Beach.

The east side of the boat ramp off of Mashpee Neck Road consists of a sandy beach, a coastal dune, and undeveloped upland with a tree canopy and several parking spots. The west side of the boat ramp consists of an undeveloped grassy area, beach, one home, and a salt marsh approximately 50 feet west of the ramp. There are approximately four houses within 150 feet of the landfall location. The transition vault would be located in this undeveloped grassy area owned by the Town of Mashpee to the west of the boat ramp and is approximately 20 feet from the water's edge.

Upon making landfall, the upland transmission line would travel in a northerly direction on Mashpee Neck Road for approximately 1.5 miles. Mashpee Neck Road dead-ends into Popponesset Bay. Mashpee Neck Road is a two-lane paved residential road approximately 23 feet wide with approximately two-foot paved shoulders and seven-foot unpaved sandy minimally vegetated shoulders. Traffic flow on this road is light but is seasonally influenced.

The transmission line would be placed on the west bound side of the street due to the water main being located on the east side of the road. Tree trimming along this alternative might be required but no trees would need to be removed for the installation of the transmission line. There are seven houses located between the landfall location and Frog Pond Close. Half-tide Marina is located off of Frog Pond Close but not within or adjacent to the transmission line route.

Just past Frog Pond Close, on the western side of the road, is Mashpee River Woodland conservation land, which will be avoided. Undeveloped private property is located on the east side of the road between Frog Pond Close and Jackborn Road. Proceeding north on Mashpee Neck Road to Simon's Narrow's Road, the road is entirely residential with approximately 25 houses on the east side. From Simon's Narrow Road to Quinaquisset Avenue, there are approximately 26 homes located on both sides of the road. The conservation land ends in the vicinity of Shipwreck Road located off of Mashpee Neck Road. Mashpee Neck Road consists of undeveloped land and residential homes. Quinaquisset Avenue is a heavily traveled road. The transmission line would then travel in an easterly direction on Quinaquisset Avenue for approximately 25 feet.

The transmission line would cross from the west corner of Quinaquisset Avenue and Mashpee Neck Road to the east corner of Quinaquisset Avenue and Orchard Road. A splicing vault would be located at the corner of Quinaquisset Avenue and Orchard Road. The transmission line would then travel in a northwesterly direction on Orchard Road for approximately 0.30 miles down the east side of Orchard Road and then turn in a westerly direction onto a paper street located off of Orchard Road to the NSTAR Electric Mashpee Substation. The Mashpee Substation, an existing 115 kV substation on a 10.6-acre parcel owned by NSTAR Electric, is located at the intersection of Orchard Street and Route 28. The area around Orchard Road is residential. There are approximately 22 homes that border Orchard Road on each side. Traffic flow along this segment of the route is light.

The interconnection with the existing 115 kV line would require a new riser substation (requiring an area of approximately 50 feet by 100 feet) adjacent to the existing Mashpee Substation to transition the underground

115 kV transmission line from the Wind Park to the existing overhead high-voltage lines. The riser substation would contain five new circuit breakers to connect the upland cable transmission line to the existing NSTAR Electric transmission line No. 115 and to a new overhead single circuit transmission line extending back to the Barnstable Switching Station. The approximate distance from the landfall to the intersection with the NSTAR Electric ROW is 1.9 miles.

A new 12.26-mile overhead single circuit transmission line from Mashpee to the Barnstable Switching Station would be constructed in the NSTAR Electric ROW. In addition, modifications would be necessary at the Barnstable Switching Station which would include adding a partial bay consisting of two 115 kV circuit breaker positions and two sets of shunt reactors which would be sized to cancel out the cable charging current.

Advantages to Alternative #2:

- The entire length of the upland transmission line to the interconnection point at the Mashpee Substation would be below grade within existing public roadways;
- The transmission line route is the least expensive of the alternatives;
- The upland transmission line route to the intersection with the NSTAR Electric ROW is relatively short; and
- The overhead transmission line from Mashpee to the Barnstable Switching Station would be within an existing electric transmission ROW that already contains similar structures.

Disadvantages to Alternative #2:

- The submarine transmission line route would require two HDD operations;
- The installation of the submarine transmission line in Popponesset Bay would be challenging due to the size and depth of the Bay;
- There is minimally the potential for direct impact to rare and endangered wildlife species as designated by MNHESP during installation of the submarine transmission line cable at Popponesset Spit. Popponesset Beach is a nesting ground for the federally- and state-listed threatened Piping Plover and therefore time of year restriction may be utilized as well as bird observers;
- There is the presence of rare and endangered plant or wildlife species and habitat as designated by MNHESP along the NSTAR Electric ROW transmission line route;
- The transmission line route within the NSTAR Electric ROW to the Barnstable Switching Station crosses 15 wetlands;
- There is an identified archaeological site within the upland transmission line route (at the landfall location) of physical disturbance area; and
- Construction of a new overhead 12.26-mile single circuit transmission line to the Barnstable Switching Substation would be required.

3.5.3.3 Alternative Route #3 – Mashpee Bryants Cove/Willowbend Landfall and Willowbend Transmission Line Route

Alternative #3 submarine transmission line would be horizontally directional drilled under Popponesset Beach, then travel northeasterly through Shoestring Bay to make landfall at Bryants Cove, at undeveloped waterfront owned by Willowbend Development Corporation (Figures 3-69 and 3-69a). The submarine transmission line would be buried in the bays via jet plow embedment and transition to the upland would be accomplished by HDD methods. The submarine transmission line would travel up through Popponesset Bay and Shoestring Bay to be installed on an undeveloped wooded property owned by Willowbend, then transition to upland transmission line via a splicing vault located beyond the steep embankment near the end of an existing cart path. Four 18-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 1,000 feet long for the land to water HDD. Under this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location is approximately 11.0 miles in length (6.5 miles within the Massachusetts three-mile territorial line).

Popponesset Bay and its transition into Shoestring Bay is a shallow narrow channel that has the potential to present installation challenges for the submarine transmission line installation. The installation vessel for the submarine transmission line would most likely be unable to enter Popponesset Bay and Shoestring Bay due to the relatively shallow and narrow characteristics of the bays and the barrier beach located at the mouth of

Popponesset Bay. As discussed above under alternative #2, this alternative would also require two HDD operations for the same reasons.

The landfall location is currently an undeveloped area with a steep embankment that is heavily wooded for approximately the first 300 feet inland. An existing cart path is located past this steep embankment. Upon making landfall, the upland transmission line would travel underground in a northerly direction on the cart path for approximately 1.25 miles, crossing Quinaquisset Avenue, Willowbend Golf Course, Old Mill Road, open space and then ultimately tying into the existing NSTAR Electric ROW. The interconnection to the NSTAR Electric transmission line system is located approximately 750 feet north of Old Mill Road, east of Quippish Road and west of the Santuit River within the golf course.

The interconnection structure at the NSTAR Electric ROW would require a new riser substation (requiring an area of approximately 50 feet by 100 feet) to transition the underground 115 kV transmission line from the ESP to the existing overhead high-voltage lines. The riser substation would contain five new circuit breakers to connect the upland cable transmission line to the existing NSTAR Electric transmission line No. 115 and to a new overhead single circuit transmission line. The approximate distance from the landfall to the intersection with the NSTAR Electric ROW is 1.25 miles.

A new 11.0-mile overhead single circuit transmission line to the Barnstable Switching Station would be constructed in the NSTAR Electric ROW. In addition, modifications would be necessary at the Barnstable Switching Station which would include adding a partial bay consisting of two 115 kV circuit breaker positions and two sets of shunt reactors which would be sized to cancel out the cable charging current.

Advantages for Alternative #3:

- The upland transmission line route to the interconnection point is relatively short in relation to Alternatives #2 and #4 that intersect the same ROW;
- The transmission line within the NSTAR Electric ROW is shorter than Alternative #2; and
- The overhead transmission line from Mashpee to the Barnstable Switching Station would be within the existing electric transmission ROW that already contains similar structures.

Disadvantages for Alternative # 3:

- The submarine transmission line route would require two HDD operations;
- The installation of the submarine transmission line in Popponesset Bay and Shoestring Bay would be challenging due to the size and depth of the Bays. There is minimally the potential for direct impact to rare and endangered wildlife species as designated by MNHESP during installation of the submarine transmission line cable at Popponesset Spit. Popponesset Beach is a nesting ground for the federally- and state-listed threatened Piping Plover and therefore time of year restriction may be utilized as well as bird observers;
- There is the presence of rare and endangered plant or wildlife species and habitat as designated by NHESP along the NSTAR Electric ROW transmission line route;
- The transmission line route within the NSTAR Electric ROW to the Barnstable Switching Station crosses 14 wetlands;
- The entire length of the upland transmission line to the interconnection point would be within undeveloped, planned developed, or open space with the exception of crossing Quinaquisset Avenue;
- The landfall location and the upland transmission line route for this alternative have identified historic properties and archaeological sites within the transmission line route of physical disturbance area;
- The upland transmission line route to the interconnection point would require crossing an intermittent stream and wetland; and
- Construction of a new 11.0-mile single circuit transmission line to the Barnstable Switching Station would be required.

3.5.3.4 Alternative Route #4 – Cotuit – Main Street Landfall and Transmission Line Route

Under Alternative #4, the submarine transmission line would make landfall on undeveloped private property at Main Street in the Village of Cotuit (Figures 3-69 and 3-69a). The submarine transmission line would travel northwest through Nantucket Sound to be installed under the beach, and then transition to upland transmission

line via a transition splicing vault located approximately 600 feet upland on Main Street. The submarine transmission line would be buried via jet plow embedment and transition to the upland would be accomplished by HDD methods. Four 12-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 1,000 feet long. Under this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location is approximately 8.4 miles in length (4.3 miles within the Massachusetts three-mile territorial line).

The transmission line would make landfall from the open ocean onto an undeveloped private property with beach and beach grass. Approximately 50 feet from the water's edge, the property is covered with a woody herbaceous understory growth. The property rises topographically to the street. The landfall location is bordered by two homes to the east and one home to the west.

Upon making landfall, the transmission line would travel in a northerly direction on Main Street and intercept the existing NSTAR Electric ROW at the intersection of Main Street and Santuit Road. The upland transmission line would be located entirely within the roadway below grade of Main Street for approximately 2.2 miles. Main Street is a relatively narrow road with heavy residential traffic. Main Street is approximately 20 feet wide near the landfall location and widens to approximately 22 feet along Main Street near Cross Street. The transmission line would be located within the west side of the road.

A portion of Main Street is located within an historical district. There are approximately a dozen old-story growth trees located between the landfall location and Popponesset Road that have the potential to be disturbed and/or removed. After this point, tree removal will not be necessary. However, a fair amount of tree trimming would be required due to the relatively narrow roadway.

Main Street is a mixed-use area consisting of residential properties and businesses. There are approximately 200 homes that border Main Street with approximately one dozen businesses interspersed. In addition, there are five community facilities located along Main Street (a church, three parks/recreational areas, and a school).

Traffic flow is moderate to heavy along this route. There are no major bends in the road until the cable route reaches the intersection of Main Street, Santuit Road, and Sampsons Mill Road.

The location where the upland transmission line intercepts the NSTAR Electric ROW is owned by the Town of Cotuit and is within the Cotuit water district and aquifer protection district. The property contains a variety of trees that provide a canopy and woody herbaceous understory that would need to be removed for the interconnection infrastructure. Approximately 50-100 trees of moderate growth would need to be removed. The interconnection location has both 23 kV and 115 kV lines running overhead. There are two to three homes that are located adjacent to the interconnection location.

The interconnection structure on land adjacent to the existing NSTAR Electric ROW and would require a new riser substation (with an area of approximately 50 feet by 100 feet) to transition the underground 115 kV transmission line from the ESP to the existing overhead high-voltage lines. The riser substation would contain five new circuit breakers to connect the upland cable transmission line to the existing NSTAR Electric transmission line No. 115 and to the new single circuit transmission line. From the landfall at this location to the interconnection point would entail approximately 2.2 miles of 115 kV upland transmission line installation.

A new 10.25-mile overhead single circuit transmission line from Cotuit to the Barnstable Switching Station would be constructed in the NSTAR Electric ROW. In addition, modifications would be necessary at the Barnstable Switching Station which would include adding a partial bay consisting of two 115 kV circuit breaker positions and two sets of shunt reactors which would be sized to cancel out the cable charging current.

Advantages for Alternative #4:

- There are no rare and endangered plant or wildlife species and habitat as designated by NHESP along the upland transmission line route to the interconnection point; and
- The overhead transmission line from Mashpee to the Barnstable Switching Station would be within an existing electric transmission ROW that already contains similar structures.

Disadvantages for Alternative #4:

- Main Street in Cotuit is a very narrow street and presents difficulties for transmission line installation and traffic disruption;
- The transmission line would pass through the Cotuit historical district along Main Street;
- The transmission line route within the NSTAR Electric ROW to the Barnstable Switching Station crosses 13 wetlands;
- There is the presence of rare and endangered plant or wildlife species and habitat as designated by MNHESP along the NSTAR Electric ROW transmission line route;
- Negotiations to acquire landfall property rights with a private owner is required; and
- Construction of a new overhead 10.25-mile single circuit transmission line to the Barnstable Switching Substation would be required.

3.5.3.5 Alternative Route #5 – Point Gammon – Whale Road Landfall and Transmission Line Route

Alternative #5 submarine transmission line would make landfall at Whale Road in the Town of Yarmouth (Figure 3-68). The submarine transmission line would be buried via jet plow embedment and transition to the upland would be accomplished by HDD methods. The submarine transmission line would travel northeast through Nantucket Sound to be installed under the beach, then transition to upland transmission line via a transition splicing vault located at the end of a paved cul-de-sac maintained by a homeowners association. Four 12-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 1,000 feet long. Under this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location is approximately 10.5 miles in length (5.8 miles within the Massachusetts 3-mile territorial line).

The landfall location is a beach and coastal dune with beach grasses. Whale Road is approximately 200 feet from the water's edge. There are two homes, one on each side of the landfall location. The road is very narrow. The transition vault would be located on the corner of Whale Road and Great Island Road and some tree clearing may be required. The upland transmission line route includes running in a northwesterly direction on Whale Road for approximately 200 feet, then proceeding in a northeasterly direction on Great Island Road which turns into South Sea Avenue for approximately 0.6 miles. Whale Road and a portion of South Street is a gated community governed by a homeowners association with private roads that are one lane (approximately 12 feet wide) with very little underground utility infrastructure.

Great Island Road is a very narrow road that would need to be closed during installation of the transmission line. Great Island Road consists entirely of residential properties with approximately eight homes adjacent to the route. Once leaving the neighborhood association, Great Island Road turns into South Sea Avenue and then the road becomes wider. South Sea Avenue is primarily residential (27 homes) along the route with only three businesses.

The transmission line would continue in a northwesterly direction on Silver Leaf Lane for approximately 0.6 miles. Silver Leaf Lane contains all residential properties with approximately fifty homes located adjacent to the route.

The upland transmission line would then intersect with Berry Avenue and continue along the same route as described in Alternative #1. The length of this alternative upland transmission line route to the intersection point with the NSTAR Electric ROW is approximately five miles. The transmission line would be installed entirely below grade within public roadways. Interconnection to the Barnstable Switching Station will occur the same way as described in Alternative #1.

Advantages to Alternative #5:

- The entire length of the upland transmission line would be below grade within existing public roadways and electric transmission line ROWs;
- The potential use of the existing bike path along Higgins Crowell Road is a benefit in that it will help minimize traffic impacts along this portion of the route;
- No direct impact is expected to any rare and endangered plant or wildlife species and habitat as designated by MNHESP;

- No identified historic properties and archaeological sites are within the upland transmission line route of physical disturbance; and
- The route was one of three that was judged better in terms of reliability.

Disadvantages to Alternative #5:
- This route has high construction costs;
- The submarine transmission line installation would require disturbance of mapped eelgrass beds;
- The submarine transmission line approach would be difficult due to seabed geomorphology and the area near the landfall has been characterized as rocky;
- The landfall location is owned by the private sector;
- This route would be a construction challenge requiring more bends and turns for the installation;
- Access to Point Gammon, off of Great Island Road, would be closed during installation due to the narrow street width, thereby causing public and emergency access to be cut off, and
- The route crosses under an active rail line.

3.5.3.6 Alternative Route #6 – Hyannis Inner Harbor – Lewis Bay Road Landfall and Transmission Line Route

Alternative #6 submarine transmission line would make landfall in Hyannis Inner Harbor at a concrete boat ramp located on Lewis Bay Road (Figure 3-68). The submarine transmission line would be buried in Lewis Bay and Hyannis Inner Harbor via jet plow embedment and transition to the upland would be accomplished by HDD methods. The submarine transmission line would travel north through Lewis Bay into Hyannis Inner Harbor to be installed at the end of Lewis Bay Road, and then transition to upland transmission line via a splicing vault located approximately 50 feet upland on Lewis Bay Road. Four 12-inch diameter boreholes would be constructed using HDD techniques. Each borehole would be approximately 500 feet long. Under this alternative, the submarine transmission line from Horseshoe Shoal to the landfall location is approximately 10.5 miles in length (6.3 miles within the Massachusetts three-mile territorial line).

The landfall location is located off of Lewis Bay Road at a concrete boat ramp. The boat ramp is bordered to the north by a wooden dock and a sandy beach to the south. The landfall is adjacent to Hyannis Marina to the east and a motel to the north. The U.S. Coast Guard and the Woods Hole, Martha's Vineyard and Nantucket Steamship Authority ("SSA") are located within the vicinity of the landfall location to the west. The transition vault would be placed within the paved roadway of Lewis Bay Road approximately 50 feet upland before Willow Street. Lewis Bay Road is a dead-end road used by boaters.

The distance of the 115 kV upland transmission line from landfall to the interconnection location at Hyannis Junction is approximately three miles in length. The route runs in a northerly direction on Lewis Bay Road for approximately 0.3 miles. Lewis Bay Road is approximately 23-25 feet wide and heavily traveled with heavy underground utility infrastructure present. At the corner of Willow Street and Lewis Bay Road is one residential property. Cape Cod Hospital and Cape Cod Medical Center are located on the east side of Lewis Bay Road. At the intersection of South Street and Main Street, there is a nursing home, the Greenery, on the west side and medical offices on the east side. The SSA parking lot is also located on the west side of this roadway. As the transmission line continues on Lewis Bay Road, there are approximately half a dozen homes, and more than a dozen businesses.

The transmission line would then cross Main Street, through the Park Square Rotary, and continue in a northerly direction on Camp Street for approximately 0.3 miles. The rotary is populated with medical offices and businesses. After crossing the rotary, Camp Street consists of equally mixed residential and business properties. Camp Street is a two-lane narrow road that is approximately 25 feet wide with heavy underground utility infrastructure present.

The transmission line would then cross under Route 28 via HDD and run in a northeasterly direction on Yarmouth Road for approximately 0.50 miles. Route 28 is a heavily traveled roadway with commercial businesses located on each corner. Yarmouth Road is a two-lane road that is approximately 25 feet wide and heavily traveled. Yarmouth Road consists of more than two dozen business/commercial properties with approximately three residential properties mixed in along the transmission line route.

The transmission line would leave Yarmouth Road in the vicinity of a service station located at the intersection of Yarmouth Road and Camp Street and cross under the active railroad bed via HDD and enter the Barnstable Airport property. No tree removal or trimming would be required for this portion of the route. The transmission line route would cross through the Barnstable Airport at the end of the northeasterly runway and then travel in a southwesterly direction in open space consisting of ground cover and a woody herbaceous understory. This open space is designated by MNHESP as rare and endangered plant or wildlife species and habitat.

The transmission line would run along the outside of an upland forest that is located approximately 500 feet from the airport runway. The transmission line would run along the perimeter of the upland forest to avoid any unnecessary tree removal. The transmission line would travel for approximately 1.5 miles in a southwesterly direction around the airport to the access road and then make a 90-degree turn and head northwest and enter a cleared area of the upland forest that is a dirt access road for maintenance purposes for a water supply pump house located to the east of the transmission line route. The transmission line would travel on this dirt access road for approximately 400 feet before entering Mary Dunn Road. Trimming of trees along this portion of the route would be required. Upon reaching Mary Dunn Road, the transmission line runs approximately 1,000 feet north to the Hyannis Junction Substation. Several industrial developments are located in this general area, but none are present directly along the transmission line route. Mary Dunn Road is approximately 24 feet wide and is not a heavily traveled road.

The transmission line would intersect the existing transmission line ROW located on the Hyannis Junction Substation property and then continue underground approximately 1.0 mile to the Barnstable Switching Station.

In addition, modifications will be necessary at the Barnstable Switching Station which would include the installation of three 115 kV circuit breakers and two banks of shunt reactors which would be sized to cancel out the cable charging current.

Advantages to Alternative #6:
- Short upland transmission line route;
- Possible use of land owned by airport authority;
- One of three routes that was judged better in terms of reliability; and
- The route utilizes existing electric transmission ROW from Hyannis Junction to Barnstable Switching Station.

Disadvantages to Alternative #6:
- There would be direct impact to rare and endangered plant or wildlife species and habitat as designated by MNHESP;
- The potential to impact wetlands is present;
- A portion of the upland transmission line would be within undeveloped open space;
- Construction along this route would be constrained by workday hour limitations;
- This alternative would present potential traffic impacts and would require traffic detouring;
- This route traverses the most densely populated area of all routes considered;
- This alternative would restrict access to the hospital; and
- This route would cross under an active rail line.

3.5.4 Screening Criteria

The alternative routes that were evaluated allowed for a reasonable range of geographic and environmentally diverse options. Six distinct route alternatives were identified through the application of the siting criteria. The six routes are compared using the 26 screening criteria identified below which includes 11 installation and maintenance complexity criteria, 13 environmental and land use criteria, cost and reliability criteria. A comprehensive, quantitative method of comparing the identified alternatives was developed to ensure that alternative routes that were clearly superior to the proposed route were not overlooked or eliminated.

In order to evaluate each of the routing alternatives, a ranking system was developed to identify those routes that minimize environmental and natural resource impacts, community impacts, and costs, while still maintaining or improving system reliability and providing geographical diversity. The ranking system is structured so as to

apply quantitative values to the routes to determine an individual score. Each criteria was assigned an individual score value between zero and five, where a score of five is a high value or more favorable, and a score of zero is a low value or less favorable. Table 3-60 summarizes the ranking of each criterion based upon the quantitative values. Below is a description of the criteria applied to all the routes.

3.5.4.1 Installation and Maintenance Complexity

Underground Utility Congestion

Each route was evaluated for difficulty with respect to the degree of utility congestion under the routes. It is unlikely to find roads that are entirely free of underground utility infrastructure. Some streets will be more congested than others presenting increased difficulty with the transmission line route for the installation of the upland transmission line, ductbanks, and splicing vaults. In addition, if there is congestion within the roadways and ROWs, installation of the upland transmission line could be more complex and involve more costly construction techniques, or present future maintenance problems. The upland transmission line routes were evaluated for overall construction difficulty with respect to underground congestion within street segments. The evaluation consisted of review of town utility maps, discussions with town departments, and field visits. It is more favorable to have a route that provides sufficient room for ductbank construction and to be able to place them at locations along the route without increased difficulty. It would be less favorable to have a route that would require ductbanks to be placed deeper than normal to avoid other underground infrastructure or attempt to relocate existing underground utilities.

Intersection Crossings

Each route was evaluated for the number of intersection crossings that would occur. In addition, the routes were evaluated for whether the transmission line would require crossing any major or heavily traveled intersections. Based on discussions with the Massachusetts Highway Department (MHD), if the transmission line were to cross a state roadway, HDD would be required, thereby increasing the cost of construction. Therefore, crossing a state highway or road is considered a major intersection, whereas crossing a town or local road/highway is considered a minor intersection.

Traffic

Traffic impacts associated with the installation of the upland transmission line route will be limited to temporary interruptions and will impact only small areas at a time. Installation of the duct banks will require approximately 18-22 feet of road surface for set up of equipment during most operations. Construction within the roads is anticipated to progress at approximately 150 feet per day, thereby limiting the amount of traffic restrictions. It would be favorable to have a route that proceeds through roads that are not heavily traveled, thereby limiting the potential for temporary traffic impacts. In addition, routes were evaluated for whether the road segments along the route were of sufficient width to accommodate the installation of the transmission line. This will also help alleviate any potential for restricting vehicle travel access during installation. Therefore, a more favorable route would be along roads that are not heavily traveled and with a street width that would maintain vehicle travel access at all times during installation. Observations of vehicular traffic were conducted during June of 2002.

Upland Transmission Line Length

Each route was evaluated for the distance and difficulty of the transmission line route from the landfall location to the intersection point with the existing NSTAR Electric ROW. Avoidance of a lengthy route will help to minimize electric losses between the Wind Park and the transmission interconnect and will typically be less costly with fewer construction and environmental impacts.

In addition, each applicable route was evaluated for the distance and difficulty of the transmission line route from the intersection/interconnection point to the Barnstable Switching Station within the existing NSTAR Electric ROW.

Manhole/Splicing Vaults

Manhole/splicing vaults will be placed every 1,500 – 3,000 feet along the transmission line route. In addition to the vaults placed every 1,500 – 3,000 feet, the number of bends, utility congestion, and the existence of any state highways or railroad crossings also dictates the number of manholes/splicing vaults required for each route. Therefore, a transmission line route with minimal additional splicing vaults is more favorable because the additional splicing vaults increase the overall construction costs.

Railroad Crossings
The crossing of a rail line typically involves a process of negotiation with the railroad as the property owner. Depending on the particular practices of the railroad, rights to cross under (or over) the rail line potentially could be in the form of an access agreement, easement, or more typically a license, which can have yearly fees and renewal provisions. When a utility crosses a state or local road, a road opening permit and possible easement are typically required which have a one-time fee and more defined process. Therefore, crossing a rail line can be a more time consuming, less certain, and more costly undertaking, affecting the construction and maintenance of the transmission line. Therefore, it is more preferable that the route crosses few or no railroads.

Access During Construction
During construction on frequently traveled roads, it is important that the community's access to roads is not entirely blocked without alternative routes or detouring. If a road must be temporarily blocked off during construction, it is ideal that an alternate route or detour exists so that traffic flow is maintained, and access to businesses and homes on that road are still available. On routes where the transmission line is to be buried, it is preferred that: (1) the road is wide enough for traffic to be routed around construction; or (2) other roads are present to serve as detours or other access points so access to homes and businesses are not completely blocked.

Submarine Transmission Line Distance
Each route was evaluated for the distance and difficulty of the installation of the submarine transmission line from the ESP to the landfall location. Avoidance of a lengthy route will help to minimize electric losses between the Wind Park and the transmission interconnects and will typically be less costly with fewer impacts.

Submarine Horizontal Directional Drilling
The transition of the interconnecting 115 kV submarine transmission line from water to land will be accomplished through the use of HDD to minimize shoreline impacts and sediment disturbance within the intertidal zone. Based upon current technology, HDD methodology involving borehole and conduit, and pulling high voltage cables, is limited to approximately 1,000 feet. The primary limiting factor is the tolerance of the cable to the forces of the pull. HDD would be staged at the upland landfall area and involve the drilling of a hole from land to an offshore exit point, after which a conduit would be installed in the length of the hole. With the conduit installed, the transmission line cable would be pulled from the drill exit point offshore through the drill entrance point upland. A transition manhole/splicing vault would be installed using conventional excavation equipment (backhoe) at the HDD entry point for the transition joints between submarine and upland transmission line. HDD is complex and costly; therefore, a favorable route would limit HDD to a one-time operation with a minimal pulling distance.

Navigational Impact - Construction Vessel Access and Marine Traffic Impact
The installation of the submarine transmission line will require work within Nantucket Sound and, along certain routes, work within bay areas. Work will include shoreline landfall construction activities and submarine transmission line installation activities. All work within the waterway will be temporary, localized, and short term. Once the submarine transmission line is installed, there are no anticipated impacts to commercial or recreational navigation activities since the transmission line will be buried approximately six feet below the seafloor. This criterion looked at whether the channel widths and depths along each submarine route alternative were ample enough to allow the cable-laying and support vessels to operate, and whether or not the route would cross through a maintained or heavily traveled channel. The most favorable submarine route would be through open, infrequently traveled waters deep enough to allow the cable vessel to maneuver easily.

3.5.4.2 Environmental Impact Criteria

The environmental impact criteria listed evaluate the potential effect of the installation and operation of the transmission line on the surrounding transmission corridor.

Wetlands
The upland transmission line routes are predominantly upland (i.e., non-wetland) consisting of existing roads and shoulders. However, wetland resources may be observed adjacent to or located near the transmission line route

(i.e., within the buffer zone of a wetland resource area). Avoidance of passing through wetland resource areas, protected under the Massachusetts Wetlands Protection Act and, if applicable, town wetland bylaws, was desirable and important in route selection. Erosion and sedimentation controls would be placed along the work corridor upslope of any wetland resource areas located within the Project Area, and would be routinely monitored and maintained during construction. The work area would be restored and stabilized prior to removal of erosion control measures. In addition, the work area would be restored and repaved or revegetated, as appropriate, and monitored after construction to ensure its stability.

The existing NSTAR Electric ROWs are predominantly upland with existing vegetation management/ maintenance and access roads. However, wetland resource areas were observed adjacent to or located within the ROW. The ROW was evaluated for the degree of difficulty to install the transmission line. Avoidance of passing through or crossing wetlands resource areas was desirable and important in route selection.

Terrestrial Rare and Endangered Species and Habitat

The Applicant located the upland transmission line route within existing roadways and maintained transmission ROWs/easements to avoid disturbing natural communities, such as listed habitats for rare species including endangered plants and wildlife. The most favorable routing option would be to place the transmission line in areas that do not contain natural communities. The next most favorable routing option would involve placing the transmission line along a route that would be within a roadway or ROW that has minimal encroachment into these habitats.

Tree and Vegetation Removal

Each route was evaluated for avoidance of tree and/or vegetation removal during installation of the transmission line including the interconnection and the NSTAR Electric ROW and landfall locations. Accordingly, to minimize impacting tree or vegetation, installation of the transmission line within the existing cleared width of the ROW is preferred. Tree removal may also affect the visual impact of the transmission line where overhead construction is used.

Shade Tree Removal

The removal of shade trees negatively effects neighborhood and community aesthetics and visual impact and is often opposed by local communities. Avoidance of shade tree removal is most favorable.

Percentage of New ROW

It is preferred that the transmission line follow existing ROWs along which land has already been disturbed and easements already exist, such as roadways. It is unfavorable for the transmission line to cross undeveloped land and/or open space, including conservation, agricultural and recreational land, town forests, parkways, and cemeteries. It is most favorable for the transmission line to follow existing ROWs or easements and not to cross open space in order to reduce installation impacts to environmental and natural resources.

Water Supply – Groundwater

Cape Cod has an abundance of high quality drinking water and is an EPA-designated sole source aquifer. One of the goals on the Cape is to maintain the overall quality and quantity of the groundwater to ensure a sustainable supply of high quality untreated drinking water. Therefore, the protection of groundwater is important and many Cape communities have adopted groundwater protection districts or aquifer protection overlay districts via zoning bylaws. In addition, protective zones (i.e., Zone I and Zone II) have been established around public water supply sources in accordance with MADEP regulations. Zone I is a protective radius required around a public water system well or wellfield. The radius of the Zone I is dependent on the approved pumping rate for the well and is 400 feet for public water supply wells with approved yields of 100,000 gallons per day (gpd) or greater. Zone II is that area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated. Municipalities often base their groundwater protection districts on the MADEP-approved Zone II. According the MADEP, the most preferable option would be not to place any new utilities within or through a Zone I. However, on a case-by-case basis, the MADEP would review the route option if it was determined to be the most environmentally benign.

Disruption to Properties During Construction
The upland transmission line routes were evaluated for the number of residential, commercial/business, and industrial properties abutting the route. None of the routes had industrial properties located along them. Impacts to any of these developments will be temporary in nature; however, routes were favored with minimal effect on homes and businesses. The routes were ranked among themselves on potential level of disruption by experienced field representatives who visited the sites. The percentage of residential and commercial property was also estimated for each route to assist in the ranking.

Cultural Sites
There have been many cultural sites discovered and mapped throughout Cape Cod. These sites are important historic and archaeological resources and must be avoided if at all possible. A favorable route would be one that does not cross any known historic or archaeological sites.

Historic Districts
Although any construction through registered historic districts would only be temporary, construction through historic districts is often opposed by local communities. Cape Cod is treasured for the traditional historic character of its communities and landscapes and is well known for the preservation of its distinctive historic buildings and villages. Avoidance of these areas was important in considering possible routes.

Community Facilities
Since the transmission line will be installed entirely below grade, the overall impacts to the surrounding community during installation and operation will be minimized. Therefore, the transmission line route selection was evaluated so as to avoid and/or minimize impacts to schools, hospital and medical facilities, and churches.

Hazardous Waste Sites
The MADEP "Searchable Site Data" website was reviewed to identify any listed hazardous waste sites that were present along the alternative routes. Each route was evaluated to determine if any listed hazardous waste sites were located within the proposed route or within reasonable proximity such that they may need to be addressed during construction.

Eelgrass
Eelgrass beds are protected as Land Under Ocean in accordance with the Massachusetts Wetlands Protection Act, 310 CMR 10.00, and projects must be consistent with associated performance standards. Projects that will affect Land Under Ocean shall, if water-dependent, be designed and constructed, using best available measures, so as to minimize adverse effects. If projects are non-water dependent, they shall have no adverse effects on marine fisheries habitat or wildlife habitat caused by destruction of eelgrass beds (310 CMR 10.25(6)). Projects proposed to be located near or specifically within eelgrass beds have no particular exclusions, but are highly scrutinized. Therefore, the most favorable routing option would be to place the transmission line outside of mapped eelgrass beds.

Fish Runs
Fish runs are present in the area of all proposed alternatives and will be addressed by construction techniques. This impact was judged to be essentially equivalent for all routes.

Shellfish
Shellfish areas are present for all proposed alternatives and will be addressed by construction techniques. This impact was judged to be essentially equivalent for all routes.

3.5.4.3 Cost of Facilities

This criterion covers the cost of the installation of the submarine and upland transmission to the interconnection point with the Barnstable Switching Station. The cost of the transmission line was derived from estimates of the cost of materials and installation of the transmission line for both the submarine and upland portions, including the cost of the submarine transmission line, submarine HDD operation, transition vault, the upland transmission line, ductbanks, manholes, and civil work. Also included are costs for the new NSTAR Electric overhead lines and substation construction/modifications. The line costs varied with the different lengths of the submarine and

upland transmission line, different conductor sizes of the upland cable, number of HDD operations required both on the submarine and upland route, routing and general difficulties of installing the cable. In addition, the estimates include costs for specific installation and design difficulties such as performing additional HDD operations and/or requiring a jack up barge, crossing state highways or railroads, and installation in an underground utility congested area. The cost of each route is shown in Table 3-62.

3.5.4.4 Reliability

Reliability is considered in the assessment of the transmission interconnection route analysis because of the potential for the new electric capacity being tied into the existing system to impact the existing system's performance. This can occur in three different ways: the new interconnection could improve reliability or be favorable; reduce reliability and therefore be unfavorable; or have no net impact, positive or negative.

A benefit of the interconnection of the Wind Park to the transmission system is the ability of the WTGs to supply system voltage support. The design of the WTGs incorporates a variable speed feature. Through the use of the "Dynamic VAR Control (DVAR)" control system, the generators are capable of controlling the overall voltage or power factor of the Wind Park at the ESP or at Barnstable Switching Station. The rapid response of DVAR to supply or absorb VARS during system disturbances is expected to contribute to the stability of the transmission grid. Finally, the power electronics are also used to "smooth start" the machines, thereby avoiding undesirable voltage dips on the utility system.

The effect of adding WTGs with these features to the grid is an improvement in system reliability that has been demonstrated by installations on utility grids in the central and western states of the U.S. and internationally.

Alternatives that interconnect from the east of the Barnstable Switching Station are generally viewed as more favorable than tie-in points from the west of the Barnstable Switching Station. The routes that tie-in from the east of Barnstable Switching Station are accomplished by underground lines within the existing ROW, whereas tie-ins from the west are accomplished via overhead lines within the ROW.

In sum, the addition of new electric generating capacity and the new transmission lines that will deliver the power to the Barnstable Switching Station will not have a detrimental impact on the transmission system and to the extent the generators are operating, will help provide additional reliability benefit to the local electric supply system and to the regional system. There are currently no major generating facilities that can provide capacity on Cape Cod beyond the Mirant Canal Plant located on the Cape Cod Canal in Sandwich.

Alternatives that interconnect from the east of the Barnstable Switching Station are generally viewed as more favorable than tie-in points from the west of the Barnstable Switching Station. The routes that tie in from the east of Barnstable Switch Station are accomplished by underground lines within the existing ROW whereas tie-ins from the west are accomplished via overhead lines within the ROW. While both overhead and underground transmission systems are inherently reliable, underground lines, are comparatively viewed as more favorable in terms of reliability.

Detailed studies are currently being performed under the ISO-NE Minimum Interconnection Standard for the Barnstable Switching Station alternative by NSTAR Electric to determine whether there are any thermal, short circuit or stability impacts and assess any transmission system upgrades that may be necessary. These studies will be provided as supplemental information when completed.

3.5.5 Application of Screening Criteria

Construction of the proposed 115 kV transmission line is feasible on any of the six routes discussed above in a manner consistent with the environmental policies and regulations of the Commonwealth. To evaluate the six route alternatives in a consistent manner, criteria were developed and evaluated based upon field investigations and a matrix-based evaluation methodology was employed. A matrix for both the submarine transmission line and the upland transmission line to the Barnstable Switching Station was developed and the screening criteria were applied to the routes. A ranking system was developed that consisted of cost, reliability, environmental, and installation and maintenance complexity criteria for each route. According to typical EFSB practice, a group

of experts from the Applicants' and their consultants' Project team assigned scores for each of the criteria for each route alternative. The ranking system was structured so as to apply quantitative values versus qualitative considerations to the routes thereby minimizing any potential bias on the part of the individual scoring the routes. The upland and submarine transmission line portions of the routes were assessed and rankings were applied separately. The rankings were totaled in order to provide an overall individual score. The ranking system ranged from a score of zero to five, with a score of five being most favorable. Please refer to Tables 3-59 through 3-61.

Scores computed for the individual routes were then adjusted based upon a weighting factor that was applied to each criterion described above. The weighting was based on the Project team's judgment of the relative importance of each criterion relative to the other criteria within its group. Criteria the Project team felt were very important to the overall development of the Proposed Project received a weighting of three. Criteria considered to be moderately important received a weighting of two and criteria considered to be of minor importance received a weighting of one. The weighting factor applied to each criterion is listed in Table 3-61.

To complete the comparison of each route, the ranking score was multiplied by the weighting factor to develop an overall weighted score for each route. The weighted scores for each criterion were then summed to determine which routes would be evaluated further.

3.5.6 Selection of Preferred Route

The highest scoring route is Alternative #1 - New Hampshire Avenue Landfall Location and Upland Transmission Line Route. This route scored well in terms of the installation criteria for the upland portion and ranked high in regard to submarine installation criteria. It ranked superior to all other routes in terms of the environmental criteria. It also scored high with respect to potential navigational issues during construction and to the HDD criteria, both of which are considered very important to construction of the transmission line. Although it was not the lowest cost alternative evaluated, its expected cost is reasonable and it was one of three alternatives ranked as most favorable with respect to reliability. It was thus selected as the preferred route for the proposed transmission line facility.

The second highest scoring route was Alternative #2 - Mashpee Neck Road Town Landing and Upland Transmission Line Route. This route scored well with respect to the upland installation criteria, specifically, the number of intersection crossings and utility congestion. This route also scored second highest with respect to the environmental criteria. The route scored on the lower end of the routes for the submarine cable criteria, mainly due to the HDD work involved with crossing under and the embedment work within Popponesset Bay. This route represents a reasonable alternative with limited impacts, but does present some technical complexity and possible additional costs associated with the submarine cable landing and HDD. It also represents the lowest estimated cost of the alternative routes.

3.5.7 Conclusion on Preferred Route Selection

The Siting Board has tentatively approved the proposal of Cape Wind and NSTAR to construct two approximately 18-mile, 115-kilovolt underground electric transmission lines along the primary route (Alterntive #1-Yarmouth – New Hampshire Avenue Landfall and Transmission Line Route) identified by Cape Wind and NSTAR (EFSB, 2004).

The Applicant has conducted a comprehensive analysis to identify the best route to provide the needed transmission interconnection. This process examined a full and diverse range of alternative approaches to satisfy the demonstrated need for a transmission interconnection. Through this evaluation, which included technical feasibility, costs, reliability, and environmental impacts of a geographically diverse set of options, the preferred approach of connecting the transmission line from the Wind Park to the Barnstable Switching Station was shown to be superior to other approaches. The Applicant then developed six route alternatives for the transmission line to the Barnstable Switching Station that could provide the required connection and provide a degree of geographical diversity between routes. Each route alternative was comprehensively evaluated based on a set of criteria that covered the potential impacts, costs, and installation complexities to provide a consistent basis for comparison. The preferred route proposed for construction was selected based upon the combined assessment of the selected criteria. The route selection process conducted by the Applicant utilized appropriate standards to compare route alternatives and ensured that no superior route alternative was overlooked. The process

ultimately resulted in the identification of a preferred route that was superior to others evaluated in terms of balancing reliability, cost and environmental impacts, and the spectrum of alternative routes evaluated reflects the appropriate degree of geographical diversity.

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