New England Aqua Ventus I Offshore Wind Demonstration Project

Draft Project Description

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2.2 PROPOSED ACTION

2.2.1 Overview of the Proposed Project

New England Aqua Ventus I Offshore Wind Demonstration Project (the Proposed Project) would include the design, construction, installation, operation, maintenance, and eventual decommissioning of an offshore wind advanced technology demonstration project. The Proposed Project would consist of a single wind turbine generator (WTG) in the approximate 11-megawatt (MW; ranges from 9.5 to 11 MW) size supported on a floating concrete foundation, a subsea electric transmission export cable, an upland electric transmission export cable and a step-down substation that would transmit energy generated by the facility to the onshore electric grid.

The Proposed Turbine Location is located within the Maine Offshore Wind Energy Research Center Test Site (Turbine Area) (**Figure 2.2-1**), which was selected by the State of Maine (State) under legislation implemented to encourage the development of offshore wind energy production in Maine (Title 12 M.R.S.A. Section 1868). The Turbine Area encompasses 1,384 acres (5.6 km^2) of leased, submerged, State land located approximately 2.2 nautical miles (nm) (4.0 km) south of Monhegan Island in Lincoln County, Maine. This area was identified by the State after a siting study, public outreach, and stakeholder engagement (see Appendix A). The Turbine Area is leased by the State to the University of Maine (UMaine).[1] Once operational, the Proposed Project would be anticipated to operate 8,766 hours per year over a projected 20-year life, excluding forced and unforced outages. Water depths in the Turbine Area range between 197 and 328 feet (ft; 60 and 100 m).

The power generated from the Proposed Project would be transmitted to the onshore transmission distribution system by a 66kV subsea export cable. The projected length of this export cable is approximately 19 nm (35 km) from the WTG to the cable landing location in East Boothbay (Subsea Cable Route). From the cable landing location on the west bank of the Damariscotta River in East Boothbay (Cable Landing Area), the export cable would transition from a subsea cable to an upland cable and travel approximately 2.5 miles (4.0 km) (Onshore Cable Route) to the Point of Interconnection at the Central Maine Power (CMP) distribution substation at the southeast corner of State Route 27 and State Route 96 (Interconnection Substation). Along Onshore Cable Route would be staged the static synchronous compensator (STATCOM)[2], the grounding transformers, and a step-down transformer station that would transition the voltage from 66kV to 34.5kV for injection into the distribution system. Energy generated from the Proposed Project would be sold into the local transmission system under a Power Purchase Agreement (PPA), which was executed by CMP and UMaine in 2019 and approved by the Maine Public Utilities Commission on December 10, 2019.

[1] Per Title 38: Waters and Navigation; Chapter 3: Protection and Improvement of Waters; Subchapter 1: Environmental Protection Board, Article 5-A: Natural Resources Protection Act, a General Permit is issued by the Maine DEP pursuant to Section 480-HH.

[2] STATCOM is a regulating device that acts as either a source or sink of reactive AC power to regulate system voltage associated with wind generation, as well as the power transfer capability from this interconnection electricity network and which, if connected to a source of power, can also provide active AC power.

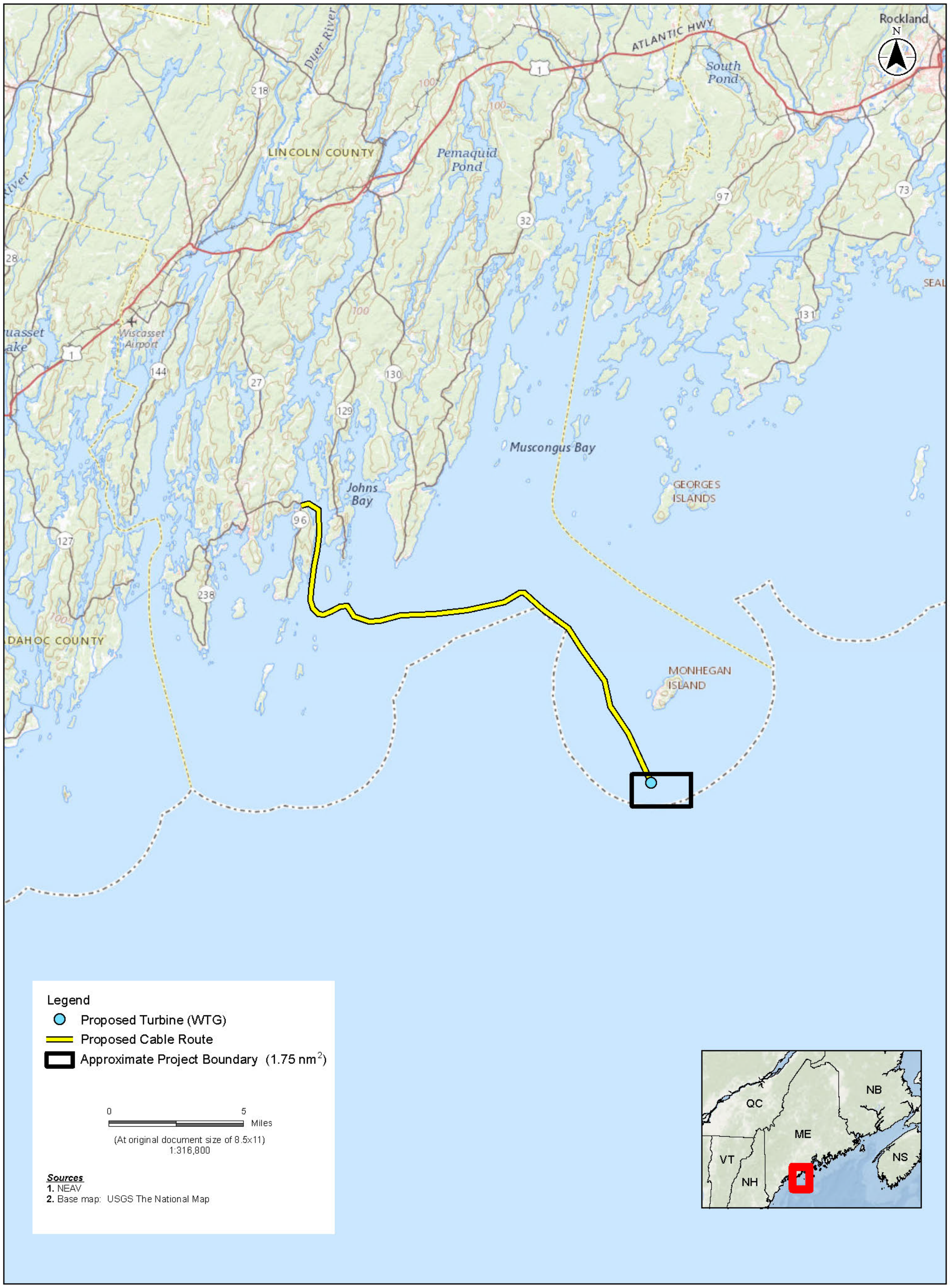

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Figure 2.2-1 Location of the Proposed Project

There are three potential foundation fabrication, hull assembly, and launch options currently under review by the Project proponent.

Under the Option 1, the foundation components would be constructed in segments at an existing fabrication facility in Brewer, ME (Brewer Fabrication Site), then loaded onto barges and floated down the Penobscot River to an area along the waterfront off the Maine Intermodal Cargo Terminal at Mack Point in Searsport, ME (Mack Point Foundation Assembly Area), for final assembly.

Under Option 2, the foundation components of the turbine would be fabricated and assembled at the existing Mack Point facility in Searsport, ME (Searsport Fabrication Site). The staging of elements fabricated off site would occur at the north end of the property currently used for transshipment of bulk material and upland turbine components. Foundation assembly would then occur at the Mack Point Foundation Assembly Area.

Under Options 1 and 2, the foundation then would be towed 3 nm (5.6 km) on the submersible barge to the State of Maine Oil Transfer Area (Turbine Launch Area), to provide enough water depth to launch the floating foundation. The barge would be submerged and the foundation would be floated off the barge; anchors may be required during launching. After launching, the floating foundation would be towed back to the Mack Point Foundation Assembly Area to complete assembly and/or commissioning. For all options, the foundation then would be floated across the harbor where the WTG would be assembled on the foundation in an area previously dredged by the Maine Department of Transportation (Turbine Installation on Foundation Area).

Under Option 3, the foundation components of the turbine would be fabricated at Brewer Fabrication Site or Searsport Fabrication Site and assembled at the existing Eastport Port Authority facility in Eastport, ME (Estes Head Pier) (Eastport Assembly and Launch Area). The staging of elements fabricated off site would occur at the north end of the Searsport property currently used for transshipment of bulk material and upland turbine components. Foundation assembly would then occur at the Estes Head Pier.

Once fully assembled, the completed structure would be towed to the Proposed Turbine Location.

A more detailed description of the construction process can be found in Section 2.2.3. It is anticipated that fabrication, hull assembly and launch would occur in 2022 and 2023.

2.2.2 Infrastructure Components

A schematic of the Proposed Project infrastructure is shown in **Figure 2.2-2**. Commencing with the WTG that is attached to the floating hull, a cable and associated electrical infrastructure would be installed to connect the WTG to the CMP electric distribution system on the mainland. The interconnection infrastructure includes a subsea cable, cable transition vault from subsea cable to onshore transmission cable/line at the cable landing, the onshore transmission cable/line, the STATCOM/grounding transformer, a stepdown transformer, and a substation interconnection.

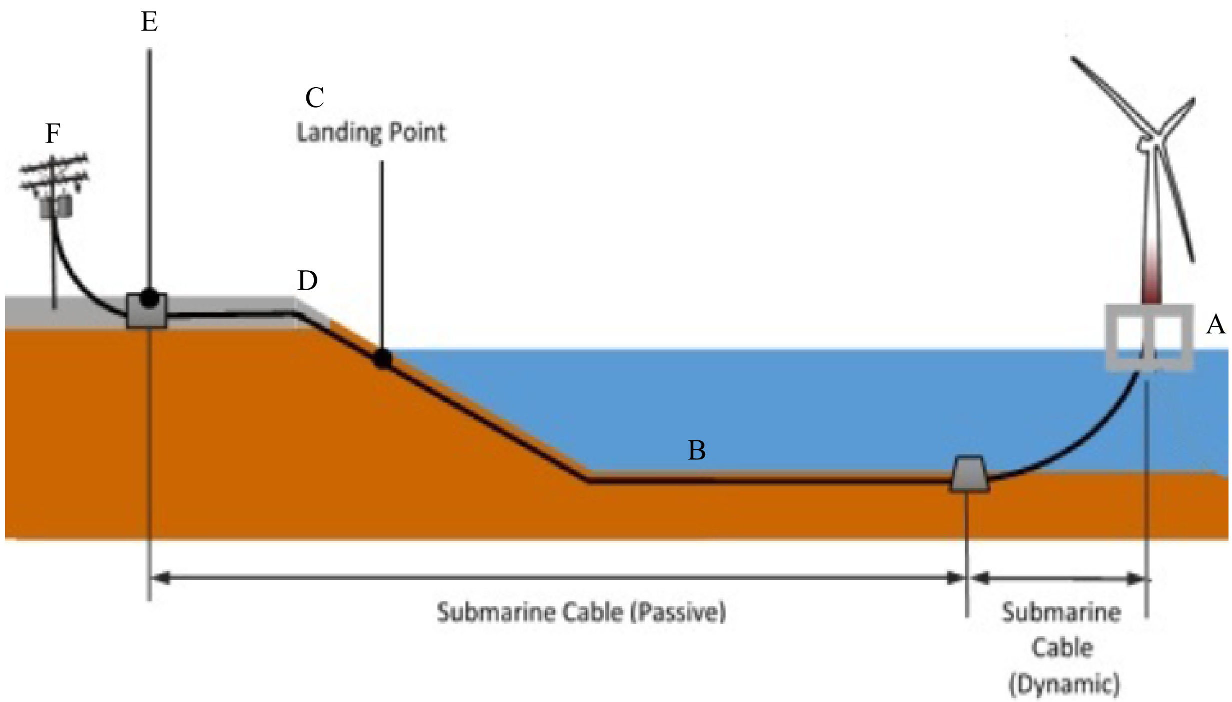


Figure 2.2-2 Components of Proposed Project Electrical Interconnection

Details are provided in the subsequent sections for the following infrastructure components:

- WTG (including foundation and mooring system (A);
- Subsea cable (B);
- Landing - Transition from subsea cable to onshore transmission cable (C);
- Onshore transmission cable (D);
- Substation (STATCOM, grounding transformer and step-down transformer) (E); and
- Substation interconnection (F)

2.2.2.1 Wind Turbine Generator

A WTG includes the following components, illustrated in **Figure 2.2-3**:

- Turbine blades that rotate under wind power;
- Nacelle that encloses the gearbox, brake, and electrical generator that transforms the kinetic energy of the moving turbine blades to electric energy;
- Tower, comprised of multiple sections, that extends from the foundation to the nacelle; and
- Lighting as required by the Federal Aviation Administration and the U.S. Coast Guard.

Several WTG models are being evaluated for incorporation into the Proposed Project. The WTG manufacturer and model would be finalized during the detailed project design process. In conformance with the National Environmental Policy Act (NEPA), a design envelope of turbine sizes in the approximate 11-MW size with maximum rotor diameter up to 657 ft (200 m) and maximum hub height up to 414 ft (126 m) would be analyzed in the Environmental Assessment (EA). The WTG would be seated on a floating foundation, described in the next section.

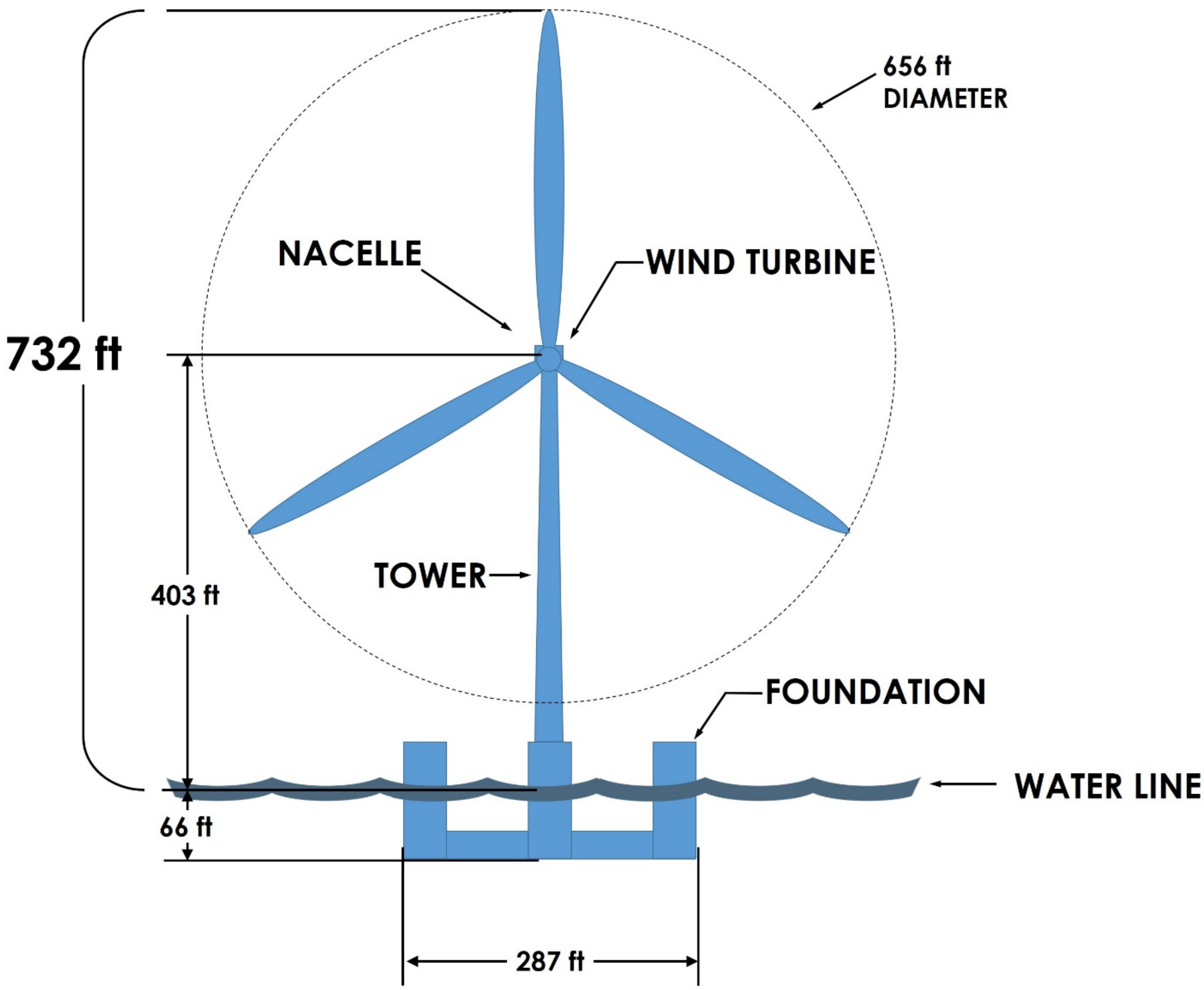


Figure 2.2-3 Floating Foundation Schematic – Approximate Dimensions (11-MW Size)

2.2.2.2 Foundation

The WTG would be supported by a reinforced concrete floating foundation known as a semi-submersible foundation. This floating foundation was designed by UMaine specifically for the Proposed Project. The floating foundation consists of a keystone and a central column connected to three outlying columns to form a tri-float (**Figure 2.2-4**). The turbine tower is seated on the center column.

Figure 2.2-4 Floating Foundation Schematic with Tower and WTG Installed

The WTG and floating foundation would carry monitoring equipment to collect data on motion and structural performance of the floating foundation under combined wind, wave, and environmental conditions. Included in the measurement equipment would be metocean buoy wave height sensors, current sensors, wind speed sensors, accelerometers, load cells, and cameras.

Generally, the preliminary dimensions of the floating foundation are depicted on **Figure 2.2-5**. All dimensions shown would be within ±5% of the final dimensions. The range of specifications for the proposed foundation are provided in **Table 2.2-1.**

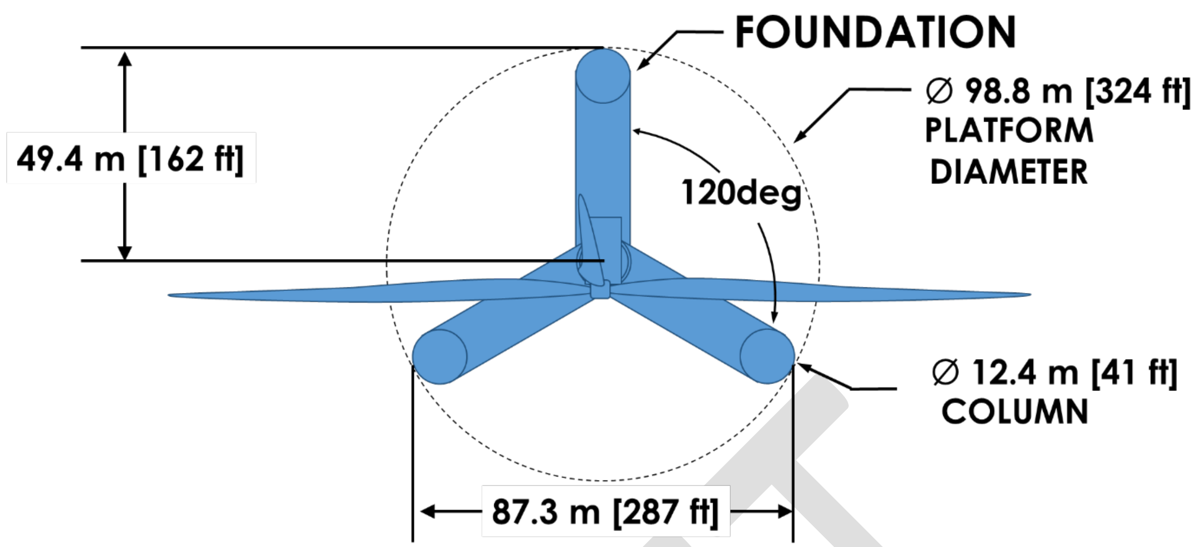


Figure 2.2-5 Floating Foundation Approximate Dimensions

Table 2.2-1 Floating Foundation – Range of Specifications for an approximate 11-MW Size WTG

Specification Type	Range of Specifications
Draft	59.1-72.2 ft (18-22 m)
Freeboard	40-48.9 ft (12.2-14.9 m)
Column Diameter	36.7-44.6 ft (11.2-13.6 m)
Radial Spacing	127.6-155.8 ft (38.9-47.5 m)
Bottom Beam Depth	23.8-28.9 ft (7.2-8.8 m)
Tower Length	321.5-383.4 ft (98.0-119.9 m)
Hub Height	370.4-453.1 ft (112.9-138.1 m)
Rotor Diameter	590.6-656.2 ft (180-220 m)
RNA Mass	642.6-786.4 US ton (583.0-713.4 metric ton [mt])
Lightship Draft	24.0-30.8 ft (7.3-9.4 m)
Hull Structural Mass	12,696-13,936 US ton (11,518-12,643 mt)
Total Installed System Mass	20,059-24,517 US ton (18,197-22,241 mt)

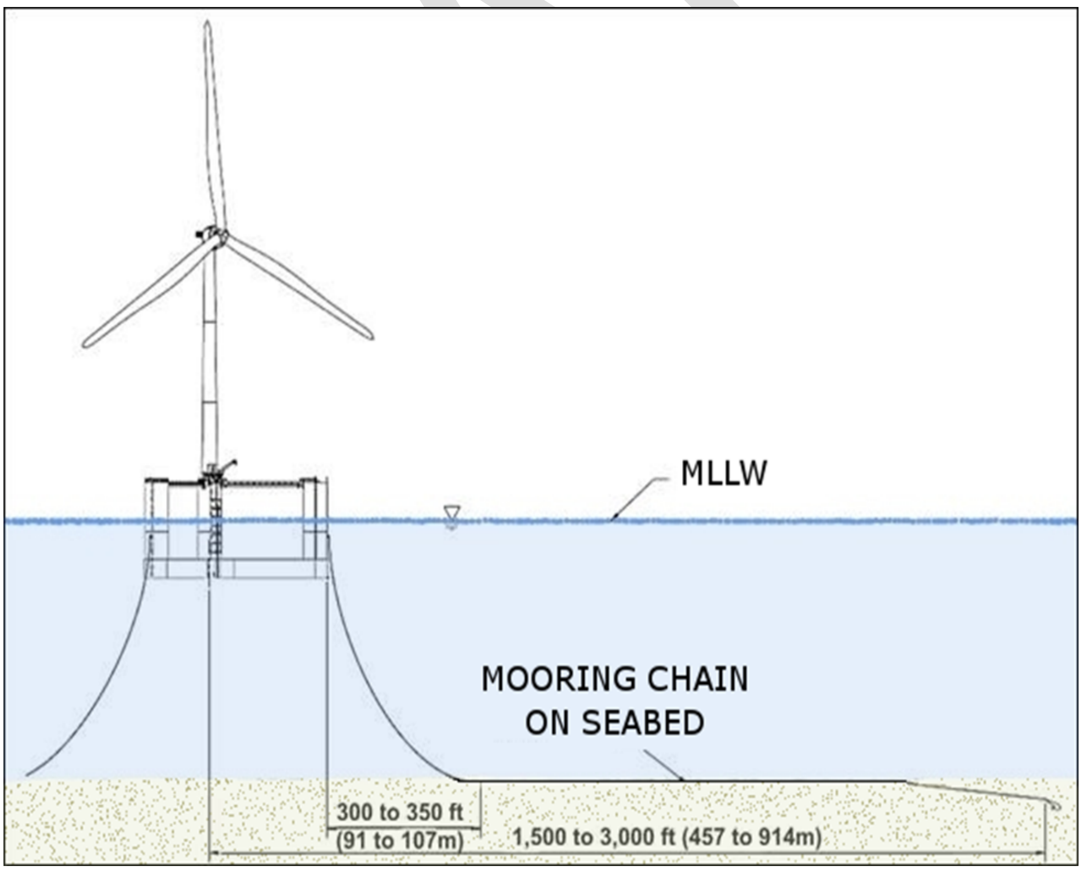
2.2.2.3 Mooring and Anchoring System

The floating foundation would be anchored to the seabed by up to four mooring lines and up to four permanent anchors. Three mooring system designs are being considered for the Proposed Project. The first mooring option, the chain catenary system, utilizes a steel chain configuration. This option is based on the American Bureau of Shipping (ABS) Guide for Building and Classing Floating Offshore Wind Turbines. Based on these ABS guidelines and the size of the hull required to support the WTG, the length of each mooring chain in a steel catenary chain mooring system would be up to approximately 2,300 ft (700 m) with a resulting mooring radius of 2,953 ft (900 m), with a design safety factor for the anchor chain. Certification of the final design would be conducted by ABS. Each chain link of the mooring line would have a diameter of approximately 6.4 inches (162 mm). The weight of the mooring line would be approximately 525 kilogram/meter (kg/m) when installed. The mooring would be attached at the turbine foundation and at the seabed anchor.

The second mooring option would be a catenary hybrid chain/synthetic rope mooring system. This option would utilize an approximate 6.4 inches (162 mm) diameter chain, approximately 35 feet (10 m) in length from the fairlead connection to the floating foundation. A synthetic rope would be connected to this chain and located in the water column. The rope would have an approximate diameter of 7.7 in (195 mm) and length of 445 ft to 1855 ft (135 m to 565 m). The synthetic rope would be connected to an approximate 6.4 in (162 mm) diameter chain along the seabed of 230 ft to 1,545 ft (70 m to 470 m) in length.

The third mooring option would be a semi taut synthetic rope mooring system. This option would be identical to the catenary hybrid option but would not connect to the chain along the seabed. This option could help minimize potential impacts to benthic resources.

In all three mooring system designs the mooring system would change positions in the water column as sea conditions change and the floating wind turbine moves in response to the environmental loading. **Figure 2.2-6** depicts a chain mooring configuration (mooring option 1) under calm, low water conditions with the maximum length of chain on the seabed. For both the chain catenary and catenary hybrid systems the length of chain on the seabed may shorten during storms and high-water conditions as the mooring chain moves with the changing forces on the wind turbine generator and the floating hull. **Figure 2.2-7** shows the hybrid catenary (mooring option 2) and semi-taut mooring systems (mooring option 3) under calm water conditions. The elastic nature of the systems containing synthetic materials may cause them to stretch or contract during storms and high-water conditions but the contact point to the seabed anchor remains the same.



Note: Mean lower low water (MLLW) is the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch (NOAA 2013).

Figure 2.2-6 Preliminary Chain Catenary Mooring System (Mooring Option 1) Schematic

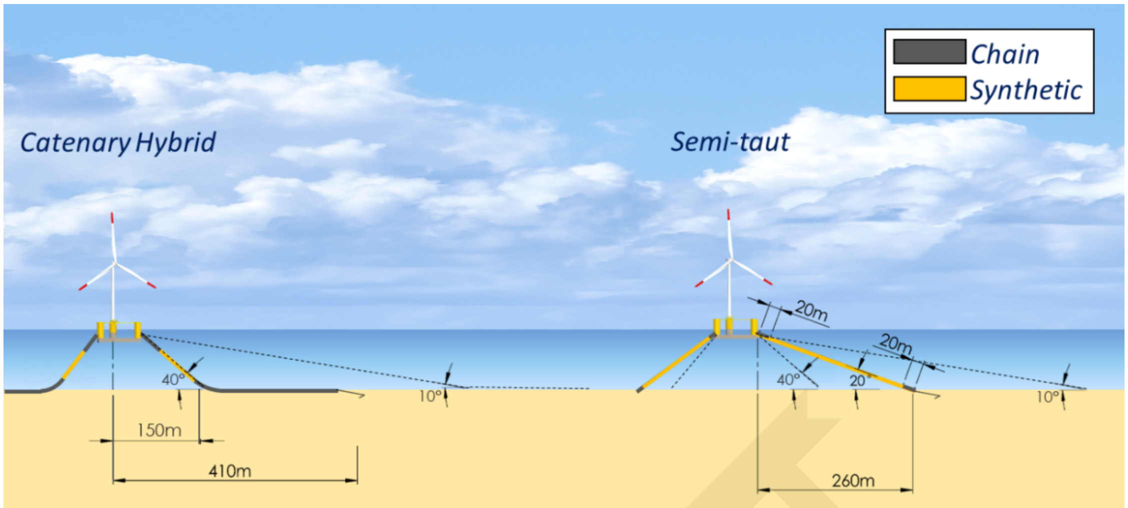


Figure 2.2-7 Preliminary Catenary Hybrid (Mooring Option 2) and Semi-taut Mooring System (Mooring Option 3) Schematics

Four types of anchors are being considered for the Proposed Project (drag embedment anchors, vertical load anchors, gravity anchors and suction bucket anchors). The preferred type is the drag embedment anchor, which is typically used for mooring large floating offshore structures such as oil and gas platforms. This type of anchor would be preferred because of the ease in removability from the seabed during decommissioning compared to other anchor types. However, the drag embedment anchor requires a mud seabed, and the required mud thickness may not be adequate at the proposed turbine location. Therefore, weighted concrete gravity anchors are also being considered. Additionally, if vertical load capacity is required and adequate soil depth is available, vertical load anchors, which are similar to standard drag embedment anchors but allow for more flexibility in the orientation of the load bearing plate, may be considered. Suction bucket anchors also require adequate soil depth but are an additional anchor type option for applications requiring vertical load capacity. Upon completion of the geophysical and geotechnical survey, a final anchor selection would be made based on the geotechnical information.

Examples of the four types of anchors under consideration are shown in **Figures 2.2-8**, **2.2-9** and **2.2-10**. Specifications for each are provided in **Table 2.2-2**.

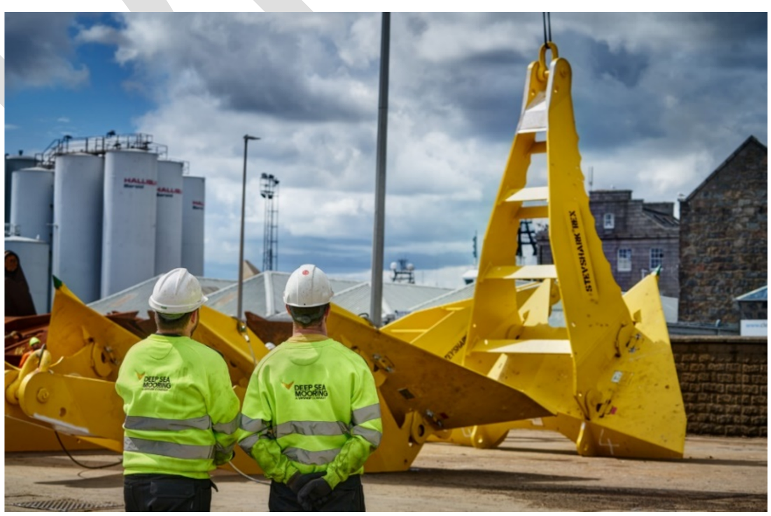


Figure 2.2-8 Example of a Drag Embedment Anchor

Source: Kiewit and Bladt Industries, respectively

Figure 2.2-9 Example of Gravity Anchor (Top) and Suction Bucket Anchor (Bottom)

Figure 2.2-10 Example of Vertical Load Anchor

Table 2.2-2 Preliminary Mooring and Anchoring Dimensions

Parameter	Drag Embedment Anchor or Vertical Load Anchor	Gravity Anchor	Suction Bucket Anchor
Mooring type	Catenary – 3 lines per WTG		
Water depth	200 to 360 ft (61 – 110 m)		
Mooring chain length	Up to 3,000 ft (914 m) depending on location of anchor		
Line material	Steel chain and/ or wire rope and synthetic rope		
Mooring chain bar diameter- thickness of chain link (largest material in the line)	5 to 7 in. (12.7 – 17.8 centimeters [cm])		
Anchor material	Steel	Concrete	Steel
Preliminary anchor weight	18 – 50 tons (16.3 – 45.4 metric tons [mtu])	150 – 400+ tons (136 – 362+ mtu)	145 – 300 tons (131.5 – 272 mtu)
Preliminary anchor dimensions	Height: ~20 ft (6.1 m) Length & Width: ~30 ft (9.1 m)	Height: ~10 – 20 ft (3 – 6.1 m) Length & Width: ~25 ft (7.6 m)	Height: 50 – 65 ft (15.2 – 19.8 m) Diameter: 18 – 30 ft (5.5 – 9.1 m)
Approximate penetration depth (depending on seabed composition)	~ 30 – 60 ft (9.1 – 18.3 m)	~ 35 ft (10.7 m)	~ 45 ft (13.7 m)

2.2.2.4 Offshore Cable

From the floating WTG to the seafloor, the cable would be in a "dynamic" configuration, allowing for movement of the hull during weather conditions and supported in the water column with a series of clamp-on buoyancy modules (floats) along the length of the cable or no floats depending upon the final design as shown in **Figure 2.2-11**. The configuration of the dynamic subsea cable is depicted is **Figure 2.2-12** and specifications are listed in **Table 2.2-3**. These buoyance modules would allow the subsea cable to move in the water column. The dynamic section of the subsea cable would be installed between two of the mooring lines so that it would not be impacted by the anchor chains. The subsea cable would extend approximately 1,000 ft (300 m) horizontally through the water column to the seabed where it would connect to a 'static' cable at a cable splice junction box installed on the seafloor. From the cable splice, the subsea cable would follow the selected Subsea Cable Route along the seabed to the Cable Landing Area in East Boothbay. Depending on the geology, the static subsea cable would be buried approximately 6 ft (1.8 m) deep in sediment or covered with gravel/rock or a concrete pad if there is insufficient sediment or bedrock exists. The configuration of the static subsea cable is depicted is **Figure 2.2-13** and specifications are listed in **Table 2.2-3**.

Table 2.2-3 Offshore Cable Specifications and Installation Details

Parameter	Dynamic Subsea Cable[1] (through water column)	Static Subsea Cable (seabed)
Cable diameter	6 to 8 in. (152 to 200 millimeters [mm]) in diameter and armored	6 to 8 in (152 to 200 mm) in diameter and armored
Power	66kV, 3-phase AC dynamic cable[1] for transmitting power	66kV, 3-phase AC dynamic cable for transmitting power
Installation vessel and anchoring system	Cable Laying Vessel	Cable Laying Vessel
Length	Approximately 1300 ft (400 m)	approximately 18.9 nm (35 km) to Cable Landing Area
Cable protection?	Armored jacket and surface marker buoys indicating the location of the dynamic cable	
Burial depth	Not Applicable	Approximately 6 ft (1.8 m) in sediment, rock gravel covering or concrete pads where insufficient sediment on bedrock exists
Burial trench width and depth	Not Applicable	Trench width is approximately 3 ft (0.9 m) and the depth is approximately 6 ft (1.8 m)

[1] Dynamic cable refers to the portion of the cable that moves as the floating foundation moves.

The Proposed Project would use the state-of-the-art position recording of the as-laid cable location to ensure that just the subsea cable is indicated on future navigational charts. Future navigational charts would show the exact subsea cable location (not simply the Subsea Cable Route, which includes a 500-foot buffer of the subsea cable).

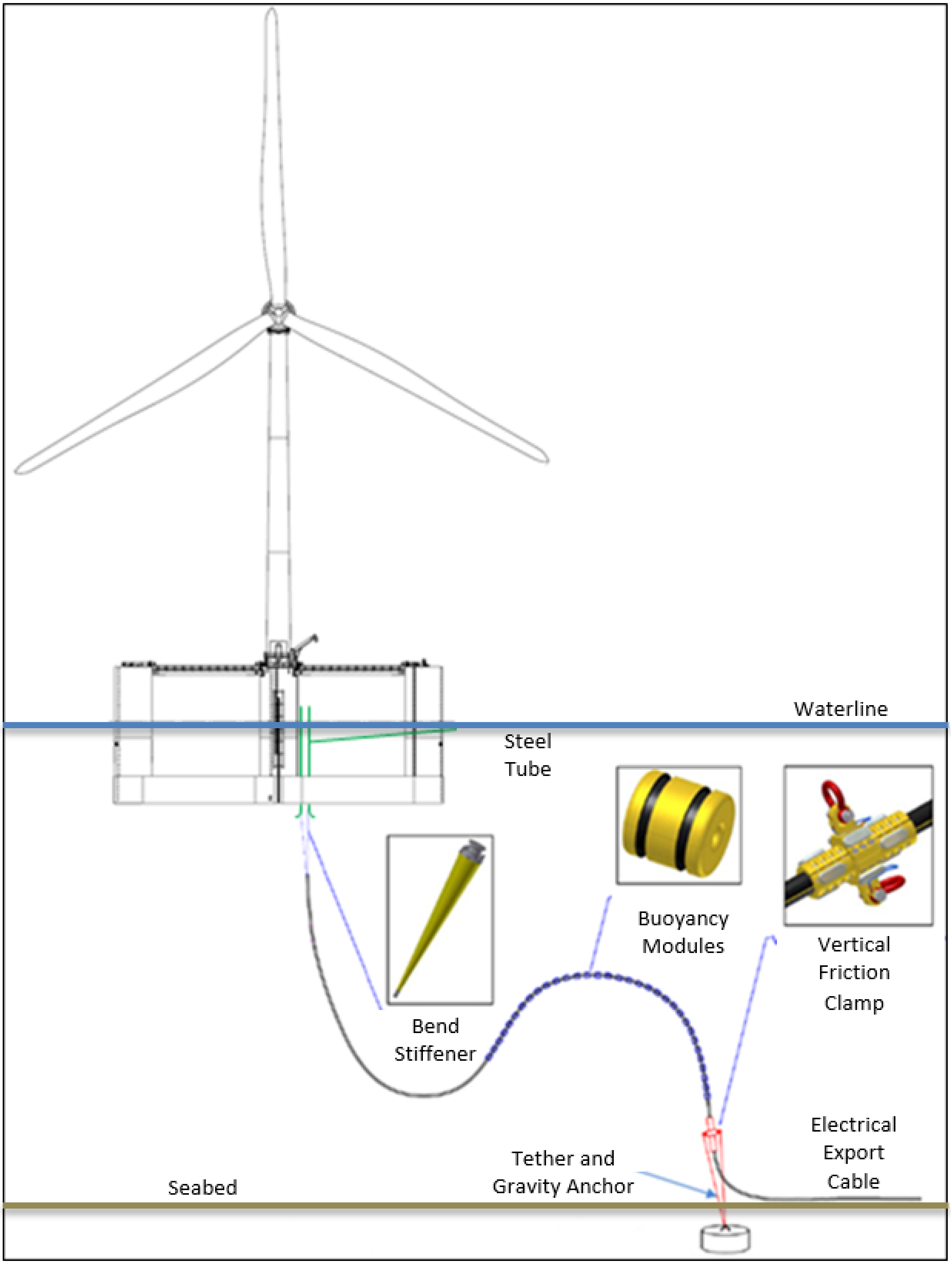
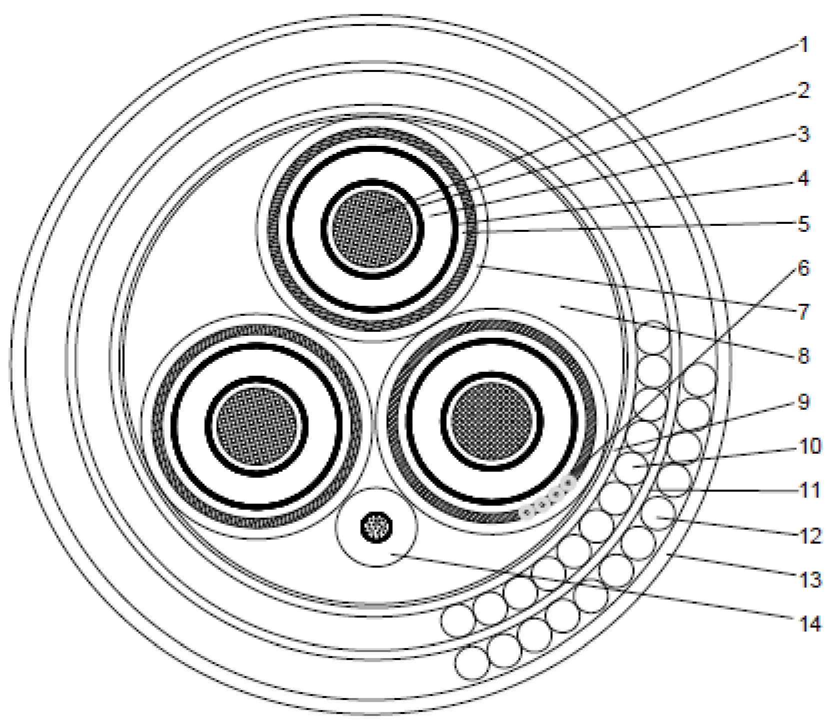


Figure 2.2-11 Typical Dynamic Cable Schematic Showing Buoyancy Floats

Rated Voltage	AC 66kV	Conductor size	3X240 ㎟



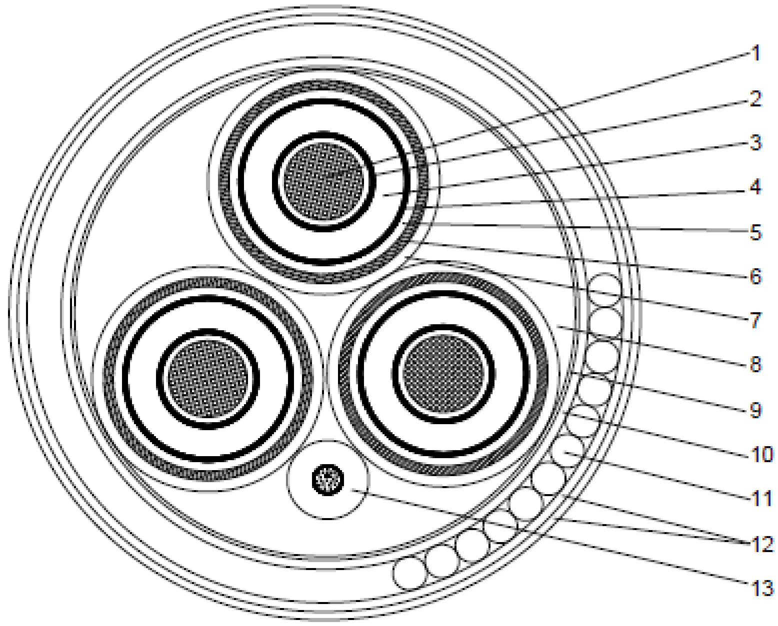
No.	Items	Material	Thickness (mm)	Approx. Diameter (mm)
1	Conductor	Circular compressed, copper, watertight	-	19
2	Conductor screen	Extruded semi-conducting compound	Min. 0.41	22
3	Insulation	Extruded tree-retardant cross-linked polyethylene (TR-XLPE)	Nom. 10	42
4	Insulation screen	Extruded semi-conducting compound	Nom. 1.0	44
5	Bedding layer	Semi-conducting swelling tape(s)	Approx. 0.5	-
6	Metallic screen	Copper wires with copper tape	Nom. 2.2	50
7	Anti-corrosion sheath	Extruded semi-conducting polyethylene	Min. 2.54	59
8	Filler	Fillers compatible with sea water	-	-
9	1st Armor bedding	Polypropylene yarn or Extruded polyethylene	Approx. 3.0	138
10	1st Wire armor	Galvanized steel wires with bitumen	Nom. 4.0	147
11	2nd Armor bedding	Polypropylene yarn	Approx. 2.0	151
12	2nd Wire armor	Galvanized steel wires with bitumen	Nom. 4.0	160
13	Serving	Extruded polyethylene	Approx. 6.0	174
14	Optical fiber cable	G.652.D(12 fibers) SSLT type armoured		
-	Net weight of cable in air/water (kg/m)		Approx. 49/25	

Remark:
Not to scale

Source: LS Cable System

Figure 2.2-12 Dynamic Armored Cable Design

Rated Voltage	AC 66kV	Conductor size	3X240 ㎟



No.	Items	Material	Thickness (mm)	Approx. Diameter (mm)
1	Conductor	Circular compressed, Aluminium, watertight	-	19
2	Conductor screen	Extruded semi-conducting compound	Min. 0.41	22
3	Insulation	Extruded tree-retardant cross-linked polyethylene (TR-XLPE)	Nom. 11	44
4	Insulation screen	Extruded semi-conducting compound	Min. 0.61	46
5	Water blocking layer	Semi-conducting swelling tape(s)	Approx. 0.5	-
6	Metallic sheath	Extruded lead alloy	Min. 2.16	53
7	Anti-corrosion sheath	Extruded semi-conducting polyethylene	Min. 1.78	57
8	Filler	Fillers compatible with sea water	-	-
9	Anti-Teredo	Cu tape(s)	Min. 0.1	127
10	Armor bedding	Polypropylene yarn	Approx. 2.0	131
11	Wire armor	Galvanized steel wires with bitumen	Nom. 6.0	144
12	Serving	Polypropylene yarn with black / yellow stripe	Approx. 2 x 2.0	153
13	Optical fiber cable	G.652.D(48 fibers) SSLT type		
-	Net weight of cable in air/water (kg/m)		Approx. 43/24	

Remark:
Not to scale

Source: LS Cable System

Figure 2.2-13 Static Cable Design

2.2.2.5 Sea-to-shore Transition

Several possible locations for the cable landing in East Boothbay, ME have been identified. Potential shore transition alternative techniques considered horizontal directional drilling, installation of a temporary coffer dam, or utilizing a temporary excavation through a “cut and cover” technique (for a full description of “cut and cover” see section 2.2.3.5, below). Based on site investigation through soil sampling and local geology, the Proposed Project’s preferred technique would be the “cut and cover” method to perform the shore crossing at the foot of the specific cable landing location within the Cable Landing Area: at the terminus of School Street. The shore crossing activities would be coordinated with the subsea cable installation to minimize the scheduled activities associate with the shore crossing.

2.2.2.6 Transmission Cable Landing and Onshore Cable Route

The cable landing would be at a location within the shoreline area in East Boothbay, as depicted on **Figure 2.2-14**. From cable landing the subsea cable would enter a transition splice vault. At this junction, the cable would transition from a subsea cable to an onshore cable; much of the cable armoring would not be required from this point. Upon exiting from the transition splice vault, three Onshore Cable Route options from the cable landing to the Interconnection Substation are being considered (**Figure 2.2-15**):

- Route 1 is left out of School Street, right on Murray Hill Road, right on Sunrise Lane to connect to Ocean Point Road to the substation.
- Route 2 is left out of School Street. right on Murray Hill Road, right on Mass Ave, which transitions into W. Street Extension/Virginia Lane with a left on Ocean Point Road to the substation.
- Route 3 is left out of School Street and right on Ocean Point Road into the substation.

The Proposed Project would look to co-locate the cable within the existing utility corridor that is within the road allowance along the selected Onshore Cable Route. As proposed, the placement within the existing utility corridor within the road allowance would not require any new improvements or modifications to corridor width or the number or height of existing poles. The Onshore Cable Route selected would be based upon detailed discussions with the Town of Boothbay Town Manager, the Town of Boothbay Harbor Town Manager, and the Maine Department of Transportation, which controls access to the proposed routes.

2.2.2.7 Interconnection Substation

The Onshore Cable Route would terminate at the CMP Interconnection Substation located near the intersection of State Route 96 (Ocean Point Road) and State Route 27 (Townsend Avenue) (see **Figure 2.2-15**). The substation would contain the STATCOM and step-down transformer, and both 34.5kV and 66kV breakers (**Figure 2.2-16**). The onshore cable would be stepped down from 66kV to 34.5kV prior to interconnection.

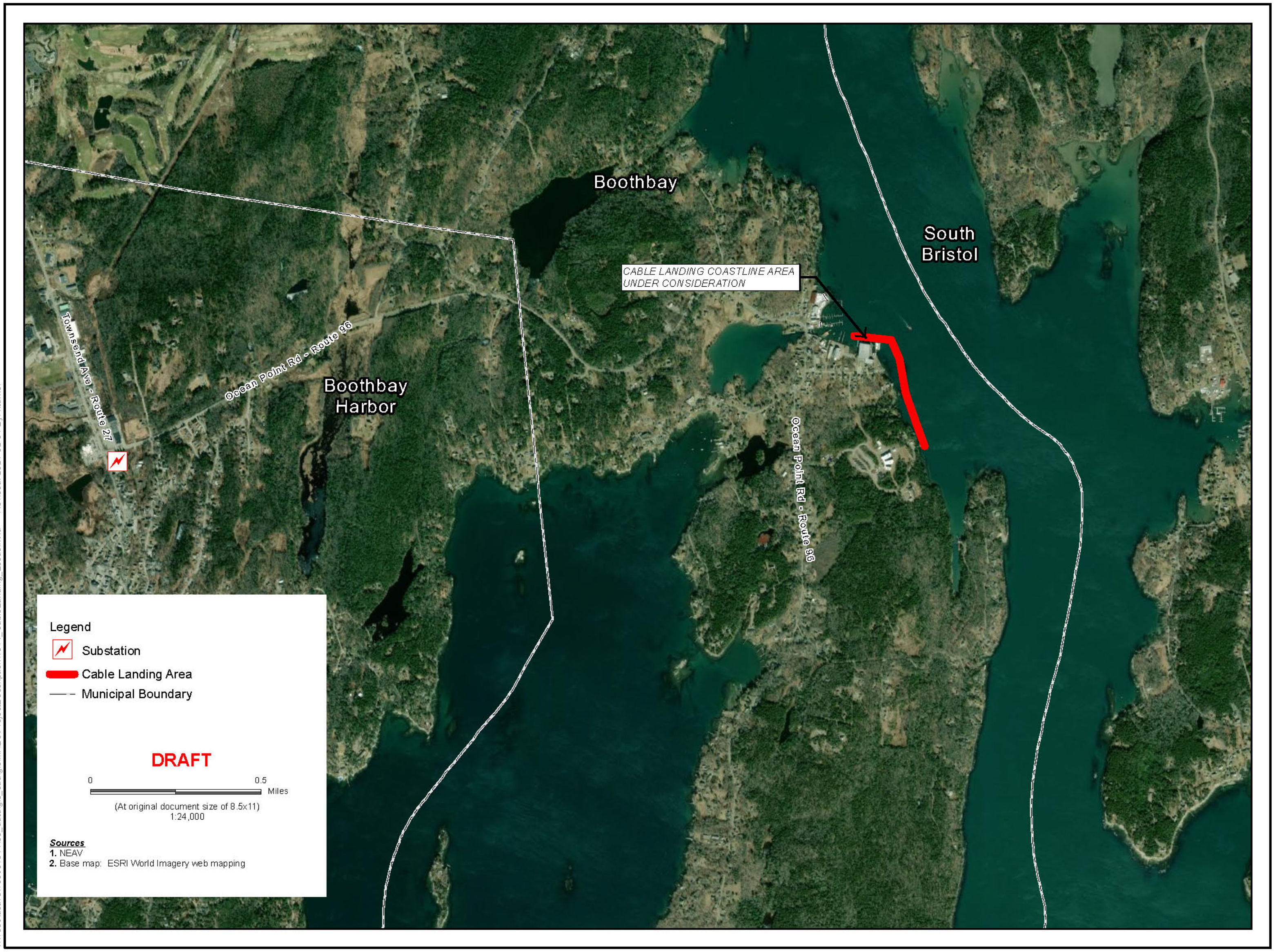


Figure 2.2-14 Proposed East Boothbay Cable Landing Area and Boothbay Harbor Interconnection Substation Locations

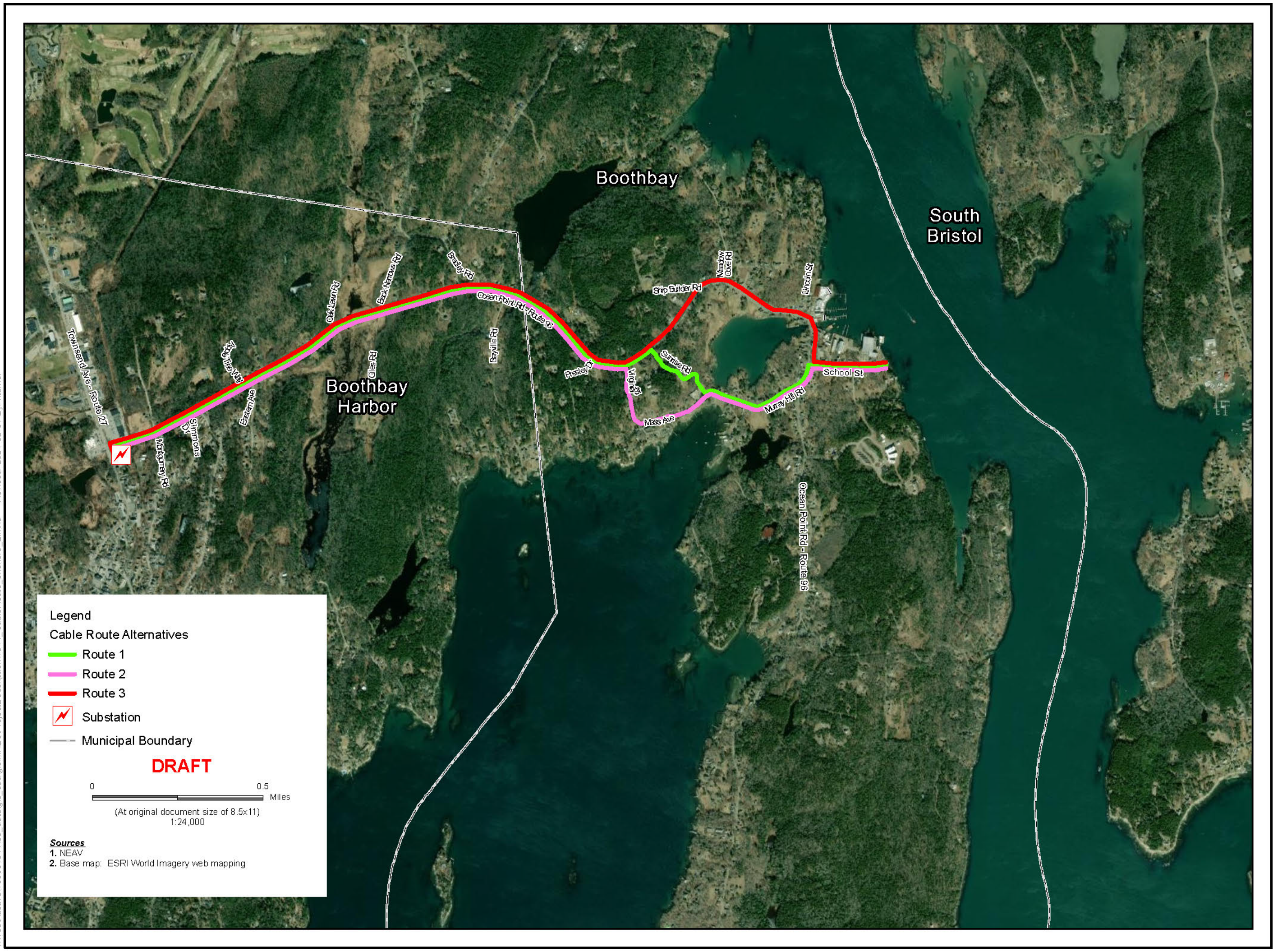


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Figure 2.2-15 East Boothbay to Boothbay Harbor Onshore Cable Route Options

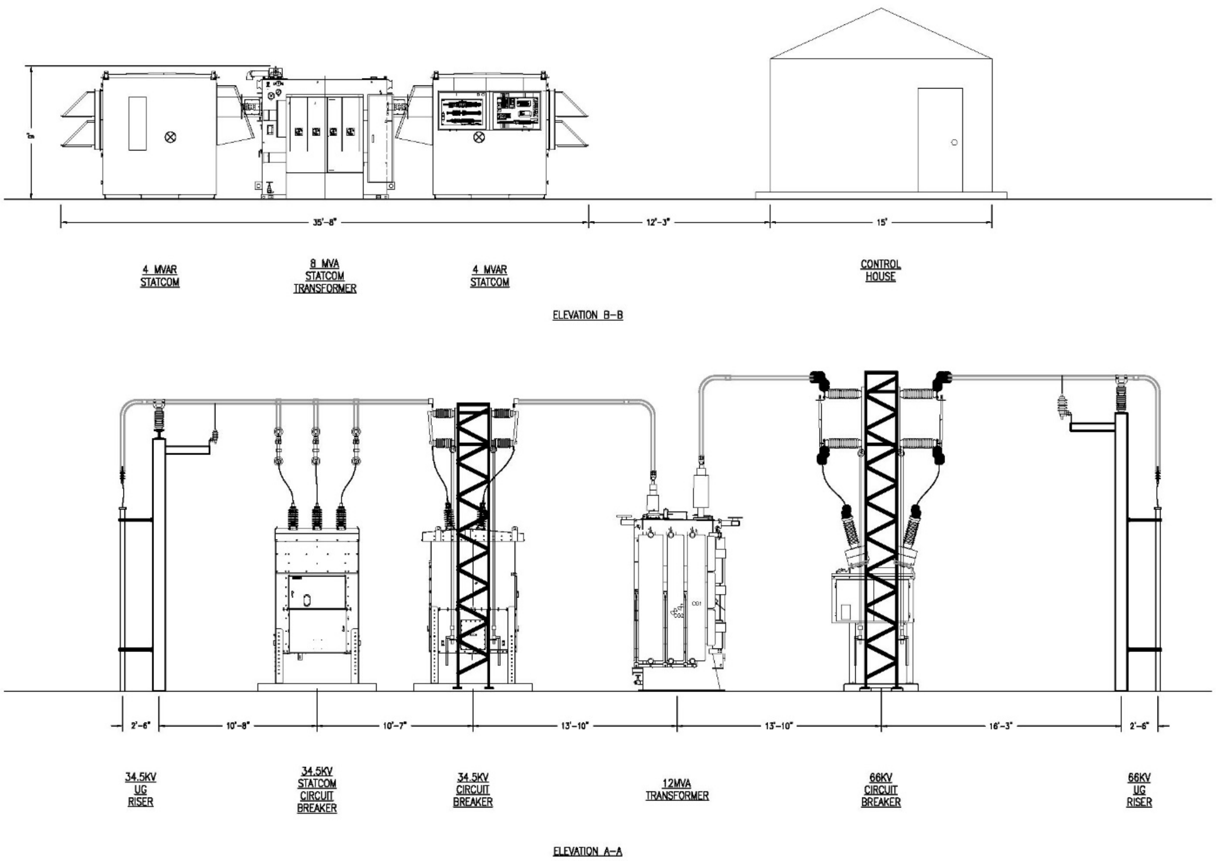

Figure 2.2-16 Proposed Interconnection Substation (STATCOM/Step-down Transformer)

2.2.3 Construction Process

Details on activities for each phase of construction are provided in the following subsections.

2.2.3.1 Fabrication, Assembly, and Launch

As currently proposed, there are three potential options for foundation fabrication, hull assembly, and launch being considered as a part of the Proposed Project. The following sections provide details for each option.

Option 1

Under Option 1, the floating foundation concrete segments would be fabricated at an existing facility owned by Cianbro Corporation, located on the eastern bank of the Penobscot River in Brewer, ME (**Figure 2.2-17**). The facility currently is used by Cianbro for large scale fabrication and has been typically used to fabricate large steel assemblies for the oil and gas industry and traditional power plants. No modifications would be needed at this facility to accommodate the Proposed Project. Fabrication of the foundation components would take approximately ten (10) months.

After fabrication, the concrete foundation segments would be loaded onto three barges at the existing barge berth adjacent to the Brewer Fabrication Site and towed to the Maine Intermodal Cargo Terminal at Mack Point in Searsport, ME (**Figure 2.2-18**). Each barge would be towed approximately 30 nm (55 km) down river (taking approximately one day) by two tugboats for partial foundation assembly at the Maine Intermodal Cargo Terminal at Mack Point (Mack Point Foundation Assembly Area. The three barges would include one submersible barge[3] (approximately 400 x 100 ft [122 x 30 m]) and two, secondary non-submersible barges (approximately 250 x 72 ft [76 x 22 m]).

Figure 2.2-17 Foundation Fabrication Site, Brewer, Maine

[3] A "submersible barge" has the ability to hold cargo on its deck while being partially submerged underwater allowing the cargo to be floated off of the barge.

Figure 2.2-18 Foundation Fabrication Site, Searsport, Maine

For partial foundation assembly, the submersible barge containing the keystone with one beam attached would be grouped with the secondary barges and secured to a crane barge which would be moored with spud piles (legs that extend from the barge into the seabed to secure the vessel) (**Figure 2.2-19-A**). The two bottom beams of the floating foundation would then be connected to the keystone and first bottom beam (**Figure 2.2-19-B**). After the bottom beams are secured to the keystone, the two secondary barges would be ballasted below the bottom beams so that they can be moved away from the submersible barge (**Figure 2.2-19-C**). All other floating foundation column pieces would remain on the secondary barges.

The partially assembled foundation then would be towed 3 nm (5.6 km) on the submersible barge to the State of Maine Oil Transfer Area (Turbine Launch Area), to provide enough water depth to launch the floating foundation (**Figure 2.2-20**). The barge would be submerged and the foundation would be floated off the barge; anchors may be required during launching. After launching, the partially assembled floating foundation would be towed back to the Mack Point Foundation Assembly Area and moored next to the crane barge and a secondary barge to complete assembly (**Figure 2.2-21**).

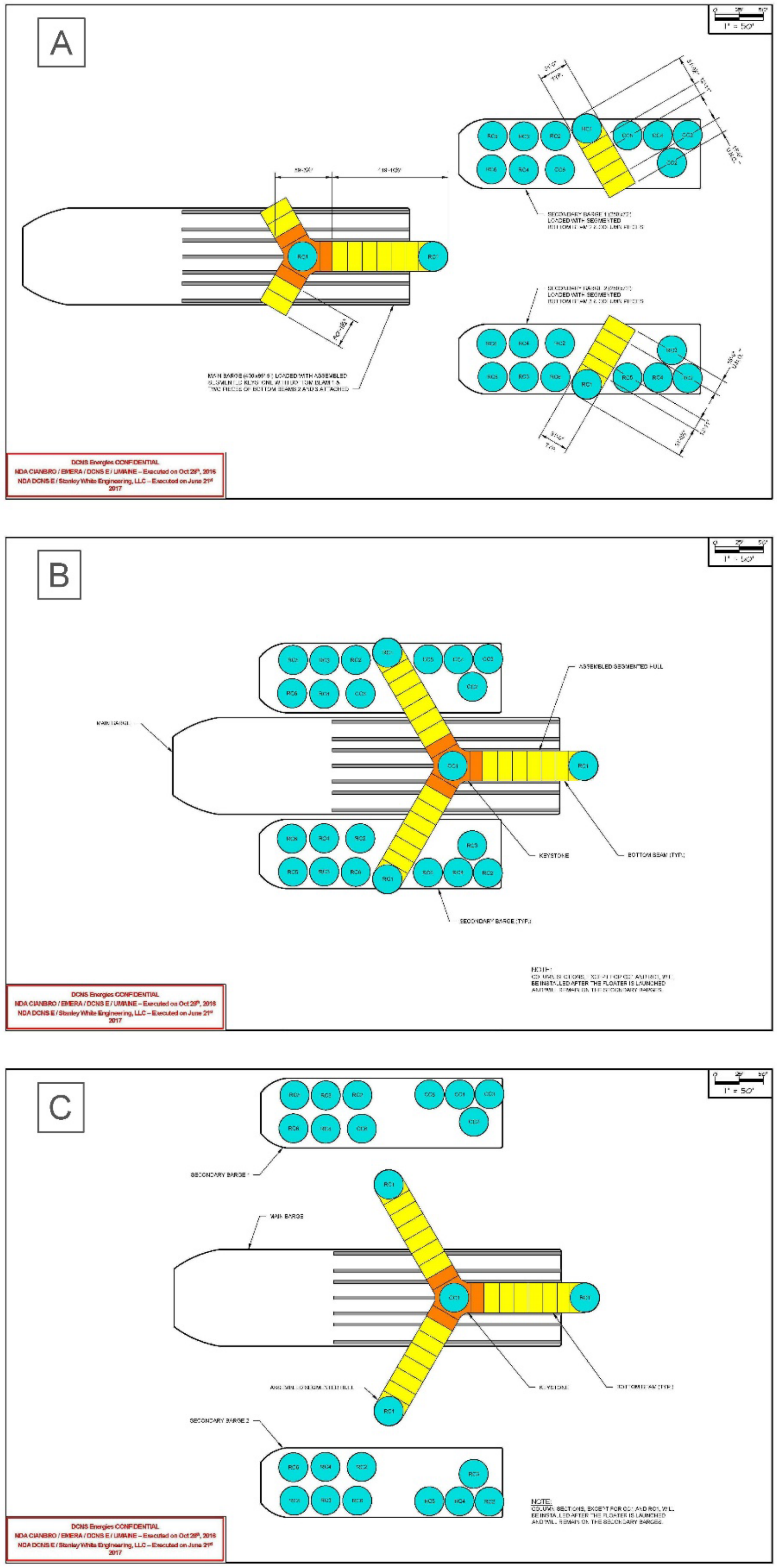

Figure 2.2-19 Sequential (A, B, C) Configuration of Assembly of Floating Foundation on Barges at Mack Point

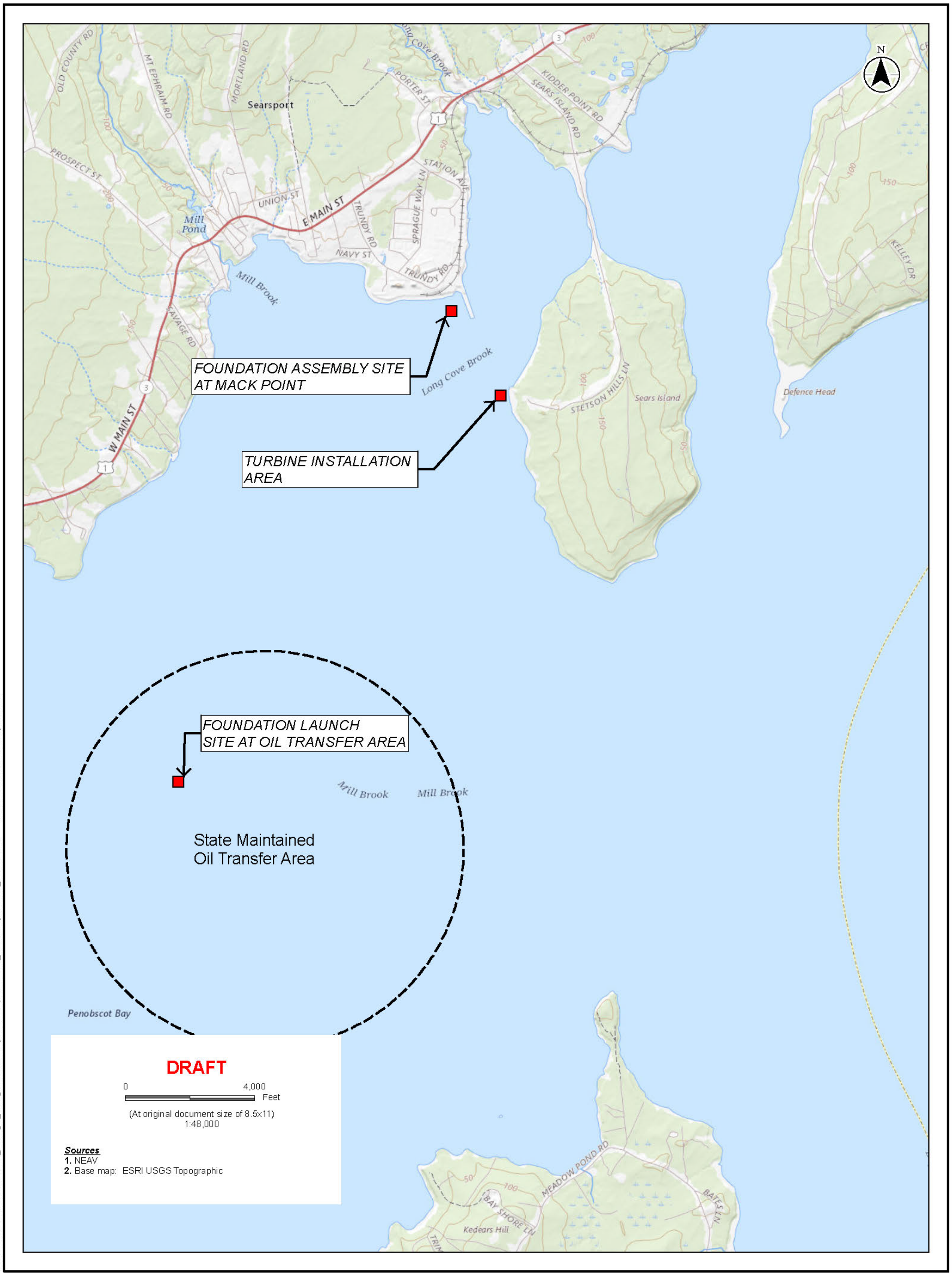

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Figure 2.2-20 Floating Foundation Assembly, Turbine Installation, and Foundation Launch Locations (Options 1 and 2)

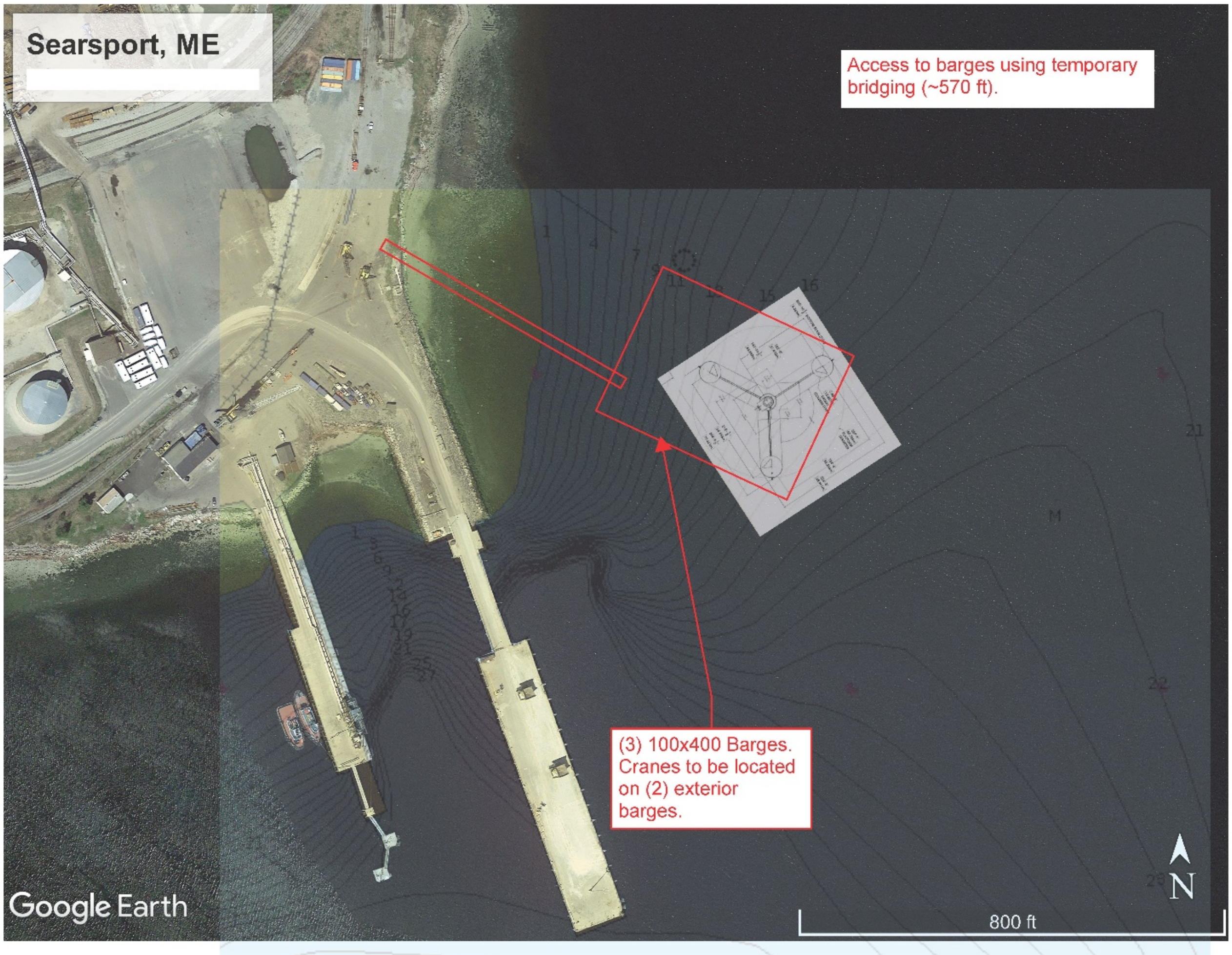

Figure 2.2-21 Assembly of Bottom Segments of Floating Foundation (Configuration of Barges Upon Arrival at Mack Point)

Finally, the spudded crane barge would transfer the remaining column segments from the secondary barges to complete assembly of the four columns on the floating foundation. Following the assembly of the columns, post tension cables would be installed in each column to create an integrated unit, and remaining assembly of the floating foundation would occur (e.g., installation of ladders and struts/access ways, electrical and mechanical systems, and other instrumentation). The floating foundation would undergo a complete pre-commissioning and testing procedure which would include, but not be limited to, ballast system, instrumentation, and water tightness tests. Assembly and launch of the floating foundation would take approximately four (4) months. The Proposed Project is evaluating several assembly techniques and associated vessels that would have the height and lift capabilities required.

Option 2

Under Option 2, the floating foundation components would be fabricated and assembled at the existing Maine Intermodal Cargo Terminal located at Mack Point in Searsport, ME (**Figure 2.2-18**). The staging of offsite fabrication of components would occur at the north end of Mack Point currently being used for transshipment of bulk material and upland turbine components that arrive or depart from the existing marine facilities (Searsport Fabrication Site). Pre-cast elements would be trucked onto the site from existing offsite commercial facilities. Concrete for cast-in-place activities would be brought to the site from existing ready-mix facilities. Standard concrete trucks would transverse the temporary access bridges to the assembly barges.

The assembly would occur off Mack Point on floating barges along the waterfront east of the Bulk Pier in an open area currently used for transshipment of bulk material and upland turbine components that utilize waterborne transport for accessing the site (Mack Point Foundation Assembly Area). Launching concepts (from the barge into the water) are being developed and could consist of transferring the floating foundation from the center barge to a launching vessel (barge or ship) using transfer rails and skid shoes in the general area of Mack Point. Fabrication and assembly of the foundation components would take approximately seven (7) to twelve (12) months.

If the full assembly of the foundation occurs on barges, the foundation would be transported 3 nm (5.6 km) on the submersible vessel to the Turbine Launch Area, as described for the Brewer Fabrication Site Option (**Figure 2.2-21**). The vessel would be submerged and the foundation would float off the vessel; anchors may be required during launching. After launching, the fully assembled floating foundation would be towed back to the Mack Point Foundation Assembly Area (probably secured to spud barges) to complete commissioning.

Option 3

Under Option 3, concrete components would be fabricated at the Searsport Fabrication Site at the staging area at the north end of the existing Mack Point facility or at the Brewer Fabrication Site. If fabricated at the Searsport Fabrication Site, the concrete components would be brought to the existing Bulk Pier and loaded onto transport barges (approximately 250 feet long) using the existing mobile crane or by a crane located on a barge secured to the Pier. The transport barges would be towed to an existing Maine Department of Transportation facility in Eastport, ME[4] where the concrete elements would be offloaded onto three 100x400-foot barges secured to the existing pier (**Figures 2.2-22** and **2.2-23**; Eastport Assembly and Turbine Area).

The foundation would be fully assembled, including electrical and mechanical internal systems and secondary steel, on the assembly barges. Once the floating foundation is complete, including commissioning systems, the two outside barges would be released and the foundation launched from the middle barge, which is a submersible barge, while the launching barge is still secured to the existing dock (the water depths at the pier face are approximately 60 feet at low water).

The completed, floating foundation would be towed approximately 120 nm ((220 km)to the dredged area west of Sears Island where the turbine components would be installed as described in Section 2.2.3.3.

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[4] The Eastport facility has historically been used for the export of pulp products. For various reasons, the throughput at the facility is a fraction of the peak throughput. The Eastport Assembly and Launch Area provides an opportunity to perform the assembly on up to three barges that are secured to an existing high-capacity pier. Furthermore, due to significant water depths along the seaward edge of the existing pier, the launching operation would occur without relocating the launching barge to an offshore launching site, such as the Turbine Launch Area (**Figure 2.2-20**) being utilized under Options 1 and 2.

Figure 2.2-22 Eastport Assembly and Launch Area

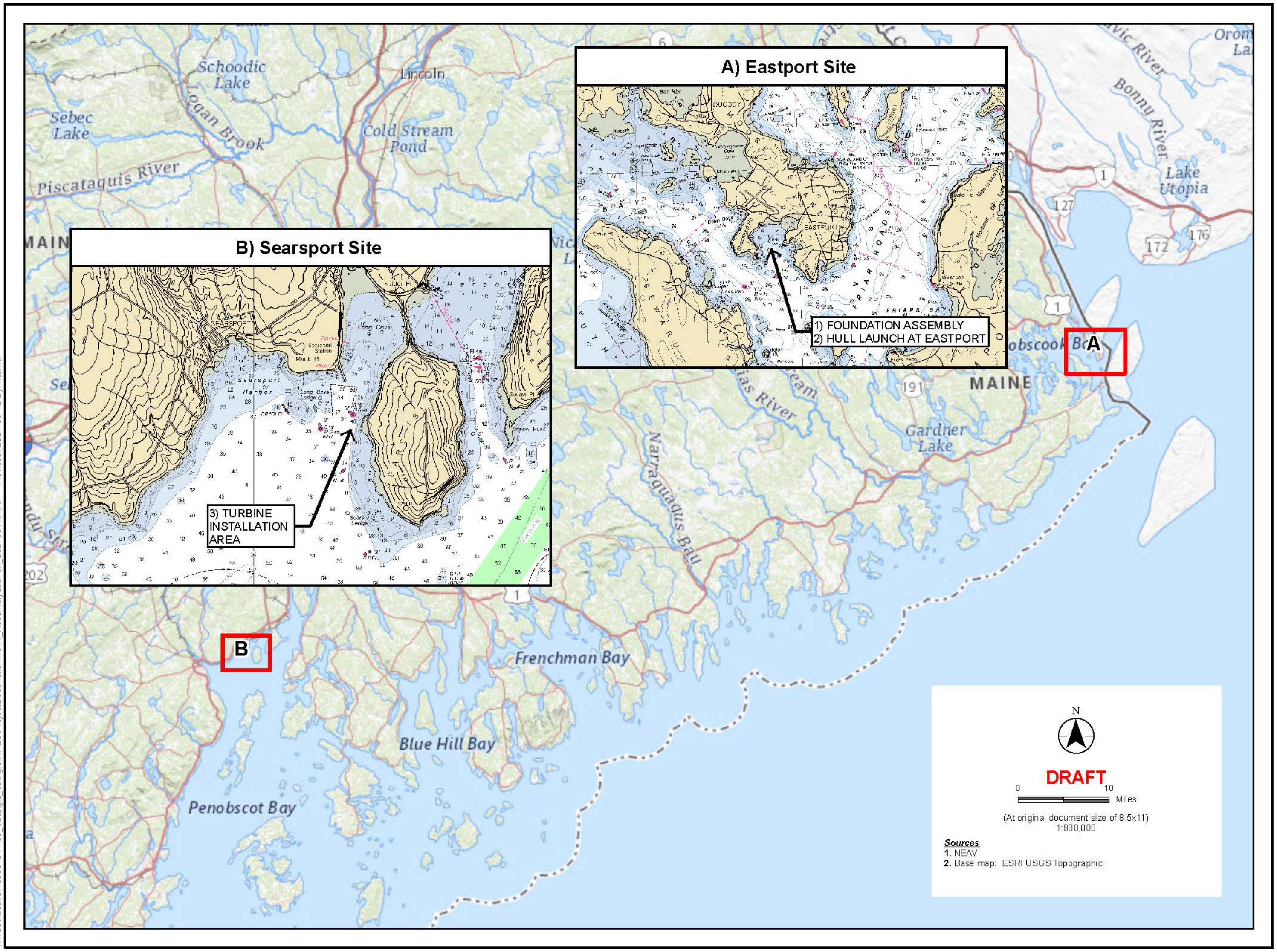


Figure 2.2-23 Floating Foundation Assembly, Turbine Installation, and Foundation Launch Locations (Option 3)

2.2.3.2 Mooring and Anchor Installation

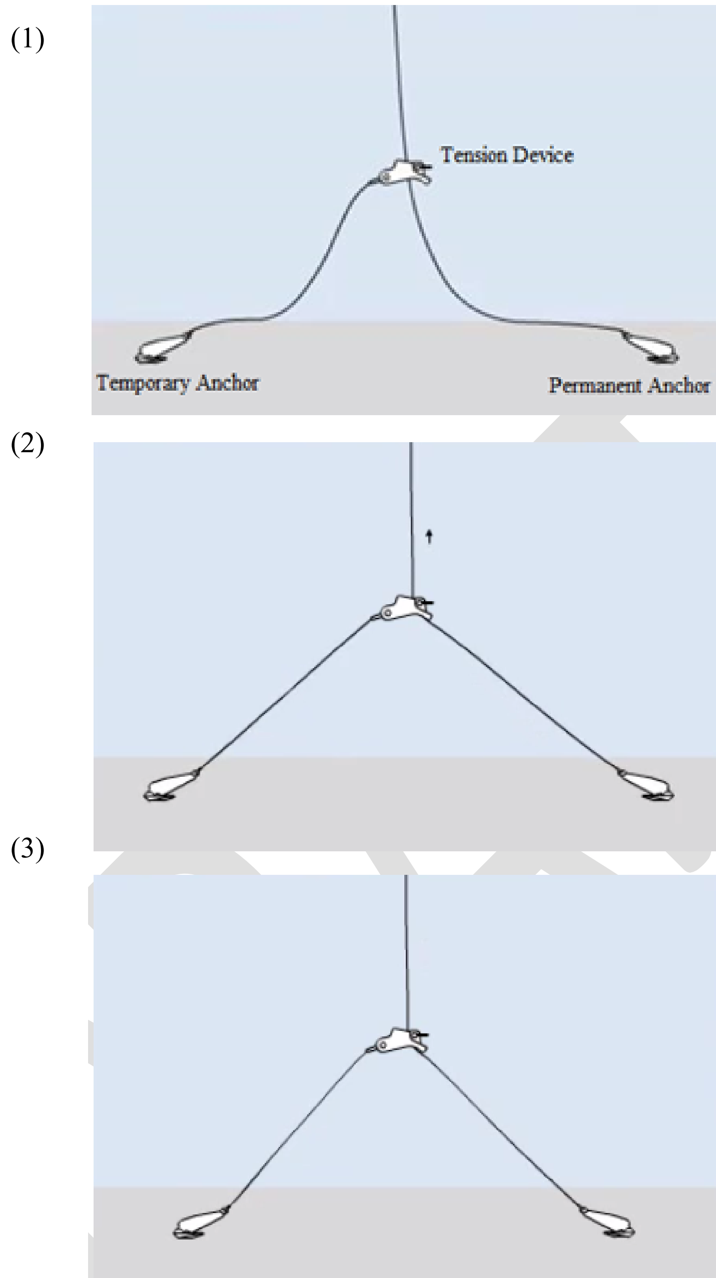
Anchors would be installed at the Proposed Turbine Location prior to deployment of the WTG. Four types of anchors are being considered, depending on seabed conditions, as described in Section 2.2.2.3.

Drag embedment anchors, which penetrate the seabed and are held in place by soil resistance, would be used if there is enough seabed mud. A vertical load anchor, which is similar to a drag embedment anchor but allows for the carrying of significant vertical load, may be used if vertical load is required. If mud thickness is insufficient for a drag embedment anchor or a vertical load anchor, either a gravity anchor or a suction bucket anchor would be used.

The method for installing the drag embedment anchor is depicted and described on **Figure 2.2-24**. A temporary anchor and the drag embedment anchor would be placed on the seafloor. The anchor line from the temporary anchor would be attached to the drag embedment anchor line. The line then would be pulled up vertically by a crane to apply pressure to each of the anchor lines, making the anchors drag towards each other. As the drag embedment anchor is dragged laterally along the seafloor 30 – 70 ft (9 – 21 m), it would be entirely buried in the seabed at a penetration depth of approximately 30 – 50 ft (9 – 15 m). The temporary anchor would then be decoupled from the permanent drag embedment anchor and pulled by a tugboat in the opposite direction to remove it from the seafloor.

If vertical load anchors are selected, their installation would consist of one of three methods which are similar to the standard drag embedment anchor. The first method is a single line installation which consists of towing the anchor as it embeds into the seafloor. The second method is a variation of the first, requiring two lines instead of one. The third method is similar to that described for the drag embedment anchors. Gravity anchors, if used, would be placed directly on the seabed. Suction bucket anchors, if used, would be placed directly on the seabed, and a pump would be used to remove the air and water from within the anchor to penetrate the anchor in the seabed.

The mooring system installation would take place at or around the same time as the anchor installation. Regardless of which mooring option would be selected (as described in Section 2.2.2.3), the anchors would either be installed with associated mooring lines or the mooring lines would be connected to the anchor after anchor installation. In the case where the mooring would be installed after the anchor, this process can be completed with an ROV. The moorings would be tied off to floatation buoys for storage and retrieved for connection when the foundation is towed to site. The mooring lines will be tensioned to their appropriate pretension values using inline tensioners and then inspected using a remotely operated vehicle (ROV). An ROV also could be used to monitor the mooring connection process, as needed.



(1) Two anchors are placed opposite of each other. A vertical chain is run from a vessel above to the anchor. A tensioning device is installed on the chain underwater. Another passive chain is attached to a temporary anchor.
(2) The vessel lifts up using a winch or crane and applies tension to the anchors.
(3) The tension applied to the anchor forces the anchors to move inward and sink deeper into the seabed. The temporary anchor is then decoupled from the permanent anchor and pulled by a tug vessel in the opposite direction to remove it from the seafloor.

Figure 2.2-24 Drag Embedment Anchor Placement

2.2.3.3 Assembly of Turbine at Temporary Turbine Installation on Foundation Area

Using three (3) tugboats, the fully assembled floating foundation would be moved to an area previously dredged by the Maine Dept of Transportation west of Sears Island, ME and east of an existing federal channel (Turbine Installation on Foundation Area). Foundation pre-commissioning activities would be completed, and the floating foundation would be partially ballasted so that it rests on the seabed, in a previously dredged area, eliminating the need to temporarily anchor the floating foundation (**Figure 2.2-25**). Water depth at this location is approximately 40 ft (13 m). Ballasting of the floating foundation to the seabed is necessary to provide for stability during installation of the tower and turbine on the floating foundation. To reduce impacts to the seabed, a minimum amount of ballast would be used so that only a portion of the full weight of the foundation would rest on the bottom. It is anticipated that the floating foundation would be ballasted on the seabed in the previously dredged area for approximately four weeks.

The Turbine Installation on Foundation Area was previously dredged by the Maine Department of Transportation in the early 1990s and provides adequate water depth, a flat dredged bottom, and space to deploy the heavy lift jack-up vessel (HLV) without blocking the federal channel. As such, the floating foundation would be relocated from the Mack Point Foundation Assembly Area[5] or Eastport Assembly and Launch Area to the Turbine Installation on Foundation Area using a minimum of two tugboats. Once on location, the floating foundation would be ballasted to temporarily bear on the harbor bottom. In order to protect the hull from damage, some rocks that protrude above the previously dredged bottom may need to be relocated or removable articulated concrete matrasses may need to be temporarily placed on the previously dredged bottom. The WTG components consisting of up to four tower sections, nacelle, and three blades, would be loaded on the HLV in Europe and shipped to Searsport, ME. Upon arrival at Searsport, the HLV would be located adjacent to the foundation and prepared to lift and install the WTG components. The HLV legs penetrate the seafloor during jacking operations. The HLV would be used to install the WTG onto the foundation; vessel specifications are listed in **Table 2.2-4** and an example provided as **Figure 2.2-26**.

Once in place, the first section of the tower would be installed, securing the tower to the hull foundation. This would be followed by the installation of the remaining segments that comprise the tower. Once the tower is in place, the nacelle would be raised and secured to the top of the tower. Once the nacelle is secure, the three blades would be installed, completing the mechanical installation of the turbine on the floating hull. Turbine installation would be managed and performed by the turbine supplier, and the HLV crew would be responsible for vessel and crane operations. It is anticipated that the HLV would be in Searsport for less than ten days and would not require support from shore. Upon completion of turbine installation, the HLV would return to Europe.

[5] Space at Mack Point is insufficient for deployment of the heavy lift jack-up vessel (HLV) without blocking the federal navigation channel.

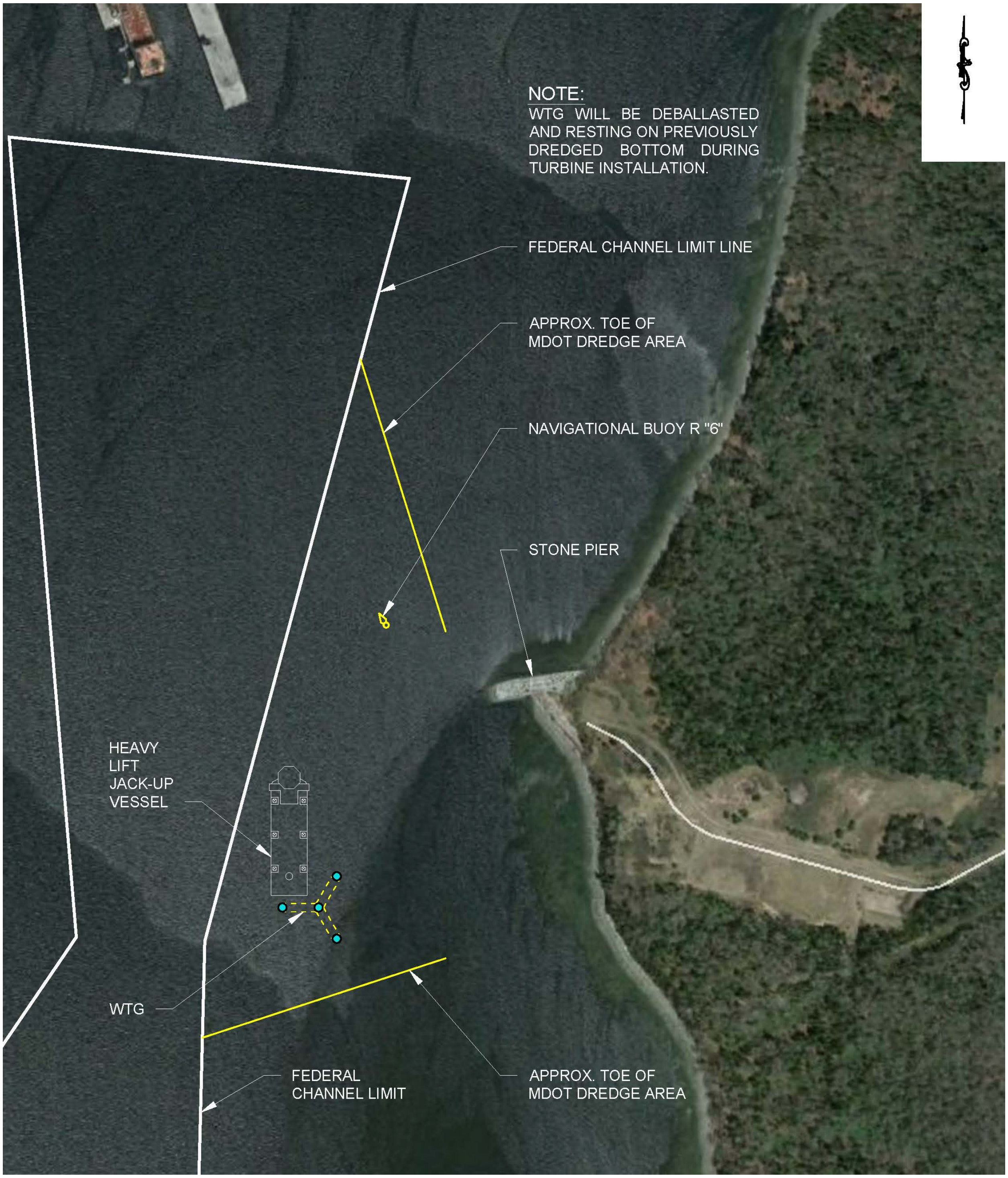


Figure 2.2-25 Turbine Installation on Foundation Area – Site Plan

Table 2.2-4 HLV Specifications

HLV Component/System	Typical Specification
HLV footprint (including spuds on seabed)	4 to 6 spuds/support legs - seabed footprint of barge dimensions range from 4,710 to 5,368 square feet (ft^2; 438 m^2 to 500 m^2)
Height of Crane	TBD
HLV overall length	246 ft (130 m)
HLV lifting speed	0.50 m/minute
Maximum operating conditions	105 ft (32.25 m) operating depth 45 mph (20 m/s) wind speed 30 to 60 days duration (dependent upon speed and crew size)[1]
Dynamic positioning	Kongsberg dynamic positioning system (used when approaching ballasted WTG and when leaving site)

[1] Duration on site is not likely to be more than 10 days for the Proposed Project.

Source: S. White – Deepwater Block Island

Figure 2.2-26 Example of Turbine Installation Using Heavy Lift Jack-up Vessel (HLV)

Initial testing and pre-commissioning of the installed WTG would take place prior to deployment at the Proposed Turbine Location. The WTG supplier would require 10 to 15 days (daylight work hours only) to complete the pre-commissioning of the turbine. When pre-commissioning is completed, the floating foundation would be de-ballasted and raised. Once mechanical installation of the turbine blades is completed and the hull is de-ballasted and raised, the lower tip of the turbine blade would be approximately 84 ft (25.5 m) above sea level. The fully assembled foundation and WTG would then be towed by tug to the Proposed Turbine Location. It is anticipated that towing the 86 nm (160 km) distance to the final location would take approximately 24 hours to complete. Once at the Proposed Turbine Location, the pre-installed mooring lines would be fastened to the hull.

2.2.3.4 Subsea Cable Installation

The subsea cable would be laid along the Subsea Cable Route prior to the floating foundation being towed to the Proposed Turbine Location. The subsea cable installation contractor would use a cable laying barge or a cable laying vessel to install the offshore cable (**Figure 2.2-27**). The installation vessel would maintain its position through Global Positioning System-controlled dynamic positioning system on the cable laying vessel. The installation vessel would operate continuously (i.e., 24 hours per day, seven days per week) until the work is completed to minimize the duration of installation. Installation of the subsea cable is not expected to take more than five [5] weeks. Typical cable laying barges and vessels are approximately 200 ft (61 m) long and 65 ft (19.8 m) wide.

Source: Nippon Salvage (Left), ZTT (Right)

Figure 2.2-27 Example of Cable Laying Barge (Left) and Cable Laying Vessel (Right)

First, the subsea (static) cable would be spliced to the dynamic subsea cable that will connect to the WTG. The cable splice would be then be lowered to the seabed. Weights would be used to keep the seabed cable splice in place on the seabed. If the WTG is not yet at the Turbine Area, the dynamic cable would be connected to a temporary buoy until the WTG arrives on site, at which time, it would be retrieved and connected to the WTG. The vessel would then begin the process of laying the subsea cable. The connecting cables would be lowered to the seabed from the barge- or vessel-mounted crane. Deployment of the subsea cable on the seabed would be monitored by an Echoscope 3D Sonar or a remotely operated vehicle (ROV).

Prior to subsea cable installation, a geological and geophysical study would be performed to identify installation methodologies and associated cable protection alternatives along the routeWhere burial is possible, the subsea cable would be buried up to 6 ft (1.8 m) using jet plow technology where the seabed sediment type is appropriate (i.e., mud/sand) (**Figure 2.2-28**). These devices blow high pressure water through a series of jet nozzles placed along one or two pair of jets. This creates a temporary trench with liquified soil where the subsea cable is placed and subsequently covered. As the subsea cable drops into the trench the liquified soil falls back in and covers the cable. After the subsea cable is buried there would be a shallow trench several feet across, and depth would be dependent upon the existing soil characteristics. A jet plow can typically operate in water depths ranging from 50 – 1,600 ft (15 – 490 m).

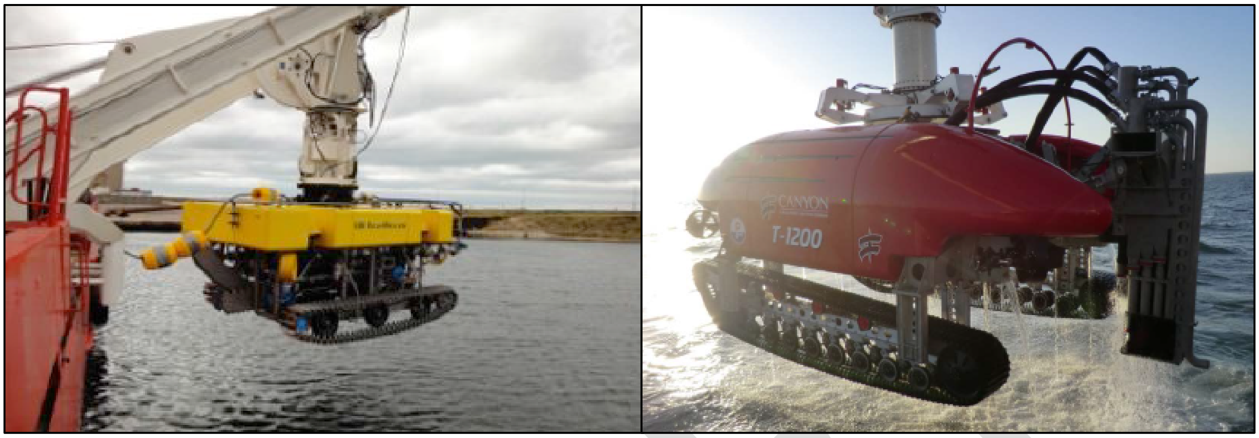


Figure 2.2-28 Examples of Jet Plows

In areas where the subsea cable cannot be buried, the cable would be placed on the seabed and protected by one or a combination of the following methods: concrete mattresses, concrete filled filter bags, rocks (rock dumping), or split-casting shells. Schematics of both a subsea buried and rock covered cable are provided in **Figure 2.2-29**. Installation of the subsea cable could be performed from the Cable Landing Area to the Turbine Area or vice-versa; in either case, the methodology would remain the same.

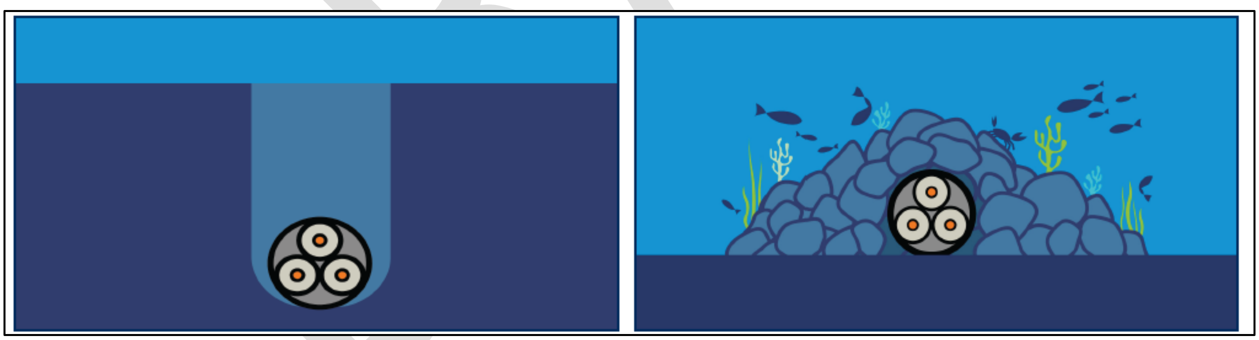


Figure 2.2-29 Cross-section Schematic of Subsea Cable Burial Under the Seabed (Left) and on the Seabed, Covered by Rock (Right)

2.2.3.5 Cable Landing

It has been determined though site investigations that the Proposed Project would use a "cut and cover" method to perform the shore crossing in East Boothbay. The basic "cut and cover" concept involves the digging of a trench, the construction of a tunnel, and then returning the surface to its original state. The shore crossing activities would be coordinated with the subsea export cable installation to minimize the scheduled activities associate with the shore crossing. The cable installation would involve the following steps:

1. A concrete splice box would be installed (top of box at ground level) at the foot of School Street;
2. A silt curtain, employed to restrict off-site migration of disturbed soil to the greatest extent, would be deployed from the shoreline out into the river to encompass where the cut and cover activities would occur;
3. A cut through the existing riprap shoreline would be made and a trench excavated back to the installed splice box (excavated material to be disposed at an approved location);
4. As the tide drops, intertidal area on the beach will be excavated and a trench would be cut in the beach allowing a traditional trench box to be deployed extending out to the low water mark;
5. The excavated material would be transported to shore and disposed at an approved disposal location;
6. The subsea export cable would be floated into shore, placed into the trench boxes, pulled into the splice box using an onshore winch, and terminated in the splice box;
7. Clean gravel would be placed over the subsea cable for a 24-inch (0.6 m) cover;
8. Clean sand and gravel mix would be used to complete the backfill operation so that the elevation of the beach after cable installation is the same as the pre-installation beach;
9. The trench boxes would be removed;
10. The existing riprap shoreline would be re-installed and filter fabric placed on the shore side of the riprap;
11. Compacted clean backfill would be placed between the shoreline and the splice box;
12. The silt curtain would be removed; and
13. Burial of the subsea cable would be performed by the cable installer using approved methods;

2.2.3.6 Onshore Transmission

The final installation method for the onshore transmission cable would be determined based on field conditions. The objective is to maximize the use of existing road allowances from the Cable Landing Area to the Interconnection Substation, thereby minimizing/eliminating wetland impacts. Direct burial using an “open cut/fill” method and placement in a buried rigid conduit would be the primary construction method. In areas with shallow ledge (rock) substrate, the cable may be encased in a metallic or non-metallic raceway and covered with concrete. In the event that an overhead option is required to span a portion of the cable right-of-way, the Proposed Project would look to install longer utilities poles and transfer the existing service to the newer pole. The Onshore Cable Route would terminate at the existing CMP Interconnection Substation in Boothbay Harbor, ME, which would be upgraded to allow for this interconnection. The additional equipment required for this interconnection would be outlined in the interconnection agreement between the Proposed Project and CMP and could include additional disconnects, revenue meter, surge arrestor, and 34.5kV breakers. Prior to the interconnection with the Interconnection Substation, the Proposed Project would install additional equipment including a STATCOM, a step-down transformer and control building. This new equipment would be placed in proximity to the Interconnection Substation and would require site preparation to provide for a foundation for this equipment. No new right-of-way is anticipated for the Onshore Cable Route.

2.2.3.7 Step-down Transformer and STATCOM

Prior to the interconnection to the Interconnection Substation, the Proposed Project would involve construction, installation, and operation of a 66kV to 34.5kV step-down transformer and a STATCOM. The purpose of the step-down transformer would be to reduce the operating voltage of the onshore transmission cable at the point of interconnection to the operating voltage at the Interconnection Substation. The WTG would be operated at 66kV through the onshore transmission cable to the step-down transformer. At this point, the voltage would be reduced to 34.5kV. This operating profile would minimize the line losses incurred by the Proposed Project and maximize the power injected into the local distribution system.

2.2.4 Operation and Maintenance

As the Proposed Project is a demonstration project, monitoring equipment would be mounted on the WTG and foundation to collect data on motion and structural performance of the floating foundation under combined wind, wave, and environmental conditions. The Proposed Project would have an obligation to conduct 5 years of post-*commercial operation date* hull monitoring. The Proposed Project would operate for twenty (20) years, with a Commence Operation Date in the fourth quarter of 2023. UMaine would maintain the scientific instruments including accelerometers, load cells, wind sensors, wave sensors, and turbine performance sensors for a minimum period of five years as required under DOE grant funding. These measurements would be used to evaluate the performance of the foundation technology and the WTG in a variety of conditions and to improve the foundation technology for future. Environmental monitoring also would occur, including monitoring of bats and birds, marine life, and noise within the Turbine Area and in the surrounding region. The duration and type of environmental monitoring would be determined in consultation with resource agencies.

Operation of the turbine would require continuous remote, shore-based monitoring and control, scheduled onsite maintenance and inspection, and unscheduled responses for repair, faults, or equipment/structural damage. The monitoring schedule would be developed as part of an operations and maintenance (O&M) plan. Typical O&M activities are expected to include the following:

- Floating foundation: maintenance of mechanical equipment (e.g., pumps, piping, crane, etc.) and electrical equipment (e.g., lighting, cabinets, transformer), as required, annual inspection of above-water structure, five-year inspection cycle of underwater structure, and annual re-certification;

- Moorings and dynamic cables: cleaning of chain mooring lines and dynamic cables using diver or ROV “hand-held” high-pressure water jet every five (5) years and annual visual inspection by diver or ROV;

- Turbine: implementation of maintenance activities specified in the turbine supplier warranty and O&M plan, as applicable; and

- Balance of plant including all project components except the WTG and floating foundation (i.e., from the dynamic cables to the CMP interconnection): inspection every five years and performance of repairs if fault is found within this interval.

Regular O&M activities would be conducted by trained staff brought to the Turbine Area by a crew transfer vessel measuring approximately 59 ft (18 m) in length. Routine maintenance for the WTG would occur on site, and depending on the required maintenance, additional typical offshore support vessels may be required. Heavy maintenance (i.e., replacement, if required, of a large internal component) would be conducted based on the original equipment manufacturer's recommendations. For major repairs (i.e., changing blades or nacelle), where a large crane is required, the WTG would be towed to shore. This would require the hull to be disconnected from the mooring system, the dynamic cable disconnected from the static cable, and the WTG to be towed back to Searsport, ME. Once maintenance has been completed, the floating hull would be towed back into position and reconnected to both the mooring system and the dynamic cable, allowing for production to resume.

The Project proponent is evaluating two locations for the O&M center that would support the Proposed Project. The first is the Darling Marine Center located in Walpole, ME, on the Damariscotta River, approximately 21 miles (34 km) from the Proposed Turbine Location (**Figure 2.2-30**). The Darling Marine Center is owned and operated by UMaine. The second location is on private property located within East Boothbay, ME (**Figure 2.2-31**). At either location, the O&M center would utilize existing facilities and would include an O&M building with car park. The O&M building would be used for remote monitoring and analysis, storage and repair of small (< 50 pounds [lbs; 22.7 kg]) and medium parts (50 - 3,500 lbs [22.7 – 1,588 kg]), and O&M team meetings. Both locations would have sufficient dockage and crane capacity, to load components up to two tons (1,814 kg) onto support vessels.

Figure 2.2-30 Proposed O&M Base at UMaine's Darling Marine Center

Figure 2.2-31 Proposed O&M Base at East Boothbay, Boothbay, Maine

2.2.5 Decommissioning

A Project Decommissioning Plan would be developed as part of the State and federal permit applications as required under 38 MRSA Sec. 480-HH. The WTG and associated moorings would be removed using similar equipment and vessels as used in the installation process. If drag embedment or vertical load anchors are used, they would be removed by pulling the anchors in the opposite direction to free them from the seabed. The anchors would then be raised to the surface, likely with an anchor handling tugboat. If gravity anchors are used, they would be removed, also likely with an anchor handling tugboat. If suction bucket anchors are used, they would be removed by pumping water back into the suction bucket to release the trapped soil contained within the bucket and to allow the bucket to slip free of the bottom. The current proposal is to deactivate the cable after the life of the project but leave it in place. The final disposition of the cable will be subject to state and federal permitting however The STATCOM and grounding transformer would be removed, the onshore distribution line would be abandoned in place or removed if required by Maine State regulations, and other Proposed Project components would be reused or disposed of in compliance with applicable requirements.