2.0 DESCRIPTION OF PROPOSED ACTION

2.1 PROJECT DESCRIPTION

The proposed action entails the construction, operation, and decommissioning of 130 WTGs located in a grid pattern on and near Horseshoe Shoal in Nantucket Sound, Massachusetts, as well as an ESP, inner-array cables, and two transmission cables. Each of the 130 WTGs would generate electricity independently of each other. Solid dielectric submarine inner-array cables from each WTG would interconnect within the grid and terminate at their spread junctions on the ESP. The ESP would serve as the common interconnection point for all of the WTGs. The proposed submarine transmission cable system is approximately 12.5 mile (20.1 km) in length (7.6 mile [12.2 km] within the Massachusetts 3.5 mile [5.6 km] territorial line) from the ESP to the landfall location in Yarmouth. The two submarine transmission cables would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue. The applicant seeks to commence construction in 2009 and begin operation in 2010.

2.1.1 Wind Turbine Generator

Each turbine is pitch-regulated with active yaw to allow it to turn into the wind, and has a three-blade rotor. The main components of the WTG are the rotor, transmission system, generator, yaw system, and the control and electrical systems, which are located within the nacelle (see Figure 2.1.1-1, in Appendix A). The nacelle is the portion of the WTG that encompasses the drive train and supporting electromotive generating systems that produce the wind-generated energy. The WTGs nacelle would be mounted on a manufactured tubular conical steel tower, supported by a monopile foundation system. A pre-fabricated access platform and service vessel landing (approximately 32 ft [10 m]) from mean lower low water (MLLW) would be provided at the base of the tower. The rotor has three blades manufactured from fiberglass-reinforced epoxy, mounted on the hub. The monopiles within the proposed action area would utilize two different diameter foundation types depending on water depth. The proposed action is designed for a maximum electrical energy capacity of 468 MW (130 WTG's each capable of producing up to 3.6 MW), however the maximum delivered capacity is approximately 454 MW (due to line losses, etc.) Water depths up to 40 ft (0 to 12.2 m) would utilize a 16.75 ft (5.1 m) diameter monopile and water depths of 40 to 50 ft (12.2 to 15.2 m) would utilize an 18.0 ft (5.5 m) diameter monopile.

Each WTG has an energy generating capacity of 3.6 MW ± and the proposed action is designed for a maximum delivered electrical energy capacity of approximately 454 MW. The generating capacity is based on the design wind velocity of 30 miles per hour (mph) (13.4 meters per second [m/s]) and greater, up to the maximum operational velocity of 55 mph (24.5 m/s). Based on the average wind speed in Nantucket Sound of 19.75 mph (8.8 m/s), there would be an average generation capacity of approximately 182.6 MW, and the net energy production delivered to the regional transmission grid would be approximately 1,600 gigawatt hours/year (GWh/y). The actual amount may vary depending upon the actual turbines in the supply chain at the time of construction, which have varying cut-in and cut-out speeds.

In order to generate maximum wind energy production, the WTGs would be arranged in specific parallel rows in a grid pattern. For this area of Nantucket Sound, the wind power density analysis conducted by the applicant determined that orientation of the array in a northwest to southeast alignment provides optimal wind energy potential for the WTGs. This alignment would position the WTGs perpendicular to prevailing winds, which are generally from the northwest in the winter and from the southwest in the summer for this geographic area in Nantucket Sound. The WTGs would have a computer-controlled yaw system that ensures that the nacelle is always turned into the wind and perpendicular to the rotor. In addition to maximizing potential wind energy production, the WTGs must also be sufficiently spaced within the array in order to minimize power losses due to wind shear and turbulence caused by other WTGs within the array. The optimal WTG spacing within the array is 0.39 mile (629 m) by 0.62 (1,000 m) between each WTG based on wind direction analysis. The spacing of the wind turbines is discussed further in Section 3.3.6 under "Condensed Array Alternative."

As a result of technological advancements and design changes by the manufacturers of the GE 3.6 MW wind turbines, the overall dimensions of the machines have changed since the publication of the USACE draft EIS. At present, the primary change involves the use of larger rotor blades, which require mounting on a taller tower to maintain the desired 75 ft (23 m) of clearance to the sea surface. The 75 ft (23 m) of clearance beneath the WTGs was initially chosen, and will be maintained, in order to minimize any impacts to the use of the water sheet area by boats. It should be noted that the applicant may choose to use another manufacturer other than GE to produce similar WTGs as described herein depending on availability and other considerations. The following describes the other changes in the turbine specifications since the publication of the USACE draft EIS (Figure 2.1.1-1).

a. Rotor Diameter: As a result of technological advancements that allow for greater efficiencies, 3.6 MW WTGs are presently produced with a rotor diameter of 364 ft (111 m) (originally 341 ft [104 m]).
b. Nacelle Hub Height: In order to maintain the previously stated 75 ft (23 m) of clearance between the sea surface and a rotor blade tip in its lowest position, the nacelle hub has been raised to a height of 257.5 ft (78.5 m) (originally 246 ft [75 m]).
c. Overall WTG Height: As a result of the larger rotor blades and the desire to maintain the previously stated 75 ft (23 m) of clearance beneath the turbines, the maximum overall WTG height has increased to 440 ft (134 m) (originally 417 ft [127 m]).
d. Rotor Swept Zone: As a result of the changes noted above, the resulting rotor swept zone is now 75 to 440 ft (23 to 134 m) (originally 75 to 417 ft [23 to 127 m]).

The northernmost WTGs would be approximately 3.8 mile (6.1 km) from the dry rock feature (offshore near Bishop and Clerks) and approximately 5.2 mile (8.4 km) from Point Gammon on the mainland; the southernmost WTG would be approximately 13.8 miles (22.2 km) from Nantucket Island (Great Point), and the westernmost WTG would be approximately 9.0 miles (14.5 km) from the island of Martha's Vineyard (Cape Poge) (Figure 2.1.1-2). The proposed action area as presented in the application submitted to MMS on September 14, 2005, includes an expanded perimeter around the site of the proposed action in order to ensure that a sufficient buffer exists between the proposed action area and any other subsequent wind projects authorized by MMS in the future that could impact the ability of the proposed action to produce power at the anticipated level.

The water depths within Nantucket Sound range from 0.5 to 70 ft (0.15 to 21.3 m) at MLLW. Depths on Horseshoe Shoal range from as shallow as 0.5 ft (0.15 m) to 60 ft (18.3 m) at MLLW. Along the transmission cable interconnection corridor, between Horseshoe Shoal and the Cape Cod shoreline, water depths vary from 16 to 40 ft (4.9 to 12.2 m) at MLLW, with an average depth of approximately 30 ft (9.1 m) at MLLW. Water depths within Lewis Bay and Hyannis Harbor range from 8 to 16 ft (2.4 to 4.9 m) at MLLW in the center of the bay to less than 5 ft (1.5 m) at MLLW along the perimeter and between Dunbar Point and Great Island.

2.1.2 Inner Array Cables

Within the nacelle of each turbine, a wind-driven generator would produce low voltage electricity, which would be "stepped up" by a transformer to produce 33 kV electric transmission capacity. Submarine cables from each WTG would interconnect within the turbine array and terminate at their spread junctions on the ESP. The inner array submarine cable system would use a three-conductor cable with all phases under a common jacket. The inner-array cables would consist of solid dielectric alternating currents (AC) cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable would consist of three copper conductors (extruded XLPE insulation) plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers. The entire cable assembly would be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings.

The inner-array cables would be arranged in strings, each of which would connect up to approximately 10 WTGs to a 33 kV circuit breaker on the ESP. The electrical current in the cable segments within each string would vary depending on WTG's location within the string. Cable segments closer to the ESP would provide greater transmission capacity compared to cables further away from the ESP. It is anticipated that three different cable sizes (0.23 square inched [150 mm^2], 0.6 square inches [400 mm^2], and 0.9 square inches [600 mm^2]) would be used to accommodate this variation in transmission capacity related to the distance of the WTG from the ESP. The conductor cross sections would be 3x0.23 square inches (150 mm^2), 3x 0.6 square inches (400 mm^2), and 3x0.9 square inches (600 mm^2)and the overall diameter of the cable would be 5.19 inches (132 mm), 5.75 inches (146 mm) , and 6.45 inches (164 mm) respectively. The inner-array cables would be installed 6 ft (1.8 m) below the seafloor by jet plow embedment.

See Figure 2.1.2-1 for the location of the revised turbine array showing the inner-array cable layout.

2.1.3 115 Kilovolt (kV) Transmission Cable System

Two 115 kV transmission circuits would interconnect the ESP with the existing NSTAR Electric transmission grid serving Cape Cod. Two AC circuits are necessary to provide the required electric transmission capacity when operating at high capacity to the NSTAR Electric transmission system and to provide increased reliability and redundancy in the event of a circuit outage. Each circuit consists of two (2) three-conductor cables, resulting in a total of four (4) cables.

The submarine transmission line would consist of solid dielectric AC cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable would consist of three 1.24 square inch (800 mm^2) copper conductors, XLPE insulated to 123 kV and lead/PE sheathed, plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers, with an overall diameter of 7.75 (197 mm). The entire cable assembly would be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings (see Figure 2.1.3-1). The four submarine transmission cables would be installed as two circuits by bundling two cables per circuit together during installation and installing the two circuits.

The proposed transmission cable system would be approximately 12.5 miles (20.1 km) in length (7.6 miles [12.2 km] within the Massachusetts 3.5 mile [5.6 km] territorial line) from the ESP to the landfall location in Yarmouth. The transmission cables would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue (see Figure 2.1.3-2). The transmission cables would be installed 6 ft (1.8 m) below the seafloor by jet plow embedment. See Figure 2.1.3-3 for a typical cross section of a submarine cable trench using jet plow embedment. The submarine transmission cables would transition to the onshore transmission cable by using HDD methodologies to drill shafts for pulling of conduits, pulling the cable through the conduits, and then transition into a vault positioned at the end of New Hampshire Avenue.

Upon making landfall, the proposed transmission cable route would then follow New Hampshire Avenue north, merging with Berry Avenue. The route continues north on Berry Avenue, crossing Route 28 and continuing north on Higgins Crowell Road to Willow Street. Proceeding north on Willow Street, the route passes under Route 6 to the proposed intersection point with the existing NSTAR Electric 115 kV transmission cable ROW, approximately 500 ft (152.4 m) north of Summer Street. The route then turns westerly within the NSTAR Electric's existing ROW to the Barnstable Switching Station, crossing under Route 6. The proposed onshore transmission cable would be located within the existing public roadways for a length of approximately 4 miles (6.4 km) from landfall to NSTAR Electric transmission cable ROW located on the west side of Willow Street. The onshore transmission cable would then continue underground approximately 1.9 miles (3.1 km) along existing NSTAR Electric ROW and running from Willow Street to the Barnstable Switching Station (see Figure 2.1.3-2).

The onshore cables would be joined to the submarine cables at the landfall in Yarmouth. The onshore transmission cable system would utilize 12 single-conductor 115 kV cables. The 12 cables would be segregated into two circuits, each composed of two cables per phase. The cables would run in a concrete encased duct bank. The conductor cross bank would be 1.24 square inches (800 mm^2). See Figures 2.1.3-4 and 2.1.3-5 for typical duct bank cross sections.

Installation of the proposed onshore transmission cable includes constructing a utility easement within and along four roadways: New Hampshire Avenue, Berry Avenue, Higgins Crowell Road, and Willow Street. The easement would also include the crossing of Route 28 and Route 6. The onshore transmission cable would affect several intersections.

New Hampshire Avenue

New Hampshire Avenue is a two-lane residential road allowing vehicle access in a north-south direction. The roadway is a dead-end with a concrete retaining wall at its southern end. There are no sidewalks on either side of the roadway. In addition, there is no on-street parking. The transmission cable would be installed within the east side of the roadway.

Berry Avenue

Berry Avenue is a two-lane residential road allowing vehicle access in a north-south direction. There are sidewalks on both sides of the roadway. The transmission cable would cross to the west side of Berry Avenue off of New Hampshire Avenue.

Intersection 1 - Route 28 between Berry Avenue and Higgins Crowell Road

At the intersection with Berry Avenue and Higgins Crowell Road, Route 28 is a two-lane roadway with a painted divider. Vehicles on Route 28 travel in an east-west direction. The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is signalized. There are sidewalks on both sides of Route 28. The transmission cable would be installed underneath Route 28 using trenchless technologies.

Higgins Crowell Road

Higgins Crowell Road is a two-lane road with a painted divider and vehicle travel is in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. The transmission cable would be placed on the east side of Higgins Crowell Road.

Intersection 2 - Buck Island Road

At the intersection with Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle on Buck Island Road travels in an east-west direction. The intersection of Buck Island Road with Higgins

Crowell Road is signalized. The transmission cable would be installed beneath Buck Island Road using trenchless technologies.

Willow Street

Willow Street is a two-lane road with a painted divider. Vehicle travel is in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. The transmission cable would be placed on the west side of Willow Street.

Route 6 Crossings

The transmission cable would be installed using trenchless techniques as it passes underneath the Route 6 overpass. Approximately 0.5 mile (0.8 km) past the Route 6 overpass, the transmission cable would enter the NSTAR Electric ROW. The transmission cable would also cross under Route 6 from the NSTAR Electric ROW from north to south to connect with the Barnstable Switching Station. This crossing would also be accomplished using trenchless techniques.

Ancillary Structures

The duct system enclosing the onshore transmission and related cables would consist of a single duct bank system with a total of sixteen 6 inch polyvinyl chloride (PVC) ducts encased within a concrete envelope. The duct bank would be constructed within a trench beneath existing roadway corridors along the majority of the route. Twelve of the 16 ducts would be occupied with the onshore transmission cables, two ducts would contain fiber optic line for protective relaying and communications, and two vacant ducts would be reserved for future use as spares.

In addition to the landfall transition vault at the landfall site, the proposed transmission facility would include underground vaults along the public roadway and NSTAR Electric's ROW. These vaults would be required at locations utilizing trenchless techniques as well as typical splice vaults. All vault locations would include two parallel vaults constructed of reinforced concrete.

2.1.4 Electrical Service Platform (ESP)

An ESP would be installed and maintained within the approximate center of the WTG array and serve as the common interconnection point for all of the WTGs. The inner-array cable system would interconnect with circuit breakers and transformers located on the ESP in order to transmit wind-generated power through the 115 kV shore-connected submarine cable system. The ESP would provide electrical protection and inner-array cable sectionalizing capability in the form of circuit breakers. It would also include voltage step-up transformers to increase the 33 kV inner-array transmission voltage up to the 115 kV voltage level of the transmission cable connection to the land-based system.

The ESP would be a fixed template type platform consisting of a jacket frame with six 42-inch diameter (1.1 m) driven piles to anchor the platform to the ocean floor. The platform would consist of a steel superstructure supporting a platform of 100 ft by 200 ft (30.5 m by 61 m). The platform would be placed approximately 40 ft (12.2 m) above MLLW in 28 ft (8.5 m) of water. An enclosed 82 ft by 185 ft (25 m by 56.4 m) structure for the housing of transformers, circuit breakers, and the interconnection of the cable system rests atop the platform. The enclosed structure rises 49 ft (14.9 m) above the platform. The entire ESP (including a helicopter deck) rises approximately 100 ft (30.5 m) above the waterline at MLLW.

In addition to the electrical equipment, the ESP would include fire protection, battery backup units, and other ancillary systems. These systems would include ventilation, safety, communications, and temporary living accommodations. The living accommodations are for emergency periods when maintenance crews cannot be removed due to weather issues. These accommodations would utilize waste storage holding tanks that would be pumped to the service vessel for proper disposal. All equipment would be contained within an enclosed weather-protected service area.

Maintenance and service access to the ESP would normally be by service boat. A boat landing dock consisting of a fender structure with ladder is attached to the ESP to allow boat landing and transfer of personnel and equipment and temporary docking of the service craft. The ESP would have a helicopter deck to allow personnel access when conditions preclude vessel transport, and for emergency evacuation. Equipment and material transfer would be by a crane mounted on the ESP.

2.2 SPACE REQUIREMENTS

Submerged Land

The 130 WTGs and the ESP would occupy 0.67 acres (0.003 square kilometers [km^2]) of submerged land. The 33 kV inner-array cables (ranging in diameter from 5.19 in [132 millimeters [mm]] to 6.45 in [164 mm] depending on the required current load for sections of the cable) would occupy approximately 4.35 acres (0.018 km^2). The 115 kV transmission line, consisting of two circuits of two 7.75 in (197 mm) cable would occupy 1.54 acres (0.006 km^2) beneath federal waters. An additional 2.38 acres (0.01 km^2) beneath Massachusetts state waters would be occupied by the 115 kV transmission line. Scour protection for the WTGs would include a combination of scour mats and rock armor. Under the proposed scour protection plan, scour mats to be used at 106 WTGs would cover 1.96 acres (0.008 km^2) and rock armor to be used at 24 WTGs would cover 8.75 acres (0.04 km^2). Should the scour mats prove ineffective in any area, they would be replaced with rock armor. The worst case scenario would be replacement of the scour mats around all WTGs and the ESP. Under this scenario, the scour protection would cover 47.82 acres (0.19 km^2). The project facilities would occupy 0.12 percent (19.41 acres) of the total project area of 25 square miles (64.7 km^2) with scour mats and 0.35 percent (56.76 acres) with rock armor (see Table 5.3.2-3 for additional information).

During installation of the WTGs, ESP, cable, and scour protection, it is anticipated that between 820 and 866 acres (3.31 and 3.5 km^2) (depending on the method of scour protection) would be temporarily disturbed. This represents between 5.1 and 5.4 percent of the total project area.

Onshore

The proposed onshore transmission cable route to its intersection with the NSTAR Electric ROW would be located entirely along existing paved ROWs where other underground utilities already exist. All of the roadways within Yarmouth and Barnstable in which the proposed transmission cable would be placed are town owned and maintained roads with the exception of Routes 6 and 28, which are owned and maintained by MassHighway. A portion of the onshore transmission cable route would also be located underground within the existing maintained NSTAR Electric ROW.

2.3 CONSTRUCTION METHODOLOGY AND SCHEDULE

2.3.1 Schedule

The anticipated schedule for the permitting of the proposed action and its construction is provided in Figure 2.3.1-1. The anticipated construction sequence is as follows: (1) the onshore ductbanks would be installed; (2) the ESP and onshore 115 kV cables would be installed; (3) the monopiles, scour protection, WTGs, and submarine 33 kV and 115 kV cables would be installed; and (4) full operation would begin.

2.3.2 Wind Turbine Generator Installation

The installation of the WTGs would comprise four activities: (1) installation of the foundation monopiles; (2) erection of the WTGs; (3) installation of the inner-array cables; and (4) installation of the scour protection mats or rock armor.

2.3.2.1 Quonset Staging Area

The major construction activities would be supported by onshore facilities, which are anticipated to be located in Quonset, Rhode Island (see Figure 2.3.2-1). Material and equipment would be staged onshore, at existing port facilities in Quonset, Rhode Island, and then loaded onto various vessels for transportation to the offshore site, and ultimately installation. Construction personnel would be ferried by boat and/or helicopter depending upon weather conditions and other factors. Once loaded, the vessels would 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 63 miles (102 km).

The applicant has identified an existing, industrial port facility in Quonset, Rhode Island as having the attributes required for staging an offshore construction project of the magnitude of the Project. The Quonset Davisville Port & Commerce Park is located on Narragansett Bay in the town of North Kingstown, Rhode Island. It is owned and controlled by the Rhode Island Economic Development Corporation (RIEDC). This site is a portion of what once was a much larger government facility known as the U.S. Naval Reservation–Quonset Point, part of which is still actively utilized as a civilian airport and base for an Air National Guard Reserve squadron.

The Quonset Davisville Port & Commerce Park is an active marine industrial site that houses several industrial businesses such as General Dynamics (shipbuilding) and Senesco (marine construction). Following the downsizing of the U.S. Naval Reservation – Quonset Point, the commerce park was created in order to develop prime industrial sites, create job opportunities, and to improve the economic conditions throughout the region.

The entire park consists of approximately 3,150 acres (12.75 km^2), of which 817 acres (3.3 km^2) have been sold for such uses as industrial, offices, and transportation/utility (railroad and highways). Another 463 acres (1.9 km^2) have current leases, 605 acres (2.45 km^2) are used for a civilian airport (Quonset State Airport - OQU) operated by the State of Rhode Island, approximately 600 acres (2.4 km^2) are designated open space, about 200 acres (0.8 km^2) are utilized for recreation including a golf course, and the remaining 465 (1.9 km^2) acres are vacant, open land available for industrial and commercial activities.

The site has deep-water capacity (30 ft [9.1 m] depth) and two piers that are 1,200 ft (365.9 m) in length and capable of servicing large ships. One of the piers (Pier 1) is currently leased by a company as an automobile unloading and transfer operation. The other pier (Pier 2) has intermittent use as a staging area for the Rhode Island Department of Transportation bridgework. Pier 2 would become available in the near future; however, based on timing, either pier may be available for lease.

The applicant has been actively pursuing the use of Pier 2 because it has a load bearing capacity of over 1,000 pounds (lbs) per square feet (ft^2) (4890 kg/m^2) and is 1,200 ft (365.9 m) long by 650 ft (198.2 m) wide. This Pier would be used for the receiving, storing and assembly of the large turbine parts such as the monopiles, towers, nacelles, transition pieces, hubs, and blades. The applicant and RIEDC have started discussions pertaining to leasing all or part of Pier 2 and the land contiguous to it, which consists of approximately 33.5 acres (0.14 km^2) zoned for industrial or commercial activity. Additional land is also available within the park, approximately 3,000 ft (914.6 m) away, which is accessible by a public road approximately 40 ft (12.2 m) in width. These satellite parcels consist of approximately 25 plus acres (0.1 km^2) that could be used for other components of the wind turbines and associated infrastructure if needed. One of the parcels has two large buildings, which were utilized by the U.S. Navy Construction Battalion (Seabees) during the 1940's, 1950's and 1960's, which may be capable of handling certain requirements of the project for covered storage and enclosed workspace. Some modifications to the buildings and roadways may be required to accommodate the specialized equipment and wind turbine components. The deep-water piers are adequate to accommodate anticipated construction vessels and are not expected to require any additional dredging or modification.

Monopile installation would begin by loading individual monopiles onto a barge, three to four at a time, for transport to the work site. Depending upon the actual barge utilized and other logistical requirements, approximately 43 trips are anticipated to move monopiles to the work site.

Information on general types and estimated numbers of vessels expected to be involved during various phases of the proposed action is presented below. During pile driving activities, it is estimated that approximately 4-6 vessels would be present in the general vicinity of the pile installation. Most of these vessels will be stationary or slow moving barges and tugs conducting or supporting the installation. Other project vessels will be delivering construction materials or crew to the site and will be transiting from the various points on the mainland to the Project site and back. Barges, tugs and vessels delivering construction materials will travel at 10 knots (19 km/hour) or below and may range in size from 90 to 400 ft (27.4 to 122 m). The only vessels that are anticipated to be traveling at greater speeds are crew boats that will deliver and return crew to the Project site twice per day. Crew boats are anticipated to be approximately 50 ft (15.2 m) in length and may travel at speeds up to 21 knots (39 km/hour). These crew boats are similar to typical vessel traffic occurring in Nantucket Sound already on a regular basis.

Based upon site specific bathymetric survey there are no proposed turbine locations in water depths less than approximately 12 ft (3.7 m) MLLW (mean lower low water). All monopile sites are constructible at the proposed locations. Construction vessel access to each of these sites is available from at least one direction. Drafts of current equipment used for installation of similar projects are approximately 10 ft (3.0 m).

As a contingency, Cape Wind's normal construction sequence may be altered to accommodate water depths, dependent upon post-lease, site specific, pre-construction bathymetric data. For those few sites where the water depth approaches the 12 ft (3.7 m) MLLW it may require careful coordination with tides, construction sequencing and vessel loading. Once the vessel is in place and jacked up (which can occur at high tide), it will be unaffected by water depths.

2.3.2.2 Installation of Monopiles

A jack-up barge with a crane would be utilized for the actual installation of the monopiles. The jack-up barge would have four legs with pads a minimum of four meters on a side (approximately 172 ft^2 [16 m^2]). The crane would lift the monopiles from the transport barge and place them into position. The monopiles would be installed into the seabed by means of a pile driving ram or vibratory hammer to an approximate depth of 85 ft (26 m). This would be repeated at all WTG locations. Only two pieces of pile driving equipment would be present within the proposed action area at any one time, and they are not planned to be operated simultaneously. Since the monopiles are hollow, sediments would be contained within them.

Length of monopile, insertion distance, and finished elevation would vary by individual location due to water depth and structural and geotechnical parameters. Monopiles to be installed would range in length from approximately 122 ft (37 m) for those installed in the shallowest locations to more than 172 ft (52.4 m) at the deepest sites. The anticipated time to install all of the monopiles is expected to be approximately eight months plus any delays due to weather.

2.3.2.3 Installation of Wind Turbine Generators

The installation of the WTG itself would be from a specialized vessel configured specifically for this purpose (see Figure 2.3.2-2 for an example of a typical vessel). Work vessels for the proposed action would comply with applicable mandatory ballast water management practices established by the USCG in order to avoid the inadvertent transport of invasive species.

This vessel would be loaded at Quonset, Rhode Island with the necessary components to erect six to eight WTGs. The components include transition pieces to place on the monopiles, towers, nacelles, hubs, and blades.

The vessel would transit from Quonset to the work site as described above and set up adjacent to one of the previously installed monopiles. A jacking system would then stabilize the vessel in the correct location. Depending on the actual circumstance, four or six jacking legs would raise the vessel to a suitable working elevation. A transition piece unique to the specific WTG, is placed by the vessel's crane onto the monopile, leveled and set at the precise elevation for the tower. This piece would be a fabricated steel structure complete with a turbine tower flange, J-tubes for cable connections and a boat landing device. The transition piece is then grouted in place to the foundation monopile using a product such as Ducorit® D4 by Densit. The crane would then place the lower half of the tower onto the deck of the transition piece. Once this piece is secured, the upper tower section is raised and bolted to the lower half. In order, the nacelle, hub and blades are raised to the top of the tower and secured. Several of these components may be pre-assembled prior to final installation. This process is anticipated to take approximately 30 to 40 hours to cycle through one complete WTG and would be repeated for each of the 130 WTG locations. Including the twenty or so trips from Quonset to Horseshoe Shoal, this process would take approximately nine months plus any delays due to weather. The installation of the WTGs would overlap with the installation of the monopiles.

As the monopiles and WTGs are completed, the submarine inner-array cables would be laid in order to connect each string of wind turbines (up to 10 WTGs), and then the seabed scour control system would be installed on the seabed around each monopile. The scour control system would help to prevent underwater currents from eroding the substrate adjacent to the WTG foundation. The scour control system would consist of either a set of six mats arranged to surround the monopile or rock armor.

Each scour control mat is 16.5 ft by 8.2 ft (5 m by 2.5 m) with eight anchors that securely tied to the seabed (see Figure 2.3.2-3 for the arrangement of the mats). It is anticipated that the process of completing one string of WTGs (10 WTGs with associated inner-array cable and scour mats) would take up to approximately one month. The scour mats are placed on the seabed by a crane or davit onboard the support vessel. Final positioning is performed with the assistance of divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. The mats are removed with divers and a support vessel in a similar manner to installation, and are expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats.

At 24 WTGs rock armor scour protection would be used for an alternative approach to scour control. Figure 2.3.2-4 shows the turbines for which rock armor would be used. Rock armor design is driven by wave action (wind-driven and ocean swell) and currents (tidal and wind-driven). The armor stones are sized so that they are large enough not to be removed by the effects of the waves and currents, while being small enough to prevent the stone fill material placed underneath it from being removed.

At location where it would be used, the rock armor and filter layer material would be placed on the seabed using a clamshell bucket or a chute. The rock armoring would also be removed following project decommissioning.

The transition piece of the WTGs, which would be located within the submerged/splash zone, would be coated with a product equal or similar to Dupont Interzone 954. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower, would be coated with an epoxy-polyamide. A cathodic protection system using a galvanic (sacrificial) aluminum anode system would be employed to assist in preventing corrosion.

2.3.3 Electric Service Platform Installation

The ESP design is based on a piled jacket/template design with a superstructure mounted on top. The platform jacket and superstructure would be fully fabricated on shore and delivered to the work site by barge.

The jacket would be removed from the barge by lifting with a crane mounted on a separate derrick barge. The jacket assembly would then be sunk and leveled in preparation for piling. The six piles would then be driven through the pile sleeves to the design tip elevation of approximately 150 ft (46 m) below the surface of the sea bottom. The piles would be vibrated and hammered as required.

The superstructure would be installed by lifting it from the transport barge onto the jacket. It would then be connected to the jacket in accordance with the detail design requirements. After attachment, additional components including ladders, heliport and vessel docking structure would be lifted from a barge and set onto the superstructure for attachment. The installation of the ESP is anticipated to take approximately one month to complete (Figure 2.3.3-1, sheets 1 and 2).

After the ESP is fully constructed, installation of the inner-array cables and the high voltage transmission cables would take place. These cables would be routed through J-tubes located on the outside of the support jackets. Once the inner-array cables are connected to the ESP, the scour mats would be installed to the ESP piles utilizing a similar design as the WTG foundations.

The ESP would be coated with a similar paint system as the WTG. A cathodic protection system utilizing a galvanic (sacrificial) aluminum anode system would be utilized.

2.3.4 33 Kilovolt Inner-Array Submarine Cable System Installation

The 33 kV cable would be transported to Quonset Point, Rhode Island in a special cable transport vessel. The cable would be transferred onto the cable installation barge. The linear cable machines on-board the barge would pull the cables from coils on the transport vessel onto the barge, and into prefabricated tubs. The installation barge and auxiliary barge loading take place in Quonset, Rhode Island. After the cable has been transferred, the installation barge would be towed to the Horseshoe Shoal site. This would be repeated as required to deliver and install all the required cable.

The proposed method of installation of the submarine cable is by the hydroplow embedment process, commonly referred to as jet plowing (see Figure 2.1.3-3). This method involves the use of a positioned cable barge and a towed hydraulically-powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from WTG to WTG and then to the ESP. The barge would propel itself along the route with the forward winches, and the other moorings holding the alignment during the installation. The four point mooring system would allow a support tug to move anchors while the installation and burial proceeds uninterrupted on a 24-hour basis.

When the barge nears the ESP, the barge spuds would be lowered to secure the barge in place for the final end float and pull-in operation. The cable would be pulled into the J-tube and terminated at the switchgear.

2.3.5 115 Kilovolt Submarine Transmission Cable System Installation

The transmission cable system consists of the two 115 kV solid dielectric AC submarine transmission circuits (two three-conductor cable systems per trench equals one circuit, for a total of four cables). The two circuits of interconnecting transmission cables linking the ESP to the landfall location would be embedded by jet plow approximately 6 ft (1.8 m) below the sea floor, with approximately 20 ft (6.1 m) of horizontal separation between circuits.

Jet plow embedment methods for submarine cable installations are considered to be the most effective and least environmentally damaging when compared to traditional mechanical dredging and trenching operations. This method of laying and burying the cables simultaneously ensures the placement of the submarine cable system at the target burial depth with minimum bottom disturbance and with much of the fluidized sediment settling back into the trench. For these reasons, it is the installation methodology that appears to be preferred by state and federal regulatory agencies based on review of past precedent-setting projects, including the roughly 40 miles of electric cable installed between Cape Cod and Nantucket.

Jet plow equipment uses pressurized sea water from water pump systems on board the cable vessel to fluidize sediments. The jet plow device is typically fitted with hydraulic pressure nozzles that create a direct downward and backward “swept flow” force inside the trench. This provides a down and back flow of re-suspended sediments within the trench, thereby “fluidizing” the *in situ* sediment column as it progresses along the predetermined submarine cable route such that the submarine cable settles into the trench under its own weight to the planned depth of burial. The jet plow’s hydrodynamic forces do not work to produce an upward movement of sediment into the water column since the objective of this method is to maximize gravitational replacement of re-suspended sediments within the trench to bury or “embed” the cable system as it progresses along its route. The pre-determined deployment depth of the jetting blade controls the cable burial depth.

Due to the relatively shallow water depths in Nantucket Sound, shallow draft vessels/barges which typically use anchors for positioning are most likely to be used for installation. Deeper draft vessels equipped with dynamic positioning thrusters are less likely to be utilized in shallow water locations.

The cable laying barge is specifically designed for installations of submarine cable. It is used for both transport and installation. The submarine cable is installed in continuous lengths delivered from the cable factory and loaded directly onto a revolving turntable on the vessel. The cable system location and burial depth will be recorded during installation for use in the preparation of as built location plans. The jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. This information is monitored continually on the installation vessel; therefore the use of an ROV is not required. This information will be forwarded to appropriate agencies and organizations as required for inclusion on future navigation charts.

A skid/pontoon-mounted jet plow, towed by the cable-laying barge, is proposed for the Project’s submarine installation. This jet plow has no propulsion system of its own. Instead, it depends on the cable vessel for propulsion. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The cable system is deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, pump systems are initiated, and the jet plow progresses along the pre-selected submarine cable route with the simultaneous lay and burial operation. It is anticipated that, to install each transmission line circuit to the required depth providing a minimum of

6 ft (1.8 m) of cover in the sediments that are generally found along the proposed submarine transmission line route into Lewis Bay, the jet plow tool will fluidize a pathway approximately 4 to 6 ft (1.2 to 1.8 m) wide at the seabed and 8 ft (2.4 m) deep into which the cable system settles through its own weight. As mentioned above, the jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. The pontoons can be made buoyant to serve different installation needs.

The geometry of the trench is typically described as trapezoidal with the trench width gradually narrowing with depth. Temporarily re-suspended in situ sediments are largely contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediment traveling outside of the trench. Any re-suspended sediments that leave the trench tend to settle out quickly in areas immediately flanking the trench depending upon the sediment grain-size, composition, and hydraulic jetting forces imposed on the sediment column necessary to achieve desired burial depths.

This interconnection will involve the installation of approximately 12.5 circuit miles (20.1 km) (of which 7.6 miles (12.2 km) are within Massachusetts' waters) of transmission cable for each of the two circuits. The installation of the submarine transmission line via jet plow embedment is anticipated to take approximately two to four weeks to complete. As the jet plow progresses along the route, the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth. In the unlikely event that the minimum burial depth is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth.

The 115 kV cable would be transported from the manufacturer to Quonset Point, Rhode Island, the mobilization point. The cable would be transferred to the installation barge by pulling via the linear cable machines mounted on the barge. After the cable has been transferred, the installation barge would be towed to the Lewis Bay installation site offshore of the New Hampshire Avenue landfall (described in Section 2.3.6 of this document). A second smaller barge, capable of operating in shallow water, would also be used in conjunction with the larger installation barge.

Prior to pulling the cable ashore to the sea-land transition vault, the jet plow would be set up in the pre-excavation pit located at the offshore end of the drilled conduit. The cable would then be floated from the barge with assistance of small support vessels. The cable end would be anchored in place after being pulled through the Hydroplow and into the High Density Polyethylene (HDPE) conduits installed during the HDD and secured beyond the transition vault.

From the HDD exit point, the cable is embedded across the shallows by means of towing the jet plow along the cable route from the smaller barge's winch. The cable and jet hose would be supported by cable floats to maintain control of cable slack and the amount of hose out.

When the cable embedment has proceeded into deeper water and nears the larger installation barge, the operation would be transferred, and the barge would lift its spuds and begin winching along the cable route, with the six point mooring system towing the jet plow and feeding cable off the barge and into the plow funnel as it moves along the route at a rate equal to the barge movement. This would be repeated for the second circuit.

The barge would propel itself along the route with the forward winches, and the other moorings holding the alignment of the route. When the barge nears the ESP, the barge spuds would be lowered to secure the barge in place for the final end float and pull-in operation. The transmission cable would be pulled into the J-tube and terminated at the switchgear.

The following is a list of the primary installation equipment:

- Hydroplow cable burial machine designed for 6 ft burial depth;
- Installation barge 100 ft (30.5 m)wide x 400 ft (122 m) long x 24 ft (7.3 m) height;
- Anchor handling tugs - two 3000 hp twin screw (would be with the barge for the duration of the installation);
- Six-point mooring system with two 60-inch (1.52 m) spuds. The mooring system would consist of 3 double winches, plus another double drum winch for controlling the two spuds. Each winch drum would contain approximately 2,000 ft (610 m) of 1 1/8 inch (28.6 mm) mooring cable and have an anchor attached. Mid-line buoys would be attached to minimize anchor cable scour. Pendant wire with 58-inch (1.48 m) steel ball buoys would be attached to anchors for deployment and quick recovery;
- Cable burial support system including pumps, and Hydroplow accessories;
- Cable laying support system including cable machines, chute, tubs and complete diving operations center to support divers;
- Auxiliary trencher pulling barge - a barge of 40 x 100 ft (12.2 x 30.5 m) dimensions outfitted with spuds; and
- Auxiliary vessels - there would be a crew boat, two inflatable boats, and several skiffs.

Jet plow equipment uses pressurized sea water from water pump systems on board the cable vessel to fluidize sediments. The jet plow device is typically fitted with hydraulic pressure nozzles that create a direct downward and backward “swept flow” force inside the trench. This provides a down and back flow of re-suspended sediments within the trench, thereby “fluidizing” the in situ sediment column as it progresses along the predetermined submarine cable route such that the submarine cable settles into the trench under its own weight to the planned depth of burial. The jet plow’s hydrodynamic forces do not work to produce an upward movement of sediment into the water column since the objective of this method is to maximize gravitational replacement of re-suspended sediments within the trench to bury or “embed” the cable system as it progresses along its route. The pre-determined deployment depth of the jetting blade controls the cable burial depth.

A skid/pontoon-mounted jet plow, towed by the cable-laying barge, is proposed for the submarine installation. This jet plow has no propulsion system of its own. Instead, it depends on the cable vessel for propulsion. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The cable system is deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, pump systems are initiated, and the jet plow progresses along the pre-selected submarine cable route with the simultaneous lay and burial operation, creating a fluidized sediment trench approximately 4 to 6 ft (1.2 to 1.8 m) wide (top width) to a depth of 8 ft (2.4 m) below the present bottom into which the cable system settles through its own weight. The jet plow does not create an open trench of these dimensions but rather fluidizes the sediment with enough injected water that the cable can settle into the “soupy” sediments to a minimum depth of six feet below the bottom. The jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. The pontoons can be made buoyant to serve different installation needs.

The installation of the submarine transmission cable via jet plow embedment is anticipated to take approximately two to four weeks to complete. As the jet plow progresses along the route, the water pressure at the jet plow nozzles would be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 ft (1.8 m). In the event that the minimum burial depth of 6 ft (1.8 m) below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes would be utilized to achieve the required depth.

2.3.6 Landfall Transition Installation

The transition of the interconnecting 115 kV submarine transmission cables from water to land would be accomplished through the use of HDD methodology in order to minimize disturbance within the intertidal zone and near shore area. The HDD would be staged at the onshore landfall area and involve the drilling of the boreholes from land toward the offshore exit point. Conduits would then be installed the length of the boreholes and the transmission cable would be pulled through the conduits from the seaward end toward the land. A transition manhole/transmission cable splicing vault would be installed using conventional excavation equipment (backhoe) at the onshore transition point where the submarine and land transmission cables would be connected.

There would be four 18-inch (457 mm) diameter HDPE conduit pipes (one for each three-conductor 115 kV cable and fiber optic cable set) installed to reach from the onshore transition vaults to beyond the mean low water level. The offshore end would terminate in a pre-excavated pit where the jet plow cable burial machine would start. The four conduits would have an approximately 10 ft (3 m) separation within the pre-excavation area. The four boreholes would be approximately 200 ft (61 m) long (borehole diameters would be slightly larger than the conduit diameter to allow the conduit to be inserted in the borehole).

A drill rig would be set up onshore behind a bentonite pit where a 40 ft (12.1 m) length drill pipe with a pilot-hole drill bit would be set in place to begin the horizontal drilling. A bentonite and freshwater slurry would then be pumped into the hole. The HDD construction process would involve the use of bentonite and freshwater slurry in order to transport drill cuttings to the surface for recycling, aid in stabilization of the in situ sediment drilling formations, and to provide lubrication for the HDD drill string and down-hole assemblies. This drilling fluid is composed of a carrier fluid and solids. The selected carrier fluid for this drilled crossing would consist of water (approximately 95 percent) and inorganic bentonite clay (approximately 5 percent). The bentonite clay is a naturally occurring hydrated aluminosilicate composed of sodium, calcium, magnesium, and iron.

After each 40 ft (12.1 m) of drilling, an additional length of drill pipe is added, until the final drill length is achieved. To minimize the release of the bentonite drilling fluid into Lewis Bay, freshwater would be used as a drilling fluid to the extent practicable for the final section of drilling just prior to the drill bit emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. When the drill bit emerges in the pre-excavated pit, the bit is replaced with a series of hole opening tools called reamers, to widen the borehole. Once the desired hole diameter is achieved a pulling head is attached to the end of drill pipe and then the drill pipe is used to pull back the 18-inch (457 mm) diameter HDPE conduit pipe into the bored hole from the offshore end. As with the pilot hole drilling process, freshwater would be utilized to the maximum extent practicable as the reaming tool nears the pre-excavated pit.

Smaller conduits with pulling wires would be placed inside the 18-inch (457 mm) diameter HDPE pipe to house the submarine cable system. Once the internal cable conduits have been inserted into the 18-inch (457 mm) HDPE conduit, a clay/bentonite medium would be injected into the conduit system to fill the void between the cable conduits and the 18-inch (457 mm) pipe. The conduits would be sealed at both ends until the submarine cable system is ready to be pulled through the conduit. After submarine cable system installation, the conduits would be permanently sealed at each end to complete the installation process.

The HDD operation would include an onshore based HDD drilling rig system, drilling fluid recirculation systems, residuals management systems, and associated support equipment. The HDD drilling material handling equipment would be located on New Hampshire Avenue. The drilling would take place from the onshore to Lewis Bay. Excavated soils would be temporarily stored near the HDD drill rig during construction, and would then be reused onsite or removed and disposed of as required.

To further facilitate the HDD operation, a temporary cofferdam would be constructed in Lewis Bay. The cofferdam would be approximately 65 ft (19.8 m) wide and 45 ft (13.7 m) long and would be open at the seaward end to allow for manipulation of the HDD conduits. The area enclosed by the cofferdam would be approximately 2,925 ft^2 (271.7 m^2). The cofferdam would be constructed using steel sheet piles driven from a barge-mounted crane. The top of the sheet piles would be cut off approximately 2 ft (0.61 m) above mean high water (MHW). The cofferdam is intended to help reduce turbidity associated with the dredging and subsequent jet plow embedment operations and to provide a visual reference to its location for mariners. While the cofferdams would be located outside of areas normally subject to vessel traffic, the location of the cofferdam would be appropriately marked to warn vessels of the temporary cofferdam presence.

The area inside the cofferdam would be excavated to expose the seaward end of the borehole. Sediment inside the cofferdam would be excavated to expose the area where the HDD borehole would end at an elevation of approximately -10 ft (-3 m) MLLW, with a 1 ft (0.3 m) allowable overdredge. A 20 ft (6.1 m) long level area would be created at the closed end of the cofferdam at this elevation. From that point, the bottom of the excavated area would be sloped at 4 horizontal:1 vertical until it meets the existing seafloor bottom contour. Approximately 840 yd^3 (642.2 m^3) of sediment would be excavated from within the cofferdam. At the end of cable installation, the cofferdam excavation would be backfilled, rather than allowed to in-fill over time. The dredged material would be temporarily placed on a barge for storage, and then the dredged area of the cofferdam would be backfilled with the dredged material. If necessary, the dredged material backfill material would be supplemented with imported clean sandy backfill material to restore the seafloor to preconstruction grade.

The drilling fluid system would recycle drilling fluids and contain and process drilling returns for offsite disposal, and while the intention is to minimize the discharge or release of drilling fluids to marine or tidal waters in Lewis Bay, the HDD operation would be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay. It is likely that some residual volume of bentonite slurry would be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater “silt fence.” This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

It is expected that the HDD conduit systems would be drilled through sediment overburden at the landfall location. However, it is anticipated that drilling depths in the overburden would be sufficiently deep to avoid pressure-induced breakout of drilling fluid through the seafloor bottom based primarily on estimates of overburden thickness and porosity. Nevertheless, a visual and operational monitoring program would be implemented during the HDD operation to detect a fluid loss. This monitoring includes:

- visual monitoring of surface waters in the adjacent Lewis Bay by drilling operation monitoring personnel on a daily basis to observe potential drilling fluid breakout points;
- drilling fluid volume monitoring by technicians on a daily basis throughout the drilling and reaming operations for each HDD conduit system;
- implementation of a fluid loss response plan and protocol by the drill operator in the event that a fluid loss occurs. The response plan could include drill stem adjustments, injection of loss circulation additives such as Benseal that can be mixed in with drilling fluids at the mud tanks, and other mitigation measures as appropriate; and
- use of appropriate bentonite drilling fluids that would gel or coagulate upon contact with sea water.

In the event of an unexpected drilling fluid release, the bentonite fluid density and composition would cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment.

Each of the two landfall transition vaults would be approximately 8 ft (2.4 m) wide by 35 ft (10.7 m) long (outside dimensions). The submarine transmission cables would be spliced to the onshore transmission cables within these transition vaults. The transition vault would contain two 38-inch (965 mm) manholes for access and be installed approximately with its bottom 10 ft (3 m) below grade. The submarine transmission cables would enter through the four 18-inch (457 mm) HDPE conduits and the onshore transmission cables would exit the landfall transition vault to the ductbank system through 6 inch diameter PVC conduits. There would be a total of 16 PVC conduits encased within concrete: 12 transmission cable conduits, two conduits for 96 fiber fiber optic cables for telecommunications, Supervisor Control and Data Acquisition (SCADA) and protective relaying, and two spare conduits for the onshore transmission cable.

It is anticipated that the installation of the borehole and conduit by HDD techniques would take approximately two to four weeks.

Upon completion of the installation of the conduit pipes and submarine cable system, the HDD equipment would be removed and New Hampshire Avenue would be restored to its pre-construction grades and conditions. Standard stormwater erosion and sedimentation controls would be installed on the site prior to the initiation of construction activities, and would be inspected and maintained throughout construction operations. Once construction is completed, all equipment and construction materials would be removed from the site and the area would be returned to its original condition.

2.3.7 Onshore Transmission Cable Installation

Construction of the onshore transmission cable would occur in two phases. The first phase would consist of installing the ductbanks, conduits, and vaults. The second phase would consist of the installation of the onshore 115 kV transmission cables, including splices and terminations. Phase I is anticipated to take approximately five months to complete. Phase II is also anticipated to take approximately five months. Once the installation of the duct bank and vaults (Phase I) has progressed significantly from the landfall (approximately 2-3 months), the pulling and splicing of the onshore 115 kV cable (Phase II) would commence behind the duct bank installation crews. Assuming onshore construction commences in September, both Phases of installation are expected to be completed in the 9 month period prior to the following Memorial Day. Therefore, the installation of the onshore components would occur outside of the summer tourist season.

The onshore transmission cable installation, from the transition vault at the landfall to the Barnstable Switching Station, would involve installation of the transmission cable in the underground splice vaults and ductbanks within existing public ways and ROWs. Most excavation would be performed with standard machinery, including excavators and backhoes, with the exception of four railroad/state highway intersection crossings which would be accomplished using trenchless techniques. All work would be performed in accordance with local, state, and/or Federal safety standards. To minimize potential impacts to wetlands, waterbodies, and groundwater during on land construction, particularly trenching activities, Cape Wind has prepared a Draft Stormwater Pollution Prevention Plan (see Appendix C), that includes measures for erosion control, managing stormwater, and soil handling and stockpiling.

Underground onshore transition vaults would be constructed approximately every 500 to 1,700 ft (152.4 to 518 m) (the approximate length of transmission cable that can be effectively transported by truck and pulled within manufacturer’s tension specifications). These vaults would accommodate cable splicing and cross-bonding of cable metallic sheaths. Each of the two parallel underground onshore splice vaults utilized at each splice location would be approximately 8 ft (2.4 m) wide by 35 ft (10.7 m) long (outside dimensions) (see Figure 2.3.7-1). The underground onshore transition vaults would be placed approximately 10 ft (3 m) deep (bottom of vault) and each underground vault would contain two 38-inch (965 mm) manholes.

The transmission cables would be installed within a ductbank consisting of PVC conduits spaced approximately eight inches apart (on center) encased in unreinforced concrete (minimum of 2,000 lbs per square inch [psi]), which is backfilled with native material or suitable backfill to original grade. In addition, there would be two copper ground wires placed within the encasement. The trench opening would be a minimum of 10 ft (3 m) wide within the roadways and a minimum of 8 ft (2.4 m) wide within the ROW and supported by temporary trench boxes. The ductbank would be approximately 2 feet high by 5 feet 8 inches wide. Burial depth to the top of the ductbank would be a minimum of 56 inches (1.42 m) within the roadways to allow passage under existing water and gas lines and a minimum of 24 inches (610 mm) within the NSTAR Electric ROW (with the exception of road-crossings along the ROW where the burial depth would revert to 56 inches [1.42 m]). A warning tape would be placed approximately one ft below the surface of the trench opening for dig-in protection. There would be a total of 16 six-inch (152 mm) diameter PVC conduits inside the concrete ductbank. The ductbank would be installed in a single trench (see Figures 2.1.3-4 and 2.1.3-5).

The excavated soil from the trench and vaults would be temporarily stored adjacent to the worksite or transported off-site if on-site storage is not possible. Where soil is stored at the site, it would be stabilized with erosion and sedimentation controls. Following the completion of the installation of the transmission cable, the excavation would be backfilled and repaved. Stormwater erosion and sedimentation controls would be in place prior to the initiation of construction activities. Once construction is completed, all equipment and construction debris would be removed from the site and the area would be returned to its original condition.

To minimize the potential for erosion during construction, mitigation measures, such as hay bales and silt fences would be placed as appropriate around disturbed areas and any stockpiled soils. Prior to commencing construction activities, erosion control devices would be installed between the work areas and downslope water bodies and wetlands to reduce the risk of soil erosion and siltation. Erosion control measures would also be installed downslope of any temporarily stockpiled soils in the vicinity of waterbodies and wetlands. These mitigation measures would be fully described in an Erosion and Sedimentation Control and Storm Water Management Plan, which would incorporate applicable BMPs for erosion control and stormwater management during construction. It is possible that dewatering of the excavated trench or vault locations close to the transition point would be required because of high groundwater. A de-watering plan would be prepared to address the procedures for handling of any water encountered during excavation.

Trenchless technologies would be employed in several areas along the onshore cable route to cross heavily traveled state highway layouts and railroad beds and avoid the disturbances caused by standard construction methods. Trenchless technologies may include HDD, Horizontal Boring, or Pipe Jacking.

In all instances where trenchless technology is used a starting pit would be excavated to initiate the advancement of a casing or carrier pipe. Both boring and pipe jacking require pre-excavated pits on either end of the cable segment to be installed. Shoring of the pit walls and dewatering may be necessary depending upon soil and groundwater conditions. The receiving pit is excavated at the receiving end to accept the casing or carrier pipe. Four carrier pipes would be used to accommodate all the conduits from the duct bank. Depending on the method used the casing is advanced by drilling, boring or simply pushing the casing pipe through the soil. Drilling would be similar to the HDD process discussed above for the shoreline crossing. Boring involves using an auger type drill head that removes soil from the drill hole into the pit, which is then stockpiled or removed from the site, in a manner similar to drilling a hole through a piece of wood. Pipe Jacking involves pushing a casing pipe into the soil, along the desired alignment, and removing the soil from within the casing pipe. The trenchless technology utilized would be selected on a case-by-case basis at each location and would depend on the distance required to advance the carrier pipe beyond the roadway or railroad in question, the nature of the soils at the location, and the space available for mobilization and excavation of starting and receiving pits.

Following the installation of the carrier pipes, transition vaults would be installed to transition between the standard duct bank installation and the carrier pipes.

2.4 OPERATION AND MAINTENANCE REQUIREMENTS AND PROCEDURES

2.4.1 Introduction

Any WTG, whether operating as an individual unit or within an array, is designed to operate without attendance by any operators. The monitoring is conducted over a SCADA system from a remote location. Such a monitoring station could be within a short radius of the wind turbine, or hundreds of miles away.

The local or regional monitoring center would have an effective level of control allowing remote intervention in the operation of the turbine. Sensors within the turbine’s nacelle gather and transmit data via the SCADA system not only on the electrical performance of the generator itself but also on much of the critical associated equipment. Sensors include thermal, visual (web-cams), audio (microphones), vibrations (accelerometers) and a host of electrical measurements which combine to provide an accurate picture of the operating state of the turbine.

Bearing sensors are now configured throughout the drive train, including within the gearbox casing itself. Not only is the temperature of the gearbox oil monitored, but also the metallic content of it circulating within the cooling system. Changes in bearing temperature, vibration levels, acoustic profile and metallic content within the oil are all early indicators of potential failure. This level of information enables the remote operator to make decisions that would affect the degree of remedy that may be eventually required. Without remote intervention, such as shutting down the turbine, catastrophic failure of the gearbox may occur requiring an expensive and time consuming complete change-out of the gearbox. With early warning it is also possible for the remote operator to decide to reduce the output of the particular wind turbine until such time as a technician can gain physical access in order to determine the precise nature of the problem.

The SCADA system also monitors elements such as navigation and aviation warning lights. However, with today's common use of multiple light-emitting diodes (LEDs) it is very rare that any illumination would be lost completely. Within the same area each access door lock is wired to monitor any attempt to gain unauthorized access to the wind turbine tower and its equipment.

The use of wave height radar detectors and vertically aligned web-cams are also useful to the shore based maintenance crew in determining the actual sea state at the site and judging their ability to gain marine access.

The operation and maintenance (O&M) of an offshore wind farm also includes those elements pertaining to the seabed and its environs. Scouring around the base of the turbine foundation and movement of the marine electrical cables are the most significant elements requiring periodic inspection in order to determine if anything has occurred either as a result of continuous strong currents or, a significant storm.

Service and maintenance falls into two distinctive categories:

(1) The work that only requires personnel activity; and
(2) The work requiring large marine vessel operation.

The latter requires a harbor base that can accommodate vessels with a significant draft whereas crew boats can operate from a typical sailing harbor located as close to the wind farm as possible. While much of the routine service and maintenance operations would likely occur during summer months because of the greater number of days with lower wave heights, other weather windows (approximately three days duration for maintenance of a single WTG) would be used throughout the year in order to minimize wear and tear and the potential for excessive equipment breakdown or parts replacement."

2.4.2 Operation

It is anticipated that the main operation center for the proposed offshore farm would be located in the town of Yarmouth. The remote monitoring and command center where all decisions concerning the operation of the marine generating facility would be made would be located here. These operational decisions would also include any instructions received either manually or automatically from the operator of the ISO-NE. It is also to this center that all commands, instructions or requests would be received from government entities with marine and aviation safety and protection jurisdiction, such as the USCG, MMS and the FAA. All operations would be in accordance with MMS requirements, as well as the USCG terms and conditions received for this project (Appendix B).

The service and maintenance personnel would be stationed at one of two additional onshore locations: one for the parts storage and larger maintenance supply vessels and the second located closer to the site for crew transport. The maintenance operation would be based in New Bedford, Massachusetts and would also deploy several crew boats out of Falmouth, Massachusetts.

The New Bedford facility would be located on Popes Island. It would include dock space for two 65 ft (19.8 m) maintenance vessels, as well as a warehouse for parts and tool storage, and crew parking. An off-site warehouse would also be utilized to increase parts storage. The New Bedford facility would house tools, spare parts and maintenance materials and would be organized to support daily work assignments. These would be loaded into small containers, assigned to each of the work teams and loaded onto the maintenance vessel for deployment to the wind farm site. The maintenance vessel would then go to either the WTG or the ESP and offload the containers for the work crews. During maintenance operations, one vessel per day would leave the New Bedford facility, go to the site of the proposed action, and then return.

Additional dock space would be rented in Falmouth Inner Harbor. From this facility work crews would be deployed to either the WTG and/or the ESP in 35 to 45 ft (10.7 to 13.7 m) long crew boats manned by professional mariners. In addition, a high-speed emergency response boat (20 to 25 ft long boat) would be maintained at this harbor ready to respond whenever there is marine activity taking place.

The Control and Monitoring center in Yarmouth would maintain a 24/7 telecommunication protocol with all members of the operation both at management level as well as the engineers. As is normal with such operations a roster system is in place whereby designated personnel are on emergency call-out during the night, weekends and holidays. Night and holiday watch staff at the center would normally be restricted to two persons.

Depending upon the chosen manufacturer of the WTGs the SCADA system would normally monitor the following parameters through remote access:

- **Electrical:**
  - Power (Output/reactive)
  - Voltage
  - Frequency
  - Recorded Power Curve
- **Climate:**
  - Wind speeds
  - Wind direction
  - Temperature
  - Humidity
  - Atmospheric pressure/s
  - Wave heights
- **Turbine:**
  - Temperatures
  - Humidity levels
  - Acoustics
  - Particulates
  - Transformer gases
  - Other

Service

While much of the routine service and maintenance operations would likely occur during summer months because of the greater number of days with lower wave heights, other weather windows (approximately three days duration for maintenance of a single WTG) would be used throughout the year in order to minimize wear and tear and the potential for excessive equipment breakdown or parts replacement.

If a WTG required this level of repair, a longer period of low wave heights and suitable weather conditions would be required in order to allow access and suitable working conditions. The duration necessary to complete a repair would be determined and the next available opportunity would be capitalized upon to complete the repair. Given the typically more suitable conditions during summer months, more repairs may occur during summer than winter months.

Planned preventative service and maintenance of a WTG would include:

- Testing of fog horns;
- Cleaning of the machine rooms;
- Changing of carbon brushes;
- Changing of filters for air and all liquids as necessary;
- Topping up of all fluids;[5]
- Replacement of defective instruments;
- Change-out of calibrated anemometers;
- Cleaning of lenses;
- Recharging of auto-grease systems;
- Appropriate local measurements;
- Control of dehumidifiers;
- Torquing of bolts;[6]
- Replacement of brake pads;
- Control / replacement of hazard warning lights; and
- Heavy duty electrical connections.

Routine service, excluding the 100 percent bolt torquing and major oil change is usually a two day exercise for three to four persons. Such a three to four man crew would normally consist of an electrical technician, an electronics/instrumentation technician, a mechanical technician and a general helper.

All personnel would be trained in maritime operations and survival including emergency evacuation of the turbine nacelle. Every operative is equipped with a life jacket and survival suit. Provisions for emergency stays are provided in the event that conditions occur suddenly which precludes offloading of maintenance personnel.

In the event of a medical emergency it would be normal for affected personnel to be evacuated via the access platform near the base of the tower.

Servicing of the offshore ESP would be conducted by the crew of a specialist sub-contractor trained in the service and maintenance of HV equipment. The platform would be similarly equipped with survival equipment and rations to be used in the event of weather prevented egress. As this structure would include a helicopter landing platform, emergency evacuation can be affected by direct conveyance onto the aircraft.

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[5] Depending on manufacturers, gearbox oil is usually changed after one year of operation and thereafter every two years. Some manufacturers have longer intervals. For this operation a larger vessel is required than the regular crew boats. Drums of oil must be transported, lifted to the transition platform and hoisted up the tower to the nacelle machine room. Equally, the old oil must be transported in reverse. This operation is usually conducted by a separate team taking approximately one day per turbine. The Project would have a detailed Oil Spill Response Plan (OSRP) (Appendix D) to ensure proper oil handling procedures are used and to provide procedures to address possible contingencies in the use of oil or other potential pollutants.

[6] Torquing of all tower flange bolts is typically conducted after the first 100 hours of operation, and then again after twelve months of operation. Thereafter 10 percent of the bolts of each flange are torque tested on an annual basis.

Oils, Lubricants, and Coolants

Operation of the WTGs and ESP requires the use of a variety of oils, lubricants and coolants. The exact manufacturer, products, and quantities to be used will not be known until equipment suppliers are under contract. However, the Draft Cape Wind Oil Spill Response Plan (see Appendix D) provides an initial estimate of the types and volumes to be used during operations and maintenance of the proposed action (ESS, 2007). The largest source is the 40,000 gallons of naphthenic mineral oil to be used on the WTGs for transformer cooling. For the WTGs, several types of bearing and gear lubricants could be used, ranging in quantity from less than 1 gallon to 140 gallons, as well as small amounts of brake, hydraulic, and transmission fluids. Lastly, a water/glycol mix will be used for heat dissipation of the oil coolers.

2.4.2.1 Security Plan

A detailed security plan will be developed to monitor the Project. This plan will include both video surveillance and visual observations by boat. A manned operations system on land will monitor and maintain communications to ensure that the security of the equipment is not compromised. Access to the turbines will be through a hatch door on the platform that will be locked at all times. The ESP will utilize a similar locked hatch system.

2.4.3 Maintenance

Unplanned maintenance on any part of the WTG is carried out in response to a breakdown or failure. This activity may be simple and require only hand tools, in which case the normal crew vessels would suffice. If there is a requirement to exchange larger items, the use of the 65 ft maintenance vessel would be required to transport and lift the particular items. Such items of equipment could be an electrical control cabinet, and 33 kV voltage transformer, generator, gearbox parts, etc. The ability to conduct such operations would depend heavily on the prevailing weather conditions. It is unlikely that such repairs could be carried out where significant wave heights exceed 4.9 ft (1.5 m). Accurate weather forecasting is an essential ingredient in the planning of such offshore operations where a weather window of one to two days is required to complete the task.

2.4.3.1 Maintenance Intervals

Based on both offshore and onshore WTG operational experience, five days per year per turbine has been established as the anticipated maintenance requirement. These visits cover two days of planned or preventative maintenance, and three days of unplanned or forced outage emergency maintenance. The WTG design is based on a twenty year operating life and all components have been analyzed to meet this design criterion. Based on 5 maintenance days per year for each of the 130 WTGs, the total is equivalent to 650 maintenance days. Based on 252 workdays per year (which adjusts for weather days and holidays) this results in 2.5 work teams or conservatively three teams being deployed. During these deployments, maintenance on the ESP would be included. Experience has shown that wind speeds must be less than 17.9 mph (8 m/s) to gain safe access to the WTGs, although safe access with winds up to 26.8 mph (12 m/s) is possible depending on direction and sea state. Based on these weather related concerns, the number of trips per day could be altered to take advantage of good weather.

The submarine cables would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables would be re-buried. Depending upon the extent of re-burial required, either hand jetting or re-deployment of a jet plow would be used.

2.4.3.2 Number of Vessel Trips

Based on the above analysis the normal activity would include two vessel trips per working day (252 days/year), which would include one crew boat from Falmouth and the maintenance support vessel from

New Bedford. In addition, an occasional second round trip from Falmouth could take place in times of fair weather or for emergency service.

2.4.3.3 Major Repairs

Major repairs are classed as those that require the intervention of a special heavy lift jack-up vessel similar to the one that would have been used during the original construction of the wind farm.

The items requiring replacement include:

- Turbine blades;
- Hub unit;
- Main drive shaft;
- Gearbox; and
- Complete nacelle.

Limitations on jack-up vessels are usually related to the sea state at the time of jacking up/down. Due to the height of their jib crane, they are restricted to lifting when wind speeds are less than 12 m/s (25 mph). If a WTG required this level of repair, a longer period of low wave heights and suitable weather conditions would be required in order to allow access and suitable working conditions. The duration necessary to complete a repair would be determined and the next available opportunity would be capitalized upon to complete the repair. Given the typically more suitable conditions during summer months, more repairs may occur during summer than winter months.

2.4.3.4 Inspections

Under the terms of any MMS authorization, MMS would require inspections to take place to ensure worker, structural, engineering and environmental safety. Such inspections would be carried out on a regular basis, as determined by MMS and set forth in the authorizing instrument.

Blades: The WTG blades operating in a marine environment tend to be self-cleaning. Deterioration of the measured power curve is an indicator that blade surfaces have become excessively pitted or have a high level of salt encrustation, at which point cleaning of the blades would be undertaken. The degradation mechanisms that affect the structural stability of the blade (and hence also safety) will be inspected on a regular basis.

Towers: The WTG tower would normally be inspected externally once every five years unless there are obvious signs of corrosion developing that were not predicted. These visual inspections are conducted from a manned basket lowered from and with the nacelle mounted winch.

Foundations: The steel monopile foundations, and their associated transition sections and platforms are inspected on an annual basis usually at the time of the planned service visit. It is the areas within the splash zone that are most prone to corrosion as a consequence of occasional instances of inferior treatment coating during manufacturing or installation.

Cathodic Protection: The sacrificial anodes would be inspected on an annual basis and replaced as required.

Scour Protection: The seabed around the base of the monopile foundations would have scour protection (scour mats or rock armor) installed in order to provide the required level of protection from scouring. It is prudent to visually inspect the seabed footing after the first year of being installed and thereafter at least on a biennial basis if no initial deterioration has been observed. It may also be prudent to conduct sample surveys after any significant storm activity. Such inspections can be carried out by divers or by the use of Remote Operated Vehicles (ROVs) carrying underwater cameras and lighting.

Marine cables: Though the electrical cables are to be buried to a depth of 6 ft (2 m), there would be inspections of these runs conducted during the early years following their laying. A full inspection may be appropriate after the first two years, and thereafter on a random basis conducted at the same time as the scour protection inspections. As with the scour protection, it would also be prudent to conduct such an inspection after the first major storm affecting the area.

2.4.4 WTG Work Crew Deployment

The work crews would be transferred from the crew boat to the WTG by exiting the stern of the vessel. This operation would be performed only when the sea conditions are within the workable range of the crew and vessels.

2.4.5 ESP Service

The ESP would have a helicopter-landing platform in addition to the boat dock. This would allow for maintenance crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers. The helicopter platform would also allow for emergency evacuation of any individuals who may become injured.

2.4.6 Submarine Cable Repair

The potential for a fault occurring during the operational lifetime of a buried cable system is minimal, based on industry experience. However, a cable repair plan would be formulated by the applicant to cover the remote possibility of a fault occurring in the offshore submarine cable system. The focus would be to repair the cable quickly, while minimizing or eliminating environmental and community impacts.

Should a cable failure occur, a cable repair plan would be implemented. Once the location of the fault is identified, should the cable fault occur in the onshore sections of the project, then typical trench, repair and backfill methods would be used and no formal fault plan required. Communication with the appropriate people would take place at least 48 hours prior to repair and would specify the location, method, and date of work. Along the submarine cable, the procedures listed below are one way of repairing a cable fault.

- Mobilize the splice boat and fine tune the location of the fault;
- The splice boat would likely be a barge, equipped with water pumps, jetting devices, hoisting equipment and other tools typically used in repairs of cables;
- Expose the cable with hand-operated jet tools and cut the cable in the middle of the damaged area;
- Position the repair vessel above the cut cable, and raise one end;
- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and one end of the spare cable onboard;
- Pay out cable and move to the other end of the spare cable, keeping a portion of the spare cable onboard;
- Retrieve the other damaged cable end;

- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and the remaining end of the spare cable onboard;
- Lower the second joint and position it on the sea bottom;
- Hand jet the repaired and exposed sections into the sea bottom; and
- Demobilize the repair vessel.

2.5 DECOMMISSIONING METHODOLOGY

The applicant is required to submit a decommissioning plan to MMS for approval which must comply with MMS's structural removal standards. Upon decommissioning of the facility, the applicant must implement the decommissioning plan to remove and recycle equipment and associated materials, thereby returning the area to pre-existing conditions.

The applicant would be obligated to remove the project once operations have ceased. The applicant would provide a financial instrument or other assurance to the reasonable satisfaction of the MMS, which would secure its obligations to decommission the facility to the satisfaction of MMS and pursuant to the terms of its authorization.

The decommissioning process is largely the reverse of the installation process. Decommissioning can be broken down into several steps, closely related to the major components of the facilities:

- Inner-array cables;
- Submarine transmission cables;
- Turbine generators and towers, monopile foundations, scour mats or rock armor scour protection, ESP; and
- Onshore transmission cables.

It is anticipated that equipment and vessels similar to those used during installation, would be utilized during decommissioning. For offshore work, this would likely include a jet plow, crane barges, jack-up barges, tugs, crew boats, and specialty vessels such as cable laying vessels or possibly a vessel specifically built for erecting WTG structures. For onshore work, traditional construction equipment such as backhoes and cable trucks would be utilized. The environmental impacts from the use of this equipment during decommissioning activities would be similar, although not identical, to impacts experienced during construction as described in Section 5.0.

The decommissioning of the offshore facilities would necessitate the involvement of an onshore disposal and recycling facility with the capacity and capabilities of handling the large quantities of steel, fiberglass and other materials from the Project. Acknowledging the fact that other potential onshore disposal and recycling facilities may exist 20 years from now that may prove to be more desirable, facilities do currently exist that are capable of handling the materials. Prolerized New England Inc. operates several facilities, two which are located in Everett Massachusetts, and Johnston Rhode Island. Prolerized staff has indicated that they have the capabilities and capacity to handle the disposal and recycling of the materials from the proposed action, if it were to take place today. The Everett facility has deep water access, allowing for the steel towers and monopiles to be directly offloaded from the barges, cut into manageable sections, sheared into smaller pieces and then shipped to end-users as scrap metal. For this reason, the Everett facility would be the proposed location for the onshore disposal and recycling of project materials. Currently there is no commercial scrap value for the fiberglass in the rotor blades. The fiberglass from the blades would be cut into manageable pieces and then disposed of as solid waste at an approved onshore facility.

2.5.1 Decommissioning Process

The initial step in the decommissioning process would involve the disconnection of the inner-array 33 kV cables from the WTGs. The cables would then be pulled out of the J-tubes, and removed from their embedded position in the seabed. Where necessary the cable trench would be jet plowed to fluidize the sandy sediments covering the cables, and the cables would then be reeled up onto barges. The cable reels would then be transported to the port area for further handling and recycling.

The WTGs would be prepared for dismantling by properly draining all lubricating fluids according to established O&M procedures, and removing the fluids to the port area for proper disposal and/or recycling. This would be followed by the WTGs being deconstructed (down to the transition piece at the base of the tower) in much the same way as they were installed. Utilizing the same or similar types of cranes and vessels as during their construction, the blades, hub, nacelle, and tower would be sequentially disassembled and removed to port for recycling.

Once the wind turbines and towers have been removed, the foundation components (transition piece, monopile, scour mats, and rock armor) would be decommissioned. Sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (4.6 m) below the existing seabottom in order to allow access for the cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. All scour mats would be recovered, brought to the surface by crane, placed on a barge and brought to port for recycling or disposal. In those locations where rock armoring has been used for scour protection, it would be excavated with a clamshell dredge, placed on a barge, and disposed of at an upland location. The monopile would then be cut from the inside at approximately 15 ft (4.6 m) below grade. The sediments previously removed from the inner space of the monopile would be returned to the depression left when the monopile is removed, using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. Depending upon the capacity of the available crane, the assembly above the cut may be further cut into more manageable sections in order to facilitate handling, and then placed on a barge for transport to the port area for recycling. Cutting of the pile would likely be done using one or a combination of underwater acetylene cutting torches, mechanical cutting, or high pressure water jet.

2.6 POTENTIALLY POLLUTING AND HAZARDOUS MATERIALS

Construction, operation, and decommissioning would involve the transport, handling, and disposal of material considered to be potentially polluting or hazardous to the environment and humans should they be handled, released, or disposed of in an inappropriate or illegal manner. This section presents the types of oils, lubricants, and greases that would be used, and the measures the applicant has proposed to ensure compliance with relevant regulations and laws.

2.6.1 Onshore Groundwater Protection

Most onshore excavation would be performed with standard machinery, including excavators and backhoes, with the exception of four railroad/state highway intersection crossings which would be accomplished using trenchless techniques.

Conduit construction activities would require the use of certain hazardous materials such as diesel fuel, lubricating oils, grease, cleaning solvents, and glues. An accidental release of large quantities of these materials into the environmental could adversely impact soil, surface waters, or groundwater quality. For this project, the on-site storage and/or use of large quantities of materials capable of impacting soil and groundwater will not be required.

Approximately 50 percent of the onshore underground transmission line traverses a Zone II groundwater protection area and two local groundwater protection districts, with the majority of the run occurring in Yarmouth, Massachusetts and the remainder in Barnstable, Massachusetts. These areas are defined as an area of the aquifer which contributes water to a well under the most severe pumping conditions. Certain land uses are restricted and hazardous material use on a permanent basis is strictly regulated. For this project, hazardous material use will be limited to small quantities to support construction. At the time of local permit submittal for road openings in the Town of Yarmouth and the Town of Barnstable, any environmental contingency planning required for hazardous material use during construction will be addressed as part of that permitting process.

2.6.2 WTG Fluid Containment

The WTG would utilize lubricating oil, cooling liquids, and grease, all of which would be located in the nacelle or hub. The WTG has been carefully configured to contain any fluid leakage and prevent overboard discharges. The primary WTG components and the fluids are:

- **Hub -** The hub houses the blade pitching system, which is controlled by electric motors and contains only grease to lubricate parts.
- **Main bed plate -** Inside the main bed plate (located in the nacelle) is the oil conditioning system of the gearbox, main bearing, and generator bearings. The fluid capacity of the gearbox and bearings is approximately 190 gallons. As part of the oil conditioning system an oil/water cooling system is also located in the main bedplate. In the event of leaking gear oil or a broken hose/pipe, the leaking oil would be guided through the manhole in the bottom of the bedplate and collected on the upper internal platform of the tower.
- **Tower -** The upper internal platform is designed and sealed in such a way that it can withhold the total amount of gearbox and hydraulic fluid until it can be transferred to containers for safe disposal.
- **Fluids -** The fluids utilized in the various systems include gear oil, mineral oil for the hydraulic system and a water glycol mix for the cooling system.

The possibility of leaks may occur in two different situations: (1) during service and maintenance; and (2) during operation:

- **Service -** During the servicing and maintenance of a WTG, a spill could happen during oil changes of hydraulic pump units or the gearbox oil conditioning system.
- **Operation failures -** During WTG operation, leakage may occur as the result of broken gear oil hoses/pipes, and/or broken coolant hoses/pipes. Gear oil leaks would be contained within the hub and main bed frame and/or tower as described above. Coolant leaks can occur in a number of locations within the nacelle and would be contained inside the nacelle fiberglass cover.

In order to be responsive to small spill incidents associated with maintenance activities, service vessels would be equipped with oil spill handling materials adequate to control and clean up a small accidental spill. In addition, waste collection systems would be installed on board each WTG. The waste collection system is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste would be separated (i.e., used oil, coolant liquids, filters, paper/rags, etc.) for correct disposal once the containers are off-loaded at the dock.

2.6.3 ESP Fluid Containment

The ESP would have small amounts of lubricating oil, greases and coolants in pumps, fans, air compressors, emergency generators, and miscellaneous equipment, plus diesel fuel. The ESP would also have four oil-cooled step up transformers.

The primary systems and fluid contained are as follows:

- **Main Transformer -** The four 110-megavolt amp (MVA) oil cooled main step up transformers would each have a capacity of approximately 10,000 gallons (37,850 liters) of dielectric cooling oil. The oil would be circulated through oil/air heat exchangers mounted on the roof of the platform. Each transformer would be mounted in a leak proof detention area that would have the capacity of holding 150 percent of the transformer oil. Each of the detention areas would be connected via valves to a storage tank that has the capacity to store 100 percent of the oil from all four transformers. The oil piping to the coolers and the coolers would be configured so that any failures would result in oil being drained to the detention area.
- **Miscellaneous Equipment -** Various pumps, fans, and an air compressor would be installed on the platform. They would be lubricated with either grease or oil in small quantities. The equipment would be installed in such a way that any leakage would be contained on the sealed deck of the ESP.

The ESP would have sealed, leak-proof decks around the transformers and other equipment where oil and/or other lubricants exist, which would act as fluid containment. In addition, spill containment kits would be available near all equipment. The details of spill containment equipment and related spill control measures would be provided in an Oil Spill Response Plan (OSRP) (see Appendix D) prior to operation of the facility.

The type of insulating oil in general use in large power transformers of the MVA and voltage class proposed for the ESP and in use in existing offshore applications is a highly refined naphthenic mineral oil. Two types are defined by ASTM D-3487: Type I, inhibited, and Type II, uninhibited. The difference is the addition of antioxidants to the Type II oil. While a final decision remains to be made in consultation with the transformer manufacturer during the transformer procurement process, it is anticipated that Type I oil is likely to be specified for the ESP transformers. The specific brand of oil is dependent on the transformer manufacturer and so will not be known until the time of purchase.

Technical data sheets and material safety data sheets (MSDS) for several commercially available brands of transformer oil, both Type I and Type II, are provided in Appendix E. These include:

- Diekan 400, Type I, produced by FINA
- Diekan 410, Type II, produced by FINA
- Diala AX, Type II, produced by Shell
- Transvolt, Type II, produced by Royal Manufacturing Company

Reference to the MSDS will show that specific information on the toxicity to marine life is lacking. What can be culled is that because it is petroleum based the transformer oil will normally float on water and will not readily biodegrade. The hazard to marine life would be from the depletion of oxygen in a slow-flowing waterway that experienced a spill because the surface layer of oil, if allowed to remain, could interfere with natural atmospheric oxygen transport into the water. Non toxic effects could occur to birds or marine mammals from oiling of feathers or fur, which can interfere with the insulating characteristics of feathers and fur and result in harm or death. A spill into the open waters could only occur in the unlikely event of a transformer tank leak and a concurrent failure of the oil containment systems that will be part of the ESP design. Other smaller leaks at the WTGs would most likely be contained within the nacelle. There is an unlikely possibility that spills could occur during transfers of oils and lubricants to and from maintenance vessels to the ESP or WTGs. Also, it should be noted that the individual transformers at each WTG will be the dry type, containing no oil.

The MSDS also note that transformer oil does not bioaccumulate. A spill is subject to reporting under the Clean Water Act (CWA); but transformer oil is not considered a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) nor under the Superfund Amendment & Reauthorization Act (SARA) Sections 302, 311, 312 or 313.

2.6.4 Oil Spill Planning, Preparedness, and Response

MMS is the Federal agency responsible for oversight of oil spill planning, preparedness, and response for the proposed action. Specifically, the MMS requires that owners or operators of oil handling, storage, or transportation facilities that are located seaward of the coastline submit oil spill response plans (OSRPs) to MMS for approval prior to operations of that facility. As indicated earlier, the applicant has prepared a Draft Oil Spill Response Plan (draft OSRP) located in Appendix D, dated December 2005, which is intended to satisfy this requirement, upon its finalization prior to the start of construction (ESS, 2007).

The Draft OSRP (Appendix D) provides information on the types and quantities of oils, lubricants and coolants likely to be used (ESS, 2007). The applicant intends to contract with local firms that specialize in marine spill response, with the intended purpose that larger spills will be rapidly controlled and cleaned up, should one ever occur. Additionally, the OSRP describes the processes and procedures that would be used in the event of an oil spill including, but not be limited to the following components:

- Designation of a trained qualified individual;
- Designation of a trained spill management team available on a 24-hour basis;
- Description of the spill-response operating team;
- A planned location for a spill-response operations center;
- Procedures for the early detection of a spill;
- Procedures for spill notification;
- Oil Spill Response Organizations that the plan cites;
- Contact information for Federal, State, and local regulatory agencies that must be notified when an oil spill occurs;
- Methods to monitor and predict spill movement;
- Methods to identify and prioritize the beaches, waterfowl, other marine and shoreline resources, and areas of special economic and environmental importance;
- Methods to protect beaches, waterfowl, other marine and shoreline resources, and areas of special economic or environmental importance;

- Methods to ensure that containment and recovery equipment as well as the response personnel are mobilized and deployed at the spill site; and
- An inventory of spill-response materials and supplies, services, equipment, and response vessels available locally and regionally.

In addition, for on-land construction activities involving land disturbance and the potential for the release of oil and other contaminants into surface water or groundwater, including stormwater, the applicant will have to prepare a SWPPP, which will contain an SPCCP, under the NPDES program of the CWA. In Massachusetts, this program is under the jurisdiction of the USEPA.

2.7 POST LEASE GEOTECHNICAL AND GEOPHYSICAL FIELD INVESTIGATIONS

If MMS grants a lease for the proposed action, following issuance of the lease, a marine shallow hazards survey and a supplemental geotechnical program would be conducted prior to construction. The geotechnical and geophysical (G&G) field investigations would be designed to collect sufficient information, coupled with previous site-specific field data, to further characterize the surface and subsurface geological conditions within the vertical and horizontal areas of potential physical effects (APPEs), in preparation for final design and construction. These areas include the offshore construction footprints and associated work areas for all facility components, including the WTGs, the ESP, the inner array cables, and the 115 kV transmission cable to shore.

The shallow hazards survey would be designed to identify and evaluate conditions that might affect the safety of proposed activities, or conditions that might be affected by proposed activities. The supplemental post-lease geotechnical program would further analyze sediments and physical conditions within the proposed action APPEs, for use in final foundation design and to develop site-specific BMPs for constructability.

The survey plan, including the geophysical trackline spacing and coverage necessary to identify and delineate potential shallow hazards, would be finalized post-lease in consultation with the applicant and MMS. The shallow hazards survey would include a detailed geophysical program and would integrate the results of the supplemental geotechnical program, to build upon the previous offshore investigations.

2.7.1 Shallow Hazards Survey Geophysical Program

A high resolution geophysical survey (HRGS) would be conducted such that the quality and resolution of the data is adequate to delineate the extent of shallow hazards identified. Potential hazards to be assessed include, but are not limited to (subject to final development of the plan), the following:

- **Seafloor and/or shallow subsurface conditions:** locations, sizes and orientations of sand waves; boulders; man-made anomalies and debris; areas of sub-aquatic vegetation; presence of potential mud diapirs and gas venting features, areas of slope instability, shallow faulting.
- **Subsurface conditions to a minimum target depth of 200 ft (61 m) below the seafloor at the ESP location and 100 ft (30.5 m) at the wind turbine locations:** faults; shallow gas deposits, buried channels; potential for liquefaction, submarine slides, or slumping; and risk of seismic and tsunami events appropriate to the design life of the structures.

Rectilinear geophysical tracklines would be run specifically for the purpose of the shallow hazards assessment, and are anticipated to be oriented to capture expected dip and strike of the Horseshoe Shoal structure (subject to final survey design consultations). Up-to-date bathymetry would be collected using either single-beam or swath bathymetry, depending upon water depth and conditions. Two types of subbottom profiler datasets would be collected: the shallow (Chirp) and intermediate depth (Boomer) subbottom profiler data, the latter with resolution sufficient to penetrate a minimum of 200 ft (61 m) below the seafloor. If subsurface conditions are such that the intermediate Boomer cannot penetrate to the minimum target depth of 200 ft (61 m) below the seafloor, a deep-penetration Boomer profiler system would be used. Sidescan sonar and magnetometer data would also be collected, sufficient to identify potential obstacles on or just below the seafloor within the APPEs.

The shallow hazards geophysical survey would be conducted prior to the supplemental geotechnical program. Data from the survey would be used to finalize the geotechnical sampling locations.

The types of impacts to resource categories due to the geophysical survey are comparable to those resulting from the operation of an inshore lobster-fishing sized vessel. Because the trackline spacing would be finalized post-licensing, based upon the requirements of the selected contractor, the duration of the vessel deployment remains to be determined. At this time, it is expected that the geophysical survey would take several months to complete.

During the survey, an array of geophysical tools would be towed within the water column behind the vessel at certain depths above the seafloor. There would be no disturbance of the seafloor. The vessel would operate approximately 10 hours per day during relatively calm sea conditions in the warmer seasons. The vessel would travel at approximately 15 knots (27.8 km/h) when transiting between port at Falmouth to the survey area (1 hour each way), and at approximately 3 knots (5.6 km/h) during the 8 hours of actual survey time per day. The vessel would continuously transect the area, obtaining an estimated 30 miles (48.3 km) of data each day, before returning to port each night.

2.7.2 Supplemental Geotechnical Program

Whereas the geophysical investigations do not involve seafloor disturbance or the collection of samples for analysis, the geotechnical program does involve the use of coring and boring equipment to collect sediment samples for laboratory analyses, which would disturb the seafloor in small discrete locations.

2.7.2.1 Vibracores

Additional vibracores would be taken along the proposed 115 kV cable route (approximately 2 vibracores per mile [1.6 km]) and along the inner array 33 kV cable routes (1 vibracore approximately every 3.5 mile [5.6 km]). Sediments from some of these vibracores would be evaluated for thermal resistivity for final cable design.

The vibracores would be advanced from a small gasoline-powered vessel likely less than 45 ft (14 m) in length. Approximately 50 additional vibracores are planned at this time, although the final number would be determined in consultation with the selected contractor and final design firm. Up to 6 vibracores can be collected in a field day with favorable bottom conditions and calm seas. The diameter of the core barrel is approximately 4 inches (102 mm), and the cores are advanced up to a maximum of 15 ft (4.6 m). The vessel is anchored during coring.

2.7.2.2 Borings

Approximately 20 borings additional to the previous 22 would be advanced at selected WTG sites, including those at the approximate corners of the site of the proposed action on Horseshoe Shoal, to span the vertical APPE of the proposed structures, and to collect site specific geotechnical data to assist in final foundation design. The analytical program would address liquefaction potential, gas concentrations in sediments, pressure regimes of gaseous sediments, and gas saturation versus shear strength properties of sediments.

The estimated 20 borings would be advanced from a truck-mounted drill rig placed upon a jack-up barge that rests on spuds lowered to the seafloor. Each of the four spuds would be approximately 4 ft (1.2 m) in diameter, with a pad approximately 10 ft (3 m) on a side on the bottom of the spud. The barge would be towed from boring location to location by a tugboat. The drill rig would be powered by a gasoline- or diesel-powered electric generator. Crew would access the boring barge daily from port using a small boat. Borings generally can be advanced to the target depth (100 to 200 ft [30.5 to 61 m] depending on location) within one to three days, subject to weather and substrate conditions. Drive and wash drilling techniques would be used; the casing would be approximately 6 inches in diameter.

2.7.2.3 Cone Penetrometer Testing (CPT)

CPT or an alternative subsurface evaluation technique (appropriate to site-specific conditions) would be conducted prior to construction as necessary, to evaluate subsurface sediment conditions. A CPT rig would be mounted on a jack-up barge similar to that used for the borings. The top of a CPT drill probe is typically up to 3 inches (76 mm) in diameter, with connecting rods less than 6 inches (152 mm) in diameter.

2.7.2.4 Report and Maps

A shallow hazards assessment report, including analytical results of the supplemental geotechnical program, would be submitted to MMS prior to commencement of operations and pursuant to the terms of the MMS authorization. The report would describe surficial and subsurface geologic conditions and geotechnical properties of sediments within the proposed action’s marine APPEs.