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Mr. James Bennett
Director, Office of Renewable Energy Programs
Bureau of Ocean Energy Management
U. S. Department of the Interior
45600 Woodland Road
Sterling, VA 20166

May 21, 2018

Subject: Amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Research Activities Plan (RAP) and Response to Comments

Dear Mr. Bennett:

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion, formerly d/b/a Dominion Virginia Power) on behalf of the Virginia Department of Mines, Minerals, and Energy (DMME), is pleased to submit this amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Research Activities Plan (RAP). The Final VOWTAP RAP was submitted to the Bureau of Ocean Energy Management (BOEM) on April 21, 2015, and subsequently received approval from BOEM on March 23, 2016. As discussed during our meeting on September 7, 2017, Ørsted has been retained as the Engineering, Procurement and Construction (EPC) contractor for the Project. Due to advances in technology since the Project's approval in March 2016, several modifications to the RAP are required to support the Project's current requirements for construction and operation.

In accordance with 30 CFR 585.634(c), Dominion has prepared this letter to request BOEM's approval of the proposed modifications to the approved RAP in order to support a Project in service date of 2020. Detailed descriptions of the proposed modifications are provided in the following sections and a summary of the environmental effects and associated mitigation measures are provided in Attachment 1.

The proposed modifications described herein include the following:

- Site Assessment Activities
- Certified Verification Agent Scope of Work
- Permits, Approvals, and Consultations
- Wind Turbine Generator Specifications
- Turbine Foundation
- Turbine Foundation Installation Strategy
- Export Cable Installation Methods
    - Communications Cable Crossings

- Onshore Interconnection Cable Route
- Offshore Deployment and Construction
- Underwater Acoustic Modelling
- Air Emissions Calculations
- Vessel in Distress
- Construction Schedule

Dominion originally submitted this RAP amendment on December 27, 2017. BOEM provided comments on the RAP amendment on February 16, 2018, which were further discussed during a conference call on March 29, 2018. In response to BOEM's comments, Dominion has provided the comment response matrix as Attachment 2 to this revised amendment. Additionally, amendments to the Marine Archaeological Resources Assessment and the Visual Impact Assessment, a revised Terrestrial Archaeology Survey Report and an amendment to Historic Properties Assessment have been provided as Attachments 3, 5, 10 and 11, respectively, to this revised amendment.

To support BOEM's evaluation of the CVOW modifications, Dominion has enclosed the following materials to amend the contents of the approved RAP:

- Attachment 1 – Summary of Environmental Effects and Proposed Mitigation Measures
- Attachment 2 –RAP Amendment Comment Response Matrix
- Attachment 3 – Amendment to Marine Archaeological Resources Assessment (CONFIDENTIAL – Provided Under Separate Cover)
- Attachment 4 – Permits, Approvals, and Consultations
- Attachment 5 – Amendment to Visual Impact Assessment
- Attachment 6 – Revised Foundation Typical Drawing (CONFIDENTIAL – Provided Under Separate Cover)
- Attachment 7 – Revised Drivability Assessment (CONFIDENTIAL – Provided Under Separate Cover)
- Attachment 8 – Revised Underwater Acoustic Modelling
- Attachment 9 – Representative HDD Drilling Fluid Material Safety Data Sheet
- Attachment 10 – Revised Terrestrial Archaeology Survey Report (CONFIDENTIAL – Provided Under Separate Cover)
- Attachment 11 – Amendment to Historic Properties Assessment
- Attachment 12 – Air Emissions Supplement and Revised Air Emissions Calculations and Methodology Report
- Attachment 13 – Vessels in Distress Requirement Waiver Request

As demonstrated throughout this letter, the proposed modifications will have minor to negligible effects on the environmental assessments previously reviewed and approved by BOEM (Attachment 1). In addition, except as described in this update, the mitigation measures previously established in the RAP Approval remain appropriate and will be fully implemented.

The following sections provide additional detail regarding the amendments to the RAP, and the associated environmental effects and proposed mitigation measures associated with those amendments.

OVERVIEW OF PROJECT PURPOSE AND NEED

Despite the proposed Project modifications, the purpose and intent of the Project remains unchanged. The CVOW remains a research project. As described in the RAP, the five key research objectives of this Project and a summary of Dominion's current approach to achieving the objectives based on the proposed Project modifications are provided below.

Technical Innovation and Validation

- First turbines to be installed in U.S. Federal waters.
- First monopile foundation with 6MW turbines to be installed in the U.S.
- Supervisory control system will monitor turbine operation in real time.
- Power Boost technology will enable power output above nameplate capacity under certain circumstances.
- Hurricane resilient design.

Cost Reduction

- Provide a necessary step towards future commercial-scale offshore development by utilizing latest technologies to reduce Capital Expenditure (CAPEX) and Operations and Maintenance (O&M) costs.

Removal of Market Barriers

- Provide a platform for removing first-of-a-kind risks that constitute barriers to the U.S. offshore wind industry, including:
  - Navigating permitting process;
  - Installing turbines that are new to the U.S. offshore wind market; and,
  - Providing a better understanding of U.S. supply chain requirements.

Identify Potential Improvements to Permitting Process

- Build on experience gained from the permitting process by:
  - Working with BOEM to gain approval of the RAP amendment in a timely manner;
  - Being the first project to test the post RAP/COP approval permitting process.

Progressing Environmental Research and Understanding

- Allow research on wind turbine wake effect by locating the turbines in close proximity to each other; and
- Provide valuable data to enhance the understanding of the environmental effects of future offshore wind development in the U.S.

DESCRIPTION OF THE PROPOSED CVOW MODIFICATIONS

Site Assessment Activities (RAP Section 1.1)

Dominion no longer intends to install the three metocean instrumentation platforms in the Research Lease Area as detailed in the Site Assessment Plan (SAP) submitted to BOEM in December 2014. However, a small wave and current buoy will be deployed approximately 2 months prior to construction. The buoy will be temporarily deployed within the area that has been previously surveyed and evaluated in support of the Project. The buoy will remain in place for less than 1 year. The purpose of the buoy will be to monitor real time weather conditions in the project area prior to and during construction.

Depending on the selected buoy type, its diameter will be 1.6 to 4.9 ft (0.5 to 1.5 m). The buoy will have an impact resistant stainless-steel hull and be equipped with solar panels on its upper half, which may also include a transmission antenna and a navigational flashing light. The wave buoy will be powered either by lead acid or lithium batteries charged through the solar panels. The buoy will not require a backup generator and will not contain any oils, fuels, or lubricants.

The buoy mooring system will consist of an anchor weight (e.g., 1,763 lb [800kg]) and a mooring line designed as a combination of ropes and chains, which may also include floats. Based on a standard mooring configuration at a water depth of approximately 83.6 ft (25.5 m MLLW), the mooring scope will have a radius of 180 ft (55 m). A buoy with positive buoyancy will be placed a couple of meters from the clump weight to prevent entanglement and to eliminate any sweeping of the seabed. The anchor footprint on the seabed is approximately 10.7 (ft^2) (1 m^2) and the expected vertical penetration of the anchor weight into the seabed is less than -6.5 ft (-2 m). Please see the Amendment to the Marine Archaeological Resources Assessment, provided as Attachment 3 to this amendment, for the Qualified Marine Archaeologist's (QMA) assessment of site assessment activities.

The extent of the Project area is small, and therefore, one wave buoy will be sufficient to record the conditions at both turbine locations. The deployment location proposed is approximately 1,640 ft (500 m) to the east of the two turbine locations, which would provide sufficient clearance for the installation operations to occur (Table 1). The deployment will take place with an audited and certified vessel, fitted with a crane to safely deploy (and collect) the wave buoy. The wave buoy will be deployed and commissioned by one of Ørsted's suppliers. A dynamically positioned vessel will complete the buoy deployment and decommissioning so no additional seafloor disturbance is anticipated. After completion of the WTG installation, the wave buoy will be decommissioned.

Table 1. Wave and current buoy specifications.

Longitude1	Latitude1	Northing (Y)2	Easting (X)2	Depth (MLLW)	Mooring Scope Radius	Seabed Footprint	Seabed Impact
-75.485765	36.891659	4082963.205	456717.2748	-83.6 ft (-25,48 m)	180 ft (55 m)	10.7 ft^2 (1 m^2)	-6.5 ft (-2 m)

[1]Geographic coordinates are referenced to WGS 84 (decimal degrees)

[2]Coordinates are referenced to NAD 83 (2011) UTM Zone 18N (meters)

Permits, Approvals, and Consultations (RAP Section 1.3.1)

Prior to submittal of this RAP Amendment, Dominion had received and completed all non-time-sensitive permits and approvals required for construction of the CVOW Project (Attachment 4). The project modifications described in this Amendment will not require any permits, approvals or consultations in addition to those listed in Table 1.3.1 of the approved RAP. In addition, the filing strategies and timeframes for the outstanding time-sensitive permits have not changed. However, due to the updated schedule and possible minor effects of the proposed Project modifications on the environmental assessments previously reviewed and approved by BOEM, several of the permits will need to be updated or reassessed. Please see Attachment 4 for a complete list of permits, approvals and consultations, as well as their current status and anticipated next steps and timeframes.

Certified Verification Agent Scope of Work (RAP Section 1.6 and Appendix B)

As part of the RAP approval, DNV-GL was previously accepted as the Certified Verification Agent (CVA) for VOWTAP. Dominion will continue to use DNV-GL as the CVA for this Project, however, due to proposed Project modifications, there have been some revisions to the CVA Scope of Work (SOW). The revised CVA SOW and a response matrix addressing BOEM's comments on the CVA SOW were provided to BOEM under separate cover on March 15, 2018.

Wind Turbine Generator Specifications (RAP Section 3.2.1)

Dominion still intends to deploy two, 6 megawatt (MW) wind turbine generators (WTGs) for the CVOW Project. However, in order to ensure that the best available technology is being utilized for the Project and potentially leverage established market relationships and prior installation experience, Dominion is currently assessing a range of WTG suppliers beyond what was approved in the RAP. As a result, there are some minor changes to the WTG specifications (see Revised Table 3.2-1).

Each of the WTGs will be comprised of a tower, nacelle, rotor, and blades, and will be supported by a monopile foundation (see the following section on the proposed modifications to the WTG foundations). Similar to the Alstom Haliade 150 that was approved in the RAP, the selected WTG will remain a 3-bladed upwind WTG that operates at variable speeds. However, the new WTG will be equipped with Power Boost technology, which is a software enhancement that will enable the WTGs to generate up to 6.3 MW of electricity under certain operational conditions. Power Boost functionality will be governed by certain operational limits such as ambient temperature, internal components temperatures, pitch angles, and wind turbulence level. Figure 1 shows the originally proposed Alstom Haliade 150 WTG as presented in Figure 3.2-1 of the RAP, and Figure 2 shows the revised conceptual rendering of the currently proposed WTGs.

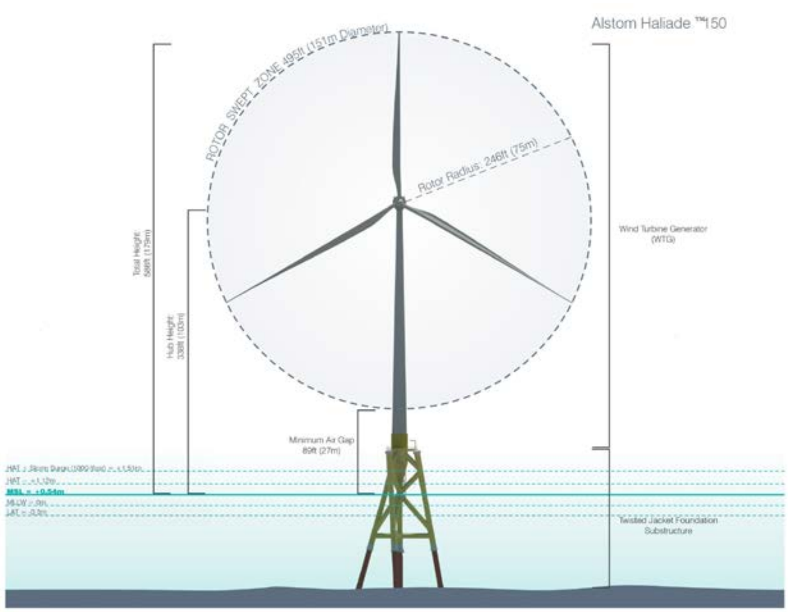


Figure 1. Alstom Haliade 150 WTG as presented in Figure 3.2-1 of the RAP

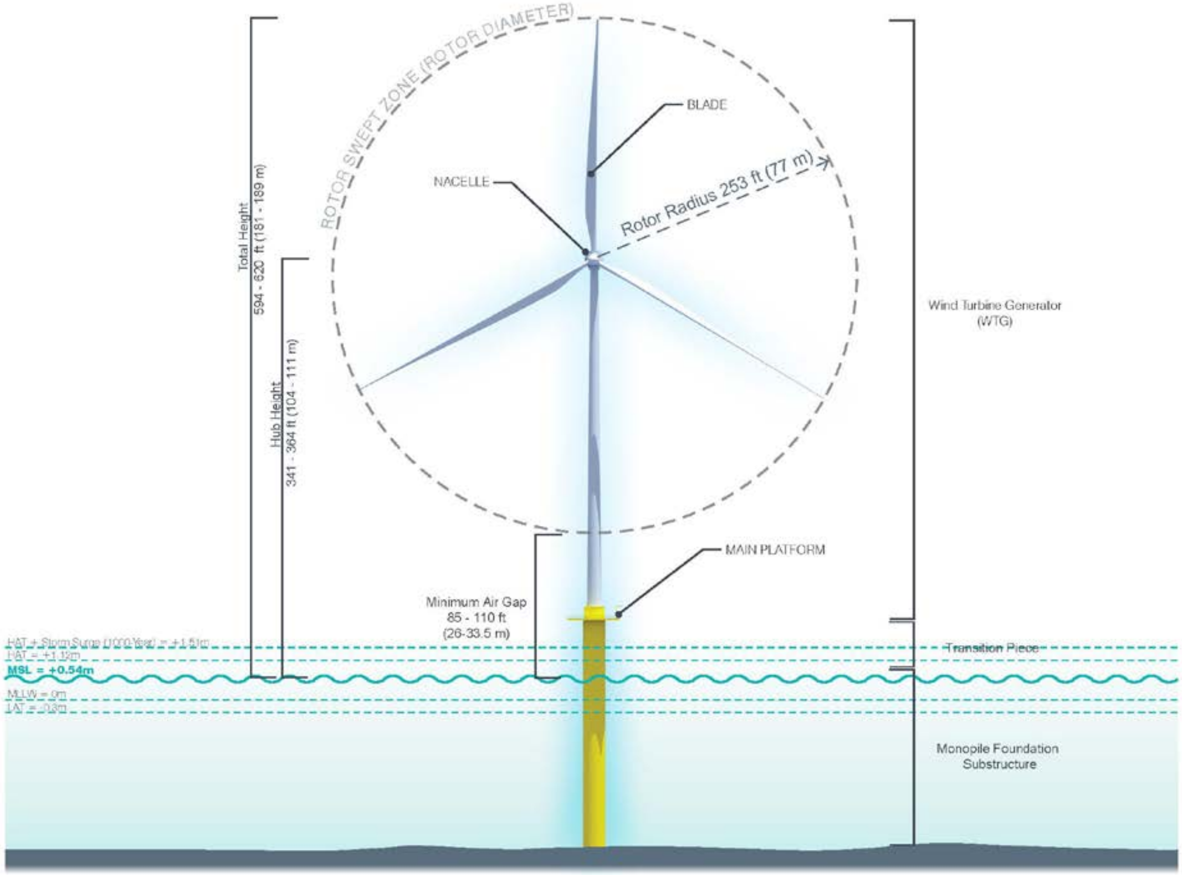


Figure 2. Revised Conceptual Rendering of the Currently Proposed WTG

The following table illustrates the changes to the WTG specifications originally presented in Table 3.2-1 of the approved RAP.

Revised Table 3.2-1. Wind Turbine Generator Specifications

Specification	Alstom Haliade 150 6 MW WTG Specifications	New WTG Specifications	Change
Individual turbine power output rating	6 MW	6 MW	N/A
VOWTAP nameplate electric generating capacity	12 MW	12 MW	N/A
Position of rotor relative to tower	Upwind	Upwind	N/A
Hub height (from mean sea level [MSL])	338 ft (103 m)	341-364 ft (104-111 m)	Increase of 3-26 ft (1-8m)
Turbine minimum height (from highest astronomical tide)	581 ft (177 m)	591-614 ft (180-187 m)	Increase of 10-33 ft (3-10 m)
Turbine height (from MSL)	584 ft (178 m)	591-617 ft (180-188 m)	Increase of 7-33 ft (2-10 m)
Turbine Maximum height (from mean lower low water [MLLW])	586 ft (179 m)	594-620 ft (181-189 m)	Increase of 8-34 ft (2-10 m)
Air gap (MSL to the bottom of the blade tip)	89 ft (27 m)	85-110 ft (26-33.5 m)	Decrease of 4 ft (1 m) - Increase of 21 ft (6.4 m)
Base height (tower height)	267 ft (81m)	269-282 ft (82-86 m)	Increase of 3-15 ft (1-5 m)
Base (tower) width (at the bottom)	20 ft (6 m)	20 ft (6 m)	N/A

Specification	Alstom Haliade 150 6 MW WTG Specifications	New WTG Specifications	Change
Base (tower) width (at the top)	13 ft (4 m)	13 ft (4 m)	N/A
Nacelle dimensions	25.3 x 64.3 x 27 ft (7.7 x 19.8 x 8.9 m)	29.8 x 65.3 x 29.8 ft (9.1 x 19.9 x 9.1 m)	Increase of 14,066 ft^3 (291 m^3)
Nacelle size	13.5 ft (4.1 m)	10.8 ft (3.3 m)	Decrease of 2.7 ft (0.8 m)
Blade length	241 ft (73.5 m)	246 ft (75 m)	Increase of 5 ft (1.5 m)
Blade width	10.5 ft +/- 0.11 in (3.2 m +/- 2.7 mm)	16.4 ft (5 m)	Increase of 5.9 ft (1.8 m)
Rotor diameter	495 ft (151 m)	505 ft (154 m)	Increase of 10 ft (3 m)
Rotor Speed	4 to 11.5 rpm	5 to 11 rpm	Increase of 1 rpm - Decrease of 0.5 rpm
Operational Cut-in Wind Speed/Cut-Out Wind Speed	6.7 mph (3 m/s) / 56 mph (25 m/s)	6.7 mph (3 m/s) / 56 mph (25 m/s)	N/A

As demonstrated in Revised Table 3.2.1 above, the change of WTG manufacturer results in a minor increase to the overall height and diameter of the WTGs. However, given the distance from shore and curvature of the earth, there will be no change to potential visual impacts associated with the increased WTG height (see Attachment 5 Amendment to the Visual Impact Assessment).

As with the Alstom Haliade 150, each of the new WTGs will contain oils, fuels, and lubricants to support the operation of the WTG's hydraulic system, generator, frequency converter, and transformer. The following table illustrates the changes in volume to the oils, fuels, and lubricants originally presented in Table 3.2-2 of the approved RAP. The spill containment strategy for each WTG is identical and will be comprised of preventive, detective and containment measures. These measures include 100 percent leakage free joints at the connectors and high pressure and oil level sensors that can detect both water and oil leakage. Secondary containment is also consistent with the Alstom Haliade 150 containment detailed in the approved RAP.

Revised Table 3.2-2. Summary of Oils, Fuels and Lubricants

WTG System	Alstom Haliade 150		New Turbine		Change
	Oil/Fuel Type	Oil/Fuel Capacity	Oil/Fuel Type	Oil/Fuel Capacity	
Hydraulic System	Hydraulic fluid, ISO Viscosity Grade DIN 51519	10.6 gal / 40 L	Hydraulic fluid	193 gal / 730 L	Increase of 182.4 gal / 690 L
Generator Cooling System	Water and Glycol	132 gal / 500 L	BASF Glysantin G30	127 gal / 480 L	Decrease of 5 gal / 20 L
Primary Transformer Cooling System	Class 3k synthetic ester liquid	528 gal / 2000 L	Transformer oil	581 gal / 2200 L	Increase of 53 gal / 200 L
Secondary Transformer Cooling System	Water and Glycol	53 gal / 200 L	N/A	N/A	N/A
Frequency Converter	Water and Glycol	53 gal / 200 L	BASF Glysantin G30	56 gal / 210 L	Increase of 3 gal / 10 L
Emergency Back-up Generator	Diesel fuel	1000 gal / 3785 L	N/A	N/A	N/A
Yaw Gear	N/A	N/A	Synthetic gear oil	2.2 gal / 8.5 L	N/A

As demonstrated in Revised Table 3.2-2 above, the changes in types and quantities of the oils, fuels and lubricants contained in the new WTGs, as compared to the Alstom Haliade 150 and the containment systems, are negligible and do not introduce additional impacts.

Except as described in this update, the proposed construction, operation, and decommissioning strategy of the proposed WTGs remains unchanged from what is described in the approved RAP.

Turbine Foundations (RAP Section 3.2.2)

Due to Ørsted's extensive experience and success with monopile foundations and the advantages of decreased installation time, each WTG will now be supported by a monopile and transition piece (MP/TP) foundation instead of the Inward Battered Guide Structure (IBGS or Twisted Jacket) foundation as described in the approved RAP. The MP/TP foundation consists of a monopile, which is the lowest part of the foundation, and a transition piece, which is mounted on the monopile once the monopile has been driven into the seabed. See Figure 3 for a comparison of the IBGS and MP/TP foundations.

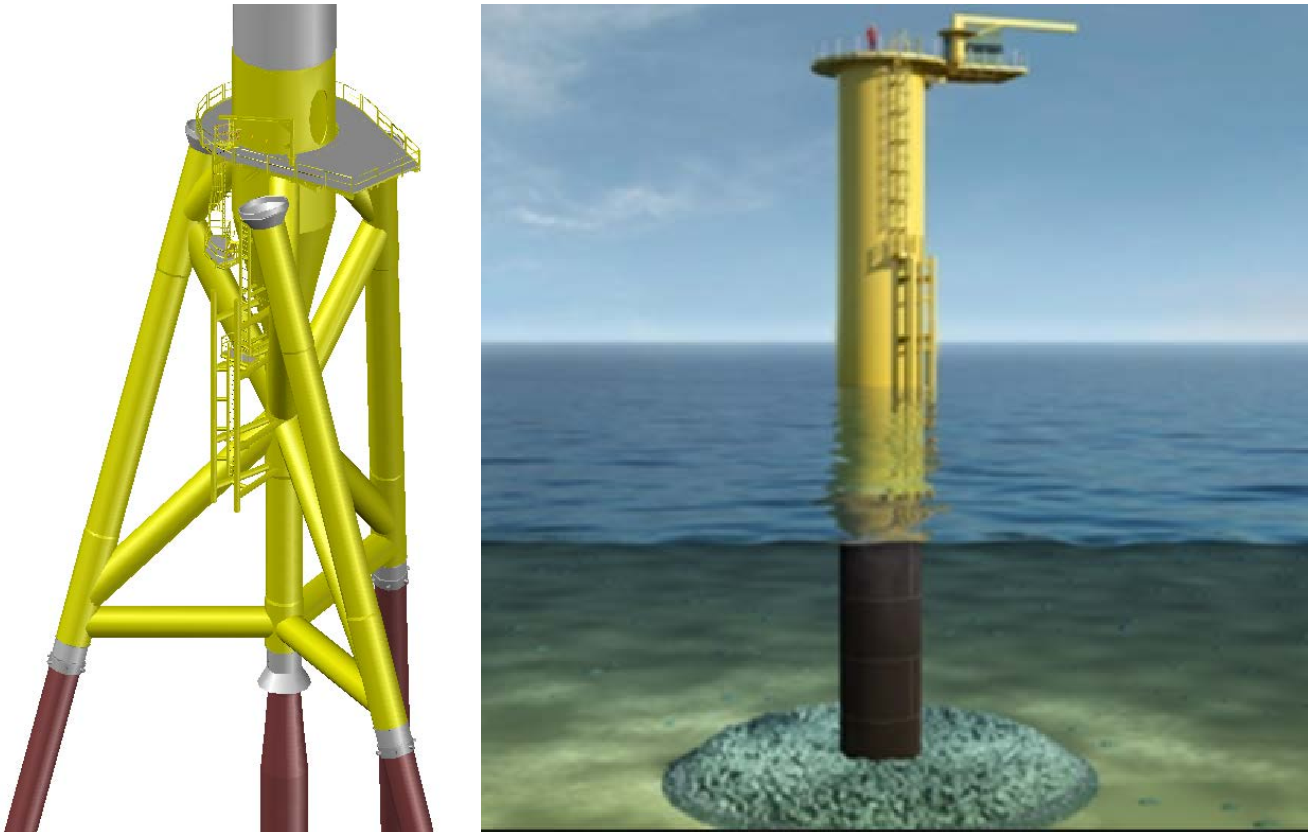


Figure 3. Comparison of IBGS (left) and MP/TP (right) Foundations

The monopile is primarily a cylindrical steel pile, with an upper conical section that shrinks the pile diameter to fit with the transition piece and WTG tower diameter. The monopile is connected to the transition piece by means of a bolted flange connection.

Main features of a Monopile (MP):

- Top Flange;
- Conical section in the middle or upper part – if necessary;
- Cable entry holes close to seabed;
- Internal corrosion protection by coating;
- External corrosion protection combining coating and anodes; and
- Individually designed for each foundation location.

Main features of the Transition Piece (TP):

- Flange in top (toward WTG tower) and bottom (towards MP);
- Suspended internal platforms;
- External platform;
- External ladder and boat landing;
- Skirt to support boat landing and external ladder;
- Sea fastening flange for upended transport of TP;
- Access door into TP from external platform; and
- Internal and external corrosion protection by coating

The diameter of the MP/TP foundation at the seabed is approximately 26.2 ft (8 m) for a total footprint of approximately 0.01 acre (0.005 ha). At sea level, the MP/TP foundation has a diameter of approximately 20.3 ft (6.2 m). Depending on the specific depth of installation, the length of the monopile will be between 164 ft to 197 ft (50 m to 60 m), and will weigh approximately 600 tons to 800 tons. The transition piece will weigh approximately 150 tons to 200 tons. Attachment 6 provides a plan and profile of the MP/TP foundation.

Turbine Foundation Installation Strategy (RAP Section 3.3.4.2)

Installation of the MP/TP foundations will be carried out by a Self-Propelled Jack-Up Vessel, in accordance with the foundation installation methodology established in the approved RAP. The MP/TP foundations will be transported to the Project site from a Canadian pre-assembly feeder port in either Halifax, Nova Scotia or Saint John, New Brunswick on the deck of the Self-Propelled Jack-Up Vessel.

Due to the larger diameter of the monopiles, as compared with the individual diameters of the central caisson and pin piles of the IBGS, there is an increased potential for scour, and as such, the MP/TP foundations will require scour protection. The scour protection system will consist of a preinstalled filter layer of crushed rock material deployed in a radius of approximately 72.2 ft (22 m) and a height of about 2.6 ft (0.8 m) at each foundation location (Figure 4). This layer will be deployed prior to installation of the MP/TP foundations. The second layer, also referred to as the “armor layer,” will be installed on top of the filter layer once the monopile is installed, and the Export and/or Inter-Array Cable(s) have been pulled through. The armor layer consists of crushed rock material weighing between 88.2 lb to 440.9 lb (40 kg and 200 kg), installed in a radius of approximately 39.4 ft (12 m) and a height of about 4.9 ft (1.5 m) around each foundation. Please see the Amendment to the Marine Archaeological Resources Assessment, provided as Attachment 3 to this amendment, for the QMA’s assessment of marine archaeological resources in relation to the foundation, scour protection, and installation.

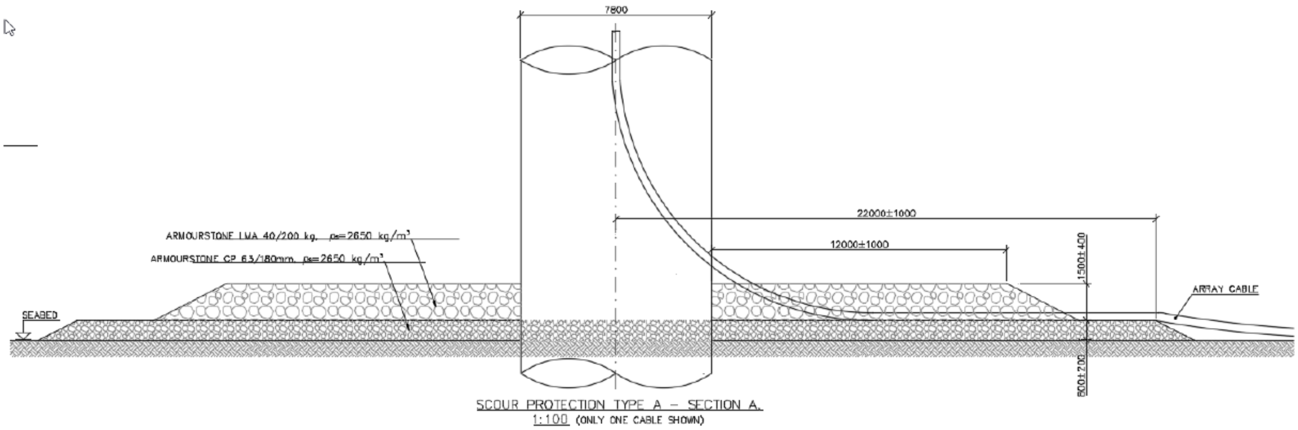


Figure 4. Generic section view of scour protection (for illustration)

After installation of the foundations, an initial local scour survey will be conducted within 6 months of commissioning. Subsequent surveys will be conducted at regular intervals after commissioning and after a major storm event. Monitoring will be carried out by multibeam sonar soundings. Should scour holes develop within 10 percent of the local scour design values, additional monitoring and/or mitigation will be performed. Mitigation measures may include the infilling of the scour hole with an appropriate crushed rock fill, or the use of frond mats or other proven systems to minimize/reverse future scour. The specific need, type, and method of additional scour protection will be determined in consultation and coordination with relevant jurisdictional agencies prior to deployment.

Similar to the installation sequence for the IBGS foundations approved in the RAP, the monopile will be upended and lifted to position in the pile gripper by the vessel crane. The initial penetration of the monopile, through the filter layer into the seafloor, will be achieved by the weight of the monopile. A hydraulic hammer will then be positioned and the monopile driven to the design penetration depth of 98 ft to 105 ft (30 m to 32 m) (see revised drivability assessment included as Attachment 7). The maximum expected hammer energy required for piling is 1,000 kJ, which is equivalent to the hammer energy approved in the RAP. A revised drivability assessment has been included as Attachment 7. Dominion will also be completing a revised pile capacity analysis. The revised pile capacity analysis and pile capacity charts will be provided with the FDR.

After the monopile is installed, the transition piece will be lifted from the deck of the Self-Propelled Jack-Up Vessel by the vessel crane and placed onto the monopile. After mounting, the transition piece will be fastened to the monopile by a bolted connection.

Total installation time for the foundation, including pile driving and transition piece installation, is expected to take between 2 to 4 days per foundation, whereas the pile driving duration alone is expected to take approximately 1 to 2 hours per foundation.

As approved in the RAP, pile driving activities will occur during daylight hours only, starting approximately 30 minutes after dawn and ending approximately 30 minutes prior to dusk, unless a situation arises where ceasing the pile driving activity would compromise safety (both human health and environmental) and/or the integrity of the Project.

The following table illustrates the changes to the construction and operation footprints for the turbine foundations from what was originally presented in Table 3.2-3 of the approved RAP.

Revised Table 3.2-3. Foundation and WTG Construction and Operation Footprint

Foundation and WTG [a/]	IBGS Foundation		MP/TP Foundation		Change	
	Construction	Operation	Construction	Operation	Construction	Operation
Foundation [b/]	0.2 ac / 0.1 ha	0.2 ac / 0.1 ha	0.76 ac / 0.30 ha	0.76 ac / 0.30 ha	Increase of 0.56 ac / 0.2 ha	Increase of 0.56 ac / 0.2 ha
Heavy Lift Vessel [c/]	0.8 ac / 0.3 ha	0	No Change	No Change	N/A	N/A
High Lift jack up Vessel [d/]	0.001 ac / 0.0004 ha	0	0.08 ac / 0.03 ha	No Change	Increase of 0.079 ac / 0.0296 ha	N/A
WTG Temporary Work Area [e/]	190 ac / 76.9 h	0	100.0 ac / 40.5 ha	No Change	Decrease of 90 ac / 36.4 ha	N/A
Foundation and WTG Total	191 ac / 77.3 ha	0.2 ac / 0.1 ha	101.64 ac / 41.13 ha	0.76 ac / 0.30 ha	Decrease of 89.4 ac / 36.18 ha	Increase of 0.56 ac / 0.2 ha

[a/] Notes are in reference to impacts approved in the RAP.
[b/] MP/TP foundation area immediately under foundation is based on the area of the monopile diameter at the diameter seabed 25.6 ft (7.8 m) and scour protection installed in a 72 ft (22 m) radius on the seafloor around the base of the foundation. Includes two foundation structures of 0.01 ac (0.005 ha)
[c/] Assumes a single set of an 8-point anchored vessel per WTG. Impact area includes anchors (0.006 ac [0.002 ha] per anchor) and anchor chain sweep (.09 ac [0.04 ha]) based on approximate 200 ft (61 m) of anchor chain resting on the bottom and a maximum of 20 ft (6.1 m) of lateral drag per chain.
[d/] Assume 1 jack up vessels per WTG position (approximately 0.02 ac [0.001 ha]). Impacts will all occur within the 50 ac (20 ha) WTG Temporary Work Area at each foundation location.
[e/] Includes the two WTG Work Areas (based on a safety radius of 500 m during construction work) of 50 ac (20 ha) each.

As demonstrated in Revised Table 3.2-3 above, the change of foundation type and the addition of scour protection results in an overall increase of 0.56 ac (0.2 ha) to the operational footprint of the WTGs, and a reduction of 90.1 ac (36.47 ha) in the size of the temporary work area. In addition, as demonstrated in the above paragraphs and below in Revised Table 3.4.1, not only does the overall installation duration decrease from 20 days to between 2 to 4 days, but the pile driving duration has decreased from a total of 14 days to a total of 2 to 4 hours. The Revised Underwater Acoustic Modelling Report has been provided as Attachment 8 and replaces Appendix M-2 of the approved RAP.

Except as described in this update, the remainder of the proposed construction strategy for the MP/TP foundations remains unchanged from what was described (and approved) for the construction of the IBGS foundations in the approved RAP.

Export Cable Installation Methods (RAP Section 3.3.4.3)

As approved in the RAP, the Export Cable will be located within a 200-ft (61-m) wide right-of-way (ROW). Detailed route engineering will determine the actual vertical and horizontal alignment. Further details will be provided in the FDR.

As required by RAP Approval Condition 2.1 - *Unexploded Ordinance (UXO) and/or Discarded Military Munitions (DMM) Investigation Survey (and 2.1.4 UXO/DMM Identification Survey if necessary)*, prior to commencement of Export Cable installation activities, a UXO/DMM investigation will be undertaken to reduce the potential risk to construction vessels, apparatus and personnel to a level as low as reasonably practicable. Dominion will make every effort to minimize deviations from the ROW granted in the RAP approval, however, pending results of the UXO/DMM surveys, Dominion may elect to shift the location and/or expand the width of the 200-ft (61-m) ROW in order to ensure the safety of installation contractors, equipment, and the asset, and minimize environmental impacts per 30 CFR 585.301 and 585.628(g). If Dominion determines that a change is necessary, the ROW will not be moved or expanded beyond the limits of the previously surveyed 984 ft (300 m) corridor. Details of the UXO/DMM survey, investigation, and mitigation campaign will be provided in the UXO/DMM Investigation Survey Plan as required by RAP Approval Condition 2.1.2 (and 2.1.4 if necessary).

The target depth of burial for the Export Cable remains approximately 6.6 ft (2 m), as previously approved in the RAP. Cable burial depths will vary dependent on specific conditions related to each individual, localized area. Factors affecting the actual target burial depth will include seabed conditions, seabed mobility, and potential risks associated with human activities, such as fishing, navigation, and other activities. The actual target depths will be determined in a new Cable Burial Risk Assessment, which will be undertaken in the detailed engineering phase. As approved in the RAP, in locations where actual target depths are not met, additional protection, such as placement of rock berms or concrete mattresses, may be employed to ensure that adequate cable protection is provided.

At each end of the Export Cable, approaching the horizontal directional drill (HDD) punch out location and at the foundation, burial depth will be reduced as the tools grade out from the target burial depth to the seabed. These sections, and sections where the target depth of burial may not have been achieved, could require protection by means of rock placement or concrete mattressing as stated in the approved RAP.

The Export Cable will cross one fiber optic communications cable that was installed after approval of the RAP in 2016. Several other fiber optic communications cables may be installed by the time CVOW is constructed, resulting in other required cable crossings. Dominion is working with the owner of the fiber optic cable to ensure that crossing agreements are in place as early as practicable in the project planning process, and will continue to coordinate with the owners of any additional fiber optic cables that are installed.

Specific details of the crossing design will be agreed upon with the fiber optic cable owners, and in accordance with the related International Cable Protection Committee (IPCP) recommendations,[1] the crossing design will comprise placement of a "separation layer" of either rock placement or mattresses on which the Export Cable will be installed. A "protection layer", also consisting of rock placement or mattresses, will then be installed over the Export Cable. Additional protection may be provided, as needed, to the Export Cable by means of a cable protection system comprised of a number of articulated plastic or metal collars around the cable.

Upon completion of the Export Cable laying activities, post-lay surveys will be conducted from the installation vessel to verify cable burial depth and installed location.

Onshore Interconnection Cable Route (RAP Sections 3.1.2, 3.2.5, and 3.3.2.2)

Due to new, previously unknown conflicts with military activities, Camp Pendleton is requiring a modification to the previously approved Onshore Interconnection Cable Route which is required to support the construction and operation of both the Onshore Interconnection Cable and Fiber Optic Cable. The portion of Rifle Range Road from

[1] ICPC Recommendation #2, Recommended Routing and Reporting Criteria for Cables in Proximity to Others, Issue 10B, 12 November 2012; ICPC Recommendation #3, Criteria to be Applied to Proposed Crossings of Submarine Cables and/or Pipelines, Issue 10A, 12 February 2014; ICPC Recommendation #7, Procedure to be Followed Whilst Civil Engineering or Offshore Construction Work is Undertaken in the Vicinity of Active Submarine Cable Systems, Issue 6B, 4 February 2014; and ICPC Recommendation #13, The Proximity of Offshore Renewable Wind Energy Installations and Submarine Cable Infrastructure in National Waters, Issue 2A, 26 November 2013

the intersection with Regulus Avenue to the intersection with the Gate 10 Access Road originally proposed as part of the Onshore Interconnection Cable Route is owned by the U.S. Navy (Navy). This portion of the route in now in conflict with proposed naval activities and the Navy will no longer allow the Project to utilize this portion of Rifle Range Road. In addition, the Switch Cabinet where the offshore Export Cable transitions to the Onshore Interconnection Cable may be relocated, but will remain in the general area, due to conflicts with the location of a proposed hygiene facility to be constructed in the existing parking lot.

The termination points for the modified Onshore Interconnection Cable Route have not changed, therefore, the Interconnection Station and Switch Cabinet where the offshore Export Cable transitions to the Onshore Interconnection Cable have not moved (Figure 5). The modified Onshore Interconnection Cable Route is a combination of segments that were previously evaluated in the alternatives analysis of the approved RAP as well as some additional areas that have recently been identified as potential alternatives. Dominion has worked closely with Camp Pendleton to identify an alternative Onshore Interconnection Cable Route that minimizes impacts to environmental, cultural, and socioeconomic resources as well as interference with Camp Pendleton and the Navy. Although the new route is longer in total length and crosses under Lake Christine via a HDD, officials at Camp Pendleton have insisted on the modification. With the exception of the HDD under Lake Christine, the modified Onshore Interconnection Cable Route will still be located entirely within the boundary of the Camp Pendleton Military Reservation in Virginia Beach, Virginia, as approved in the RAP. The portion of the route where the HDD under Lake Christine is located is Navy property. However, Camp Pendleton is currently in negotiations with the Navy to obtain an easement through that area, which will subsequently be leased to Dominion for the CVOW. Dominion is currently negotiating the ROW with Camp Pendleton. When the ROW has been agreed upon, plan and profile drawings of the modified route will be provided under separate cover as Revised Appendix D-2.

The modified Onshore Interconnection Cable Route will originate at the proposed Switch Cabinet located within an existing parking lot at the end of Rifle Range Road and adjacent to Camp Pendleton Beach, as previously identified in the approved RAP. The modified cable route then extends in a northwest direction through the rifle range for a distance of approximately 900 ft (274 m) to the northwest corner of the rifle range, just south of a canine training area. The modified cable route then extends in a generally northern direction for a distance of approximately 335 ft (102 m) to a gravel turnaround area, which will serve as an equipment laydown and staging area for the HDD under Lake Christine. From the staging area, the HDD under Lake Christine will be approximately 935 ft (285 m) long and will run in a west/northwest direction under Lake Christine to the cleared area on the western side of the lake, which will act as the HDD staging area for the HDD punch-out. After the Lake Christine crossing, the cable route turns to the southwest, for approximately 350 ft (107 m) through a previously disturbed area. The temporary work space associated with each HDD staging area on either side of Lake Christine will be located within the 30 ft (9m) temporary workspace.

Alternatively, Dominion may elect to locate the Onshore Interconnection Cable Route beginning at the Switch Cabinet extending in a west-south-west direction along Rifle Range Road for approximately 700 ft (213 m) until reaching the intersection of Rifle Range Road and Regulus Avenue. At the intersection of Rifle Range Road and Regulus Avenue, the Onshore Interconnection Cable Route extends in a general northerly direction for approximately 1000 ft (305 m) until reaching the gravel turnaround area, which will serve as an equipment laydown and staging area for the horizontal directional drill (HDD) under Lake Christine. The HDD under Lake Christine for this alternative will be approximately 1200 ft (366 m) long and will run in a generally west direction to a

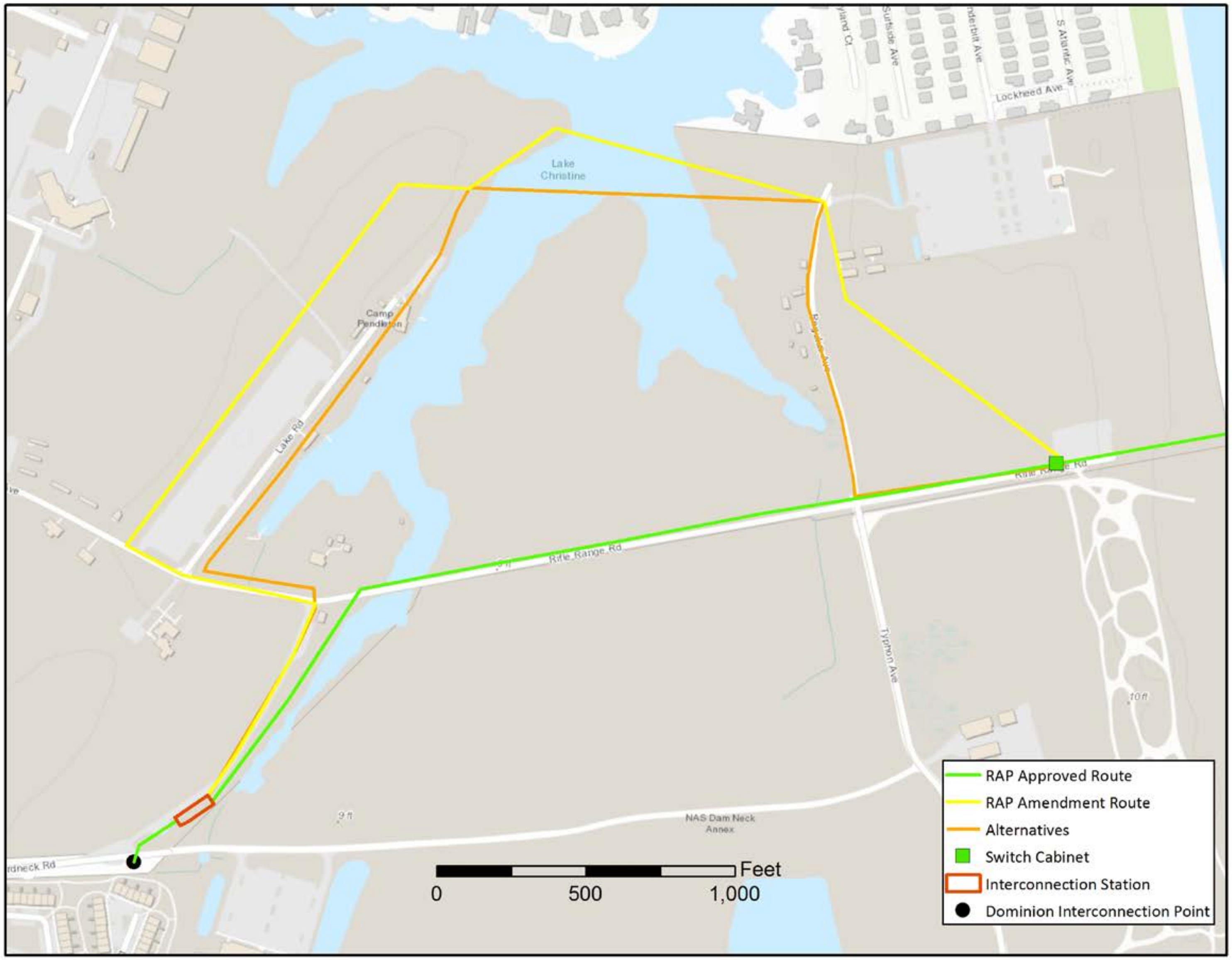


Figure 5. Comparison of Onshore Route Approved in RAP and Proposed New Onshore Route and Alternatives

previously disturbed area located approximately 350 ft (107 m) southwest the cleared area on the western side of the lake. Regardless of which HDD crossing is selected. the temporary work space associated with each HDD staging area on either side of Lake Christine will be located within the 30 ft (9m) temporary workspace.

From this point, there are two alternatives for the Onshore Interconnection Cable Route to be installed along the west side of Lake Christine. The first alternative, which would involve crossing an existing fiber optic cable at a perpendicular angle in two locations, extends west for approximately 230 ft (70 m) where it crosses the existing fiber optic cable at a perpendicular angle. The route then runs southwest for a distance of approximately 1,500 ft (457 m) along the western boundary of a paved helicopter landing area until it reaches Jefferson Avenue. The route then runs in an east-southeast direction along Jefferson Avenue for a distance of approximately 670 ft (204 m) until it crosses the existing fiber optic cable at a perpendicular angle before reaching the intersection of Jefferson Avenue, Rifle Range Road, and the Gate 10 Access Road. The second alternative, which would not require a fiber optic cable crossing, would extend in a generally south-south-west direction for a distance of approximately 1550 ft (472 m) down the east side of Lake Road, approximately 30 ft (9 m) east of the shoulder, to a location approximately 30 ft (9 m) north of Jefferson Avenue. From this location, the Onshore Interconnection Cable route would extend in a generally westerly direction for a distance of approximately 370 ft (112 m), before turning to the south for a distance of approximately 50 ft (15 m) until reaching the intersection of Jefferson Avenue, Rifle Range Road and the Gate 10 Access Road.

From the intersection of Jefferson Avenue, Rifle Range Road, and the Gate 10 Access Road, the cable route extends approximately 750 ft (229 m) down the center of the Gate 10 access road to the proposed Interconnection Station located just north of Gate No. 10 off of South Birdneck Road. As described in the approved RAP, the cable route then continues from the Interconnection Station on the Gate 10 Access Road approximately 207 ft (63 m) to interconnect with Dominion's existing electrical infrastructure located on the south side of South Birdneck Road. The total length from the Switch Cabinet at Camp Pendleton Beach to Dominion's existing electrical infrastructure ranges from approximately 1.1 mi (1.8 km) to1.2 mi (1.9 km), depending on the route alternative selected. Determination of the final Onshore Interconnection Cable Route and the Switch Cabinet location will be dependent on the outcome of ongoing easement negotiations between Dominion and Camp Pendleton. A copy of the easement will be provided to BOEM when it is finalized. Between the Switch Cabinet at Camp Pendleton Beach and the Interconnection Station on the Gate 10 Access Road, the Onshore Interconnection Cable and Fiber Optic Cable will be installed via a series of HDD segments, as approved in the RAP. No direct burial or trenching is proposed for the onshore cables, which is also consistent with what was included in the approved RAP. However, due to the longer route, the Onshore Interconnection Cable and Fiber Optic Cable will be installed in 13 segments, instead of the 12 segments detailed in the approved RAP. Each HDD segment will range from approximately 230 ft (70 m) to 500 ft (152 m) in length, with the exception of the Lake Christine crossing, which will range from approximately 935 ft (285 m) to 1200 ft (366 m) in length.

The modified cable route will require the use of up to 14 splice pits, which is an increase of 1 pit relative to the approved RAP. The size of each splice pit remains the same and will require the excavation of a 4.0 ft by 6.0 ft by 2.0 ft (1.2 m by 1.8 m by 0.6 m) splice pit. As installation conditions allow, longer HDD segments may be feasible such that fewer splice pits may be required. The splice pits and associated excavated soils will be located within the proposed construction right-of-way and will not require expanded workspaces. Upon completion of cable splicing activities, the excavated material will be returned to the splice pits, compacted, and returned to pre-construction conditions. The splice pit will serve as the location where the cable drilling will either be initiated and/or received. All activities will occur along the paved roadways and within the existing cleared areas along the route.

Dominion's onshore contractor is proposing the use of a non-toxic HDD drilling fluid (e.g. a fluid consisting of combination of 4% bentonite and soda ash and 96% water), similar to what is used to drill potable water wells, to provide more stability and reduce the risk of potential inadvertent returns associated with the HDD installation of the Onshore Interconnection and Fiber Optic Cables. A representative HDD drilling fluid Material Safety Data Sheet is provided in Attachment 9. This proposed HDD installation method will ensure that potential environmental impacts from the modified route will be avoided and/or minimized to the maximum extent practical. In addition, where the Onshore Interconnection Cable Route crosses under a road, the cables will still be installed in a steel or high density polyethylene conduit. Where the Onshore Interconnection Cable Route crosses the existing fiber optic cable, the Interconnection Cable and Fiber Optic Cable will be installed generally perpendicular to the existing utility.

To support the construction and operation of the Onshore Interconnection Cable and Fiber Optic Cable, Dominion proposes a 30 ft (9.1 m) temporary construction right-of-way along the entirety of the route for installation of the cable. Upon completion of construction, 15 ft (4.6 m) will be retained as a permanent easement for access during operation. The Onshore Interconnection Cable and Fiber Optic Cable will be installed in separate boreholes approximately 3 ft (0.9 m) apart and buried to a minimum depth of 3.3 ft (1 m) to be consistent with local utility standards. As an option, the fiber optic cable could be installed in conduit allowing fewer splices. The conduit would be installed by HDD and the fiber optic cable pulled back through the conduit. The only exception to the minimum burial depth being the HDD under Lake Christine, which will be buried to a depth of more than 3.3 ft (1 m) under the bottom of the lake to ensure that the interconnection cable and fiber optic cables will not restrict potential future dredging operations in Lake Christine. The final target burial depth under the bottom of Lake Christine will be determined through final engineering prior to construction, and in consultation with Camp Pendleton and U.S. Army Corps of Engineers (USACE). Plan and profile drawings will be provided under separate cover as Revised Appendix D-2. Please see the Amendment to the Visual Impact Assessment, Revised Terrestrial Archaeology Survey Report, and Amendment to the Historic Properties Assessment, provided as attachments 5, 10 and 11, respectively, for the subject matter experts assessments of visual, terrestrial archaeological and historic resources in relation to the modified Onshore Interconnection Cable Route and alternatives.

Dominion will conduct a formal land survey of the modified Onshore Interconnection Cable Route prior to construction to ensure the proposed location and burial depth avoid existing utilities and/or other constraints. Dominion will also complete soil testing along the route to support the final engineering design.

The Onshore Interconnection Cable and Fiber Optic Cable installation and splicing activities are estimated to take approximately 8 weeks to complete, dependent on weather and other constraints.

Except as described in this amendment, the proposed construction, operation, and decommissioning strategy of the CVOW onshore facilities remains unchanged from what is described in the approved RAP.

The following table amends the onshore facility construction and operation footprint as presented in Table 3.2-6 of the approved RAP.

Revised Table 3.2-6. Onshore Construction and Operation Footprint

Onshore Construction and Operation [a]	Approved in RAP		Modified Onshore Route		Change	
	Construction	Operation	Construction	Operation	Construction	Operation
Onshore HDD Work Area [b]	0.5 ac / 0.2 ha	0	No Change	No Change	No Change	No Change
Switch Cabinet[c]	NA [c]	0.001 ac / 0.0003 ha	No Change	No Change	No Change	No Change
Total Right-of-Way [d]	2.2 ac / 0.9 ha	0	4.0 to 4.4 ac / 1.6 to 1.8 ha	No Change	Increase of 1.8 to 2.2 ac / 0.7 to 0.9 ha	No Change
Splice Pits[e]	NA	0	No Change	No Change	No Change	No Change
Interconnection Station	0.2 ac / 0.09 ha	0.1 ac / 0.04 ha	No Change	No Change	No Change	No Change
Onshore Construction and Operation Total	2.9 ac / 1.2 ha	0.1 ac / 0.04 ha	4.0 to 4.4 ac / 1.6 to 1.8 ha	0.1 ac/ .04 ha (No change)	Increase of 1.8 to 2.2 ac / 0.7 to 0.9 ha	0.1 ac/ 0.04 ha (No change)

[a] Notes are in reference to impact assumptions in approved RAP.

[b] Onshore horizontal directional drill (HDD) work area will support the onshore HDD drilling rig, associated pumping units and mud ponds, as well as contain a site office and material storage area.

[c] Construction impacts will be within the Onshore HDD Work Area.

[d] Assumes 30-ft (9-m) wide temporary work space from the HDD Work Area to the Interconnection Station Work Area within existing road shoulders and previously disturbed areas and a 15-ft (4.5-m) wide permanent easement.

[e] Splice pits will be located within the temporary work areas.

As described above and demonstrated in Revised Table 3.2-6 above, even though the overall length of the Onshore Interconnection Cable Route has increased by 0.4 to 0.5 mi (0.6 to 0.8 km), the associated facilities (Switch Cabinet and Interconnection Station) and installation techniques (point to point HDD) have not changed. Dominion will still be utilizing low impact installation methods and schedule to minimize interference with environmental and cultural resources, as well as military activities. In addition, there will be no change to the operational footprint of the onshore facilities, aside from a possible relocation of the Switch Cabinet which will remain in the same general area.

Offshore Deployment and Construction (RAP Section 3.3.4)

The vessel market changes over time due to advances in technology, construction of new vessels, and vessel availability. As such, vessel information provided in the approved RAP was meant to provide information for representative vessel types that would be required for construction and operation of the Project. Other than slight variations in shape and lifting capacity, the vessel types described in the approved RAP are still indicative of what will be used for construction and operation of the CVOW Project.

Dominion is considering the use of helicopters for crew transfers between installation vessels and the shore during Export Cable, Foundation and WTG installation if doing so would improve construction logistics. Crew transfers would be expected approximately every two weeks. If Dominion elects to use helicopters during construction and installation activities, Dominion will consult with the Federal Aviation Administration (FAA), the U.S. Navy, Camp Pendleton, the U.S Coast Guard (USCG) and any other relevant regulatory agencies and stakeholders to ensure that all activities are coordinated appropriately prior to use of helicopters.

Project Construction Schedule (RAP Section 3.4)

The following Project Construction Schedule amends Table 3.4-1 of the approved RAP.

Revised Table 3.4-1. Project Construction Schedule

Activity	Approved in RAP		Updated Schedule		Change	
	Anticipated Timeframe [a]	Duration [b] (Weeks)	Anticipated Timeframe [a]	Duration [b] (Weeks)	Anticipated Timeframe	Duration (weeks)
Interconnection Station Installation [c]	April through June	8	January through April	12-16	Shift down 3 months	Increase of 4 to 8[j]
Onshore Interconnection Cable and Switch Cabinet installation [d]	February through April	8	No Change	9	N/A	Increase of 1
Export Cable Landfall Construction (including Offshore HDD) [e]	March through April	11	No Change	No Change	N/A	N/A
Foundation installation and pile driving [f]	May	3	No Change	2	N/A	Decrease of 1
Export Cable Installation	May through June	4	April to July	3	Shift down 1 month – Shift up 1 month	Decrease of 1
Inter-Array Cable Installation [g]	June	2	July	1	Shift up 1 month	Decrease of 1
WTG installation	June through July	3 i/	May through June	2	Shift down 1 month – Shift down 1 month	Decrease of 1
Commissioning	August through September	5	May through July	5/	Shift down 3 months – Shift down 2 month	No Change

[a] Schedule does not account for weather delays.

[b] Onshore construction activities assume a 5-day work week, offshore construction activities assume a 7-day work week.

[c] Includes site preparation, equipment installation, and commissioning.

[d] Includes site preparation of onshore HDD Work Area, HDD of the Onshore Interconnection Cable and Fiber Optic Cable (including the HDD under Lake Christine), and Switch Cabinet installation.

[e] Includes HDD and offshore conduit installation, assumes 4 weeks for drilling and reaming.

f/ Includes 4 hours of pile driving.

j/ Increase in duration is based on contractor responses to the onshore RFP.

Underwater Acoustic Modelling (RAP Section 4.15.2)

Based upon the results of the drivability analysis for the monopole foundation (Attachment 7), a maximum 1,000 kJ impact hammer will be utilized during foundation installation and hammer energy will range from 600 kJ to 1,000 kJ. This remains consistent with the size of the impact hammer and associated hammer energy described in the approved RAP. However, the geometry of the foundation has changed and instead of four separate hammering events per foundation (IBGS caisson and three inward battered/raked piles), each monopole foundation only requires one continuous hammering event. Additionally, the methodology for defining the Level A harassment threshold has been modified by National Oceanic and Atmospheric Administration (NOAA) since the RAP was approved. A revised acoustic impact analysis has been prepared, utilizing the new technical guidance from NOAA for the method of defining the Level A harassment threshold (NOAA, 2016). Based on the revised foundation geometry, the anticipated foundation installation period of 1 to 2 days per foundation, and the new NOAA guidance, the maximum ranges to the Permanent Threshold Shift (PTS) criteria, reported in dBpeak, SELcum, and RMS_{90} are provided in the following tables, including both unmitigated and mitigated data (i.e., mitigated with inclusion of a bubble curtain). The Revised Underwater Acoustic Modelling Report has been provided as Attachment 8 and replaces Appendix M-2 of the approved RAP.

Peak Sound Pressure Level

Revised Table 14-15 presents the the maximum (R_{max}) radial distances that correspond to the peak SPLs (dB re 1 µPa) for impact pile driving. The levels presented in Revised Table 14-15 (Table 9 of Attachment 8 – Revised Underwater Acoustic Modelling) correspond to auditory injury and disturbance criteria for marine mammals and injury criteria for fish for both the unmitigated scenario and with the Big Bubble Curtain (BBC). Peak thresholds are unweighted. Several of the Peak distance to thresholds do not change under the mitigated pile driving scenario as these distances will fall within the expected bubble curtain containment area of 100 meters.

Revised Table 14-15. Maximum Radii (m) That Correspond to the Peak SPLs for Impact Pile Driving

Peak SPL (dB re 1 µPa)	Criteria	Rmax
202	PTS – HF cetaceans	325
205	Injury – Fish	200
218	PTS – Phocid pinnipeds	<100
219	PTS – LF cetaceans	<100
230	PTS – MFC cetaceans	<100
Big Bubble Curtain Mitigated		
202	PTS – HF cetaceans	<100
205	Injury – Fish	<100
218	PTS – Phocid pinnipeds	<100
219	PTS – LF cetaceans	<100
230	PTS – MFC cetaceans	<100

Cumulative Sound Exposure Levels

Each foundation is anticipated to require up to 1 day to complete the installation. The drivability assessment predicts an upper bound estimate of 1,333 blows for the first foundation (position A01) and 2,470 blows for the second position (position A02) at a rate of 30 blows per minute. The radii in Revised Tables 14-16 and 14-17 correspond to marine mammal injury and disturbance criteria and fish injury and behavioral disturbance criteria for a 24-hour SEL_{cum}.

Revised Table 14-16. Radii (m) of Unweighted and M-Weighted SEL_{cum} Contours for Impact Pile Driving – 600 kJ

SEL_{cum} (dB re 1 µPa² s)	Critera	Unweighted		LFC		MFC		HFC		PINN	
		R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}
155	PTS– HF cetaceans							1,625	1,450		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	6,100	5,200	4,300	3,900						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					250	250			1,000	850

SEL$_{cum}$ (dB re 1 µPa^2 s)	Critera	Unweighted		LFC		MFC		HFC		PINN	
		R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}
187	Injury – Large fish (mass >2 g)	4,400	3,900								
Big Bubble Curtain Mitigated											
155	PTS– HF cetaceans							<200	<200		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	3,575	2,950	1,450	1,250						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					<200	<200			200	200
187	Injury – Large fish (mass >2 g)	2,625	2,050								

Revised Table 14-17. Radii (m) of Unweighted and M-Weighted SEL$_{cum}$ Contours for Impact Pile Driving – 1000 kJ

SEL$_{cum}$ (dB re 1 µPa^2 s)	Critera	Unweighted		LFC		MFC		HFC		PINN	
		R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}
155	PTS– HF cetaceans							2,100	1,800		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	6,900	6,000	5,100	4,600						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					300	300			1,200	1,000
187	Injury – Large fish (mass >2 g)	5,200	4,400								
Big Bubble Curtain Mitigated											
155	PTS– HF cetaceans							250	250		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	3,150	2,500	1,750	1,500						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					<200	<200			250	250
187	Injury – Large fish (mass >2 g)	2,050	1,700								

Sound Pressure Levels (RMS$_{90\%}$)

As shown in Revised Tables 14-18 and 14-19, the resultant distances to the Level B Harassment of marine mammals threshold of 160 dB$_{RMS90}$ ranges from 4 km to 5 km unmitigated and 2 km to 2.5 km with the bubble curtain. The distances to the 150 dB$_{RMS90}$ threshold for fisheries resources range from 8.75 km to 11.4 km unmitigated and 4.6 km to 5.7 km with the bubble curtain. The distances to the 166 dB$_{RMS90}$ threshold for sea turtles range from 2.7 km to 3.2 km unmitigated and 1.175 to 1.5 km with the bubble curtain. The historical Level A threshold or 180 dB_{RMS90} for injury of marine mammals, which is still currently in use for sea turtles, ranges from 700 m to 800 m unmitigated and 280 m to 350 m with the bubble curtain.

Revised Table 14-19 Radii (m) of dB_{rms90} SPL Contours for Impact Pile Driving – 600 kJ

dB rms90 SPL (dB re 1 µPa)	Criteria	R_{max}	R_{mean}
150	Disturbance – Fish	9.725	8,750
160	Disturbance – Marine Mammals	4,380	4,275
166	Disturbance – Sea Turtles	2,700	2,650
180	Injury – Seaturtles (Marine Mammals - Historic)	700	680
Big Bubble Curtain Mitigated			
150	Disturbance – Fish	4,700	4,570
160	Disturbance – Marine Mammals	2,110	2,060
166	Disturbance – Sea Turtles	1,200	1,175
180	Injury – Seaturtles (Marine Mammals - Historic)	300	280

Revised Table 14-20 Radii (m) of dB_{rms90} SPL Contours for Impact Pile Driving – 1000 kJ

dB rms90 SPL (dB re 1 µPa)	Criteria	R_{max}	R_{mean}
150	Disturbance – Fish	11,375	10,225
160	Disturbance – Marine Mammals	5,175	5,050
166	Disturbance – Sea Turtles	3,150	3,075
180	Injury – Seaturtles (Marine Mammals - Historic)	800	780
Big Bubble Curtain Mitigated			
150	Disturbance – Fish	5,670	5,120
160	Disturbance – Marine Mammals	2,520	2,450
166	Disturbance – Sea Turtles	1,500	1,460
180	Injury – Seaturtles (Marine Mammals - Historic)	350	330

Details related to source levels and calculation methodologies are provided in Attachment 8.

The approved RAP indicated exposure of marine mammals to Level A harassment threshold of 180 dB would be adequately addressed by the implementation of minimization measures, including observations of time of year windows, application of Protected Species Observers (PSOs) during project construction, and the establishment of exclusion and monitoring zones and associated startup and shutdown procedures for noise-producing equipment. Assessment of proposed mitigation measures will consider the feasibility as well as the frequency range and expected noise reduction for the selected mitigation measure. Bubble curtains are commonly used to reduce acoustic energy emissions from high-amplitude sources and are generated by releasing air through multiple small holes drilled in a hose or manifold deployed on the seabed near the source. The resulting curtain of air bubbles in the water provides significant attenuation for sound waves propagating through the curtain.

Soft-start mitigation procedures would be employed to reduce sound levels during the initial stages of driving a pile. This will greatly reduce the initial range over which instantaneous injury may occur and be effective in deterring aquatic life to a safe distance before the full energy piling is reached. Impact pile driving included the analysis for the expected 600 kJ and maximum 1,000 kJ hammer force, thereby describing the full range of sound levels expected to be experienced throughout an entire piling sequence. Hearing recovery time would be expected during significant gaps in piling. The 12 hour period represents the daylight time window that pile driving would occur and allows for overnight recovery time for the fish after pile driving has stopped.

The assessment of underwater noise levels associated with the operation of the WTGs demonstrates expected underwater noise levels to be well below thresholds established to be adequately protective of all marine life.

Offshore Deployment and Construction (RAP Section 3.3.4)

The vessel market changes over time due to advances in technology, construction of new vessels, and vessel availability. As such, vessel information provided in the approved RAP was meant to provide information for representative vessel types that would be required for construction and operation of the Project. Due to advances in wind turbine installation technology, as well as proposed modifications to the construction approach, the following table amends the list of vessel types to be used during construction, operation, and maintenance of the CVOW offshore facilities.

Revised Table 3.3-1. Vessel Types

Vessel	Typical Size (ft) Length x Width x Depth (Draft)	Description of typical features and equipment
Self-Propelled Jack Up Vessel	461 x 135 x 31 (21)	1,500-ton lifting capacity Dynamic Positioning System: 4x2600kW azimuth thrusters 3x2500kW bow thrusters Used to install foundations and WTGs. Will also serve as transportation vessel for foundations and WTGs.
Cable Lay Vessel	295 x 93 x 16	Dynamic Positioning System: 2x1140 stern azimuth thrusters (ZF AT 6111 electric) 2x1118 bow azimuth thrusters (ZF AT 6111 electric) 1x650 tunnel thruster (ZF TT 5001 electric) Equipped with: cable installation tool Used to transport cable to CVOW location from the construction port and install cable to correct burial depth.
Multipurpose Vessel	312 x 72 x 21 (21)	40-ton lifting capacity Dynamic Positioning System: 2x1250kW main thrusters 2x1250kW bow thrusters Used to install scour protection material for foundations and export cable.
Temporary Offshore Work Barge	400 x 120 x 25 (12)	Flat top barge. Requires supporting tug boat. Used to support cable installation activities as required.
Tug Boat	180 x 26 x 6	Ocean class tug with large horsepower (hp) and high bollard pull. Assists barge and other vessel repositioning as required.
Crew Transfer Vessel	55 x 16.5 x 6.5 (4.5)	Specialized crew transfer vessel, capable in extreme weather. Transports crew to and from construction area.
Security Vessel	100 x 32 x 12.2	Security for site work zone. Provides security for foundation and WTG construction. Maintains communications with other vessels, including non-

Vessel	Typical Size (ft) Length x Width x Depth (Draft)	Description of typical features and equipment
		Project vessels, to avoid collisions and warn of Project construction activities.
Marine Mammal Observation Vessel	100 x 26 x 6	Performs observations of the protected species monitoring and exclusions zones.
Acoustic monitoring vessel	100 x 26 x 6	Performs observations of underwater noise during foundation installation.
Support Vessel - Bubble Curtain	276 x 54 x 24 (14)	Installation/operation of noise-dampening bubble curtain during foundation installation.
Work Vessel	276 x 54 x 24 (14)	Support operating & maintenance activities.

The following table provides a comparison of the proposed vessel types approved in the RAP, versus the revised list of vessels used for the revised Air Emissions Analysis and Methodology Report (Attachment 12). As shown, a number of assumptions about the types of vessels and their specifications have changed. In addition, assumptions about the types of offshore construction tasks and their durations have changed substantially, in general becoming shorter in duration than those approved in the RAP. However, vessel assumptions and task durations for annual operational and maintenance activities are identical to those approved in the RAP. Please see the Revised Air Emissions Calculations and Methodology Report, included as Attachment 12 to this memo, for more details about the currently proposed vessels and modified installation strategy

Comparison of Approved vs. Revised List of Vessel Types in Table 3.3-1

Vessel List Approved in RAP		Revised Vessel List		Change
Vessel	Approx. Size (ft) Length x Width x Depth (Draft)	Vessel	Approx. Size (ft) Length x Width x Depth (Draft)	
Self-Propelled Jack Up Vessel	530 x 160 x 30 (18)	Self-Propelled Jack Up Vessel	461 x 135 x 31 (21)	Different vessel
Heavy Lift Vessel	355 x 160 x 26 (16)			Removed
Cable Installation Vessel	390 x 105 x 26 (20)	Cable Lay Vessel	295 x 93 x 16	Different vessel
		Multipurpose Vessel	312 x 72 x 21 (21)	Added
Jet Plow	32 x 18			Removed
ROV Jet Trencher	18 X 15			Removed
Foundation Transportation Barge	250 x 72 x 20 (16)			Removed
WTG Transportation Vessel	180 x 45 x 40 (20)			Removed
Temporary Offshore Work Barge	400 x 120 x 25 (12)	Temporary Offshore Work Barge	400 x 120 x 25 (12)	No change
Tug Boats	180 x 45 x 40 (20)	Tug Boat	180 x 26 x 6	Different vessel
Supply Vessel	160 x 40 x 35 (18)			Removed
Crew Transportation Vessel	55 x 16.5 x 6.5 (4.5)	Crew Transfer Vessel	55 x 16.5 x 6.5 (4.5)	No change
		Acoustic monitoring vessel	100 x 26 x 6	Added
		Support Vessel - Bubble Curtain	276 x 54 x 24 (14)	Added
		Work Vessel	276 x 54 x 24 (14)	Added
Security Vessel	160 x 40 x 35 (18)	Security Vessel	100 x 32 x 12.2	Different vessel
Marine Mammal Observation Vessel	160 x 40 x 25 (18)	Marine Mammal Observation Vessel	100 x 26 x 6	Different vessel
Supporting Work Vessel	300 x 80 x25 (10)			Removed
Survey Vessel	120 x 40 x 20 (16)			Removed

Construction and Operations Air Emissions (RAP Sections 4.16.2.1 and 4.16.2.2)

Emissions associated with the construction and operations phases of the Project have been revised to account for modified installation strategy and vessel availability, as well as to account for changes in projected onshore construction equipment characteristics for calendar year 2020. The revised calculations will be used to support the Outer Continental Shelf (OCS) Air Permit filing, as well as BOEM's NEPA review. Note that the assumed vessel spread, and actual vessel sizes and operations, will be determined by vessel availability and prevailing meteorological conditions. While some details may change, a conservative approach has been adopted, and actual parameters, vessels, and durations are likely to be within the envelope assessed. The following tables of emissions amend Tables 4.16-1 and 4.16-2 of the approved RAP. A revised Air Emissions Calculations and Methodologies Report has been provided as Attachment 12.

Revised Table 4.16-1. Estimated Construction Emissions

Activity	Estimated Annual Emissions (tons)							
	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	GHG (CO_2e)
Onshore Construction Emissions								
Export Cable Landfall Construction	0.23	1.49	1.63	0.09	0.09	0.004	0.06	447
Onshore Interconnection Cable & Switch Cabinet Installation	0.28	1.65	2.16	0.10	0.09	0.005	0.07	547
Interconnection Station Installation	0.24	0.95	2.55	0.04	0.04	0.006	0.07	503
Subtotal	0.75	4.08	6.35	0.22	0.21	0.02	0.20	1,497
Offshore Construction Emissions								
Offshore Turbine Installation	2.75	55.46	28.30	3.38	3.28	0.015	0.57	3,951
Offshore Cable Installation	1.18	28.59	14.58	1.36	1.32	0.008	0.24	2,041
Subtotal	3.93	84.05	42.88	4.74	4.59	0.02	0.81	5,992
TOTAL	4.68	88.14	49.23	4.96	4.81	0.04	1.01	7,489
Note: All construction emissions are assumed to occur in 2020.								

Revised Table 4.16-2. Estimated Annual Operating Emissions

Activity	Estimated Annual Emissions (tons per year)							
	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	GHG (CO_2e)
Operations & Maintenance Activities	0.34	10.31	5.26	0.36	0.35	0.001	0.07	735
Emergency Generators	0.02	0.56	0.31	0.03	0.03	0.000	0.001	30
Circuit Breaker Fugitive GHG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.2
TOTAL	0.36	10.87	5.57	0.39	0.38	0.002	0.07	765

The following two tables provide a comparison of total emissions approved in the RAP, versus the revised emissions in this Amendment. As shown, total construction emissions decrease for all pollutants, by a substantial amount in most cases. Total operating emissions decrease by a modest amount for all pollutants with the exception of GHG, which increases by a modest amount.

Comparison of Approved vs. Revised Construction Emissions in Table 4.16-1

Activity	Estimated Annual Emissions (tons)							
	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	GHG (CO_2e)
Onshore Construction Emissions								
Approved in RAP (Subtotal)	0.37	3.54	1.34	0.23	0.22	0.01	0.09	705

Activity	Estimated Annual Emissions (tons)							
	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	GHG (CO_2e)
Revised (Subtotal)	0.75	4.08	6.35	0.22	0.21	0.02	0.20	1,497
Change	+0.38	+0.54	+5.01	-0.01	-0.01	+0.01	+0.11	+792
Offshore Construction Emissions								
Approved in RAP (Subtotal)	10.61	236.55	119.41	12.41	12.03	0.05	2.13	17,223
Revised (Subtotal)	3.93	84.05	42.88	4.74	4.59	0.02	0.81	5,992
Change	-6.68	-152.50	-76.53	-7.67	-7.44	-0.03	-1.32	-11,231
TOTAL								
Approved in RAP (TOTAL)	10.98	240.09	120.75	12.63	12.26	0.06	2.22	17,928
Revised (TOTAL)	4.68	88.14	49.23	4.96	4.81	0.04	1.01	7,489
Change (TOTAL)	-6.30	-151.95	-71.52	-7.67	-7.45	-0.02	-1.21	-10,439
Note: All construction emissions are assumed to occur in 2020.								

Comparison of Approved vs. Revised Operating Emissions in Table 4.16-2

Activity	Estimated Annual Emissions (tons per year)							
	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	GHG (CO_2e)
Operations & Maintenance Activities								
Approved in RAP (Subtotal)	0.40	11.59	5.92	0.43	0.42	0.002	0.08	826 /a
Revised (Subtotal)	0.34	10.31	5.26	0.36	0.35	0.001	0.07	735
Change	-.06	-1.28	-0.66	-0.07	-0.07	-0.001	-0.01	-91
Emergency Generators								
Approved in RAP (Subtotal)	0.01	0.44	0.11	0.03	0.03	0.001	0.001	31
Revised (Subtotal)	0.02	0.56	0.31	0.03	0.03	0.000	0.001	30
Change	+0.01	+0.12	+0.20	+0.00	+0.00	-0.001	+0.000	-1
Circuit Breaker Fugitive GHG								
Approved in RAP (Subtotal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.2
Revised (Subtotal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.2
Change	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00	+0.0
TOTAL								
Approved in RAP (TOTAL)	0.41	12.03	6.02	0.46	0.45	0.003	0.08	859
Revised (TOTAL)	0.36	10.87	5.57	0.39	0.38	0.002	0.07	765
Change (TOTAL)	-0.05	-1.16	-0.45	-0.07	-0.07	-0.001	-0.01	-94
/a The approved RAP from April 2015 containd an error in Table 4.16-2. The GHG emissions for O&M were listed as 475 tpy in Table 4.16-2, but they should have been 826 tpy, which is what was stated in the Appendix I methodology attached to the approved RAP. GHG was the only pollutant affected by the error; all other O&M emissions in Table 4.16-2 of the approved RAP match what was contained in Appendix I. The comparison above was based on the correct values as stated in the Appendix I methodology attached to the approved RAP.								

OCS Air Permitting (RAP Section 4.16.3.1)

Potential air emissions from construction and operation of the CVOW Project will be subject to the OCS regulations under 40 CFR Part 55. The following modifications to the Project design and potential emissions contained in the approved RAP will affect the OCS air permitting requirements for the Project.

The WTG towers will no longer be equipped with emergency generator engines and, therefore, these towers will not be OCS sources during operation of the Project. Instead, a single emergency generator may be located at the onshore interconnection station, and will be subject to the applicable VDEQ requirements for emergency engine permitting. The extent to which vessel emissions during operation and maintenance of the Project (since the WTG towers will no longer include an OCS source) will be evaluated as part of submitting an updated 40 CFR 55 Notice of Intent (NOI) to VDEQ.

The revised potential emissions for construction and operation of the Project, as presented in revised Tables 4.16-1 and 4.16-2, indicate that the Project will have potential emissions of less than 100 tons per year for any single pollutant. The Project will, therefore, no longer be considered a state major source. However, the Project will still be required to apply for and obtain an OCS air permit, pursuant to the state minor source provisions under 9VAC5-80, because it will have potential NO_x emissions greater than 40 tons per year. A revised OCS air permit application will be submitted to VDEQ for the proposed Project, in accordance with 40 CFR Part 55.6 and with VDEQ air regulations specified in 9VAC5 Chapter 80 Part II Article 6, Permits for New and Modified Stationary Sources.

General Conformity (RAP Section 4.16.3.2)

The EPA General Conformity Rule (40 CFR Parts 51 and 93) ensures that federal actions comply with the National Ambient Air Quality Standards (NAAQS), in order to meet Clean Air Act (CAA) requirements. The CAA requires that federal actions that result in emissions in nonattainment areas and maintenance areas within states conform to the federally approved State Implementation Plan.

At the time of the approved RAP, the Hampton Roads area was designated as an ozone maintenance area with respect to the 1997 ozone NAAQS, and was designated to be in attainment with respect to the 2008 ozone NAAQS. The 1997 ozone NAAQS was revoked by EPA, effective April 6, 2015 (see 80 FR 12264), and, therefore, the Hampton Roads area has ceased to be a maintenance area and is exempt from General Conformity requirements altogether.

Vessels in Distress (RAP Sections 4.18.7)

Based on discussions with BOEM and the USCG, in Sections 4.17.2.2 and 4.18.7 of the approved RAP, Dominion committed to making the WTG foundations available as a mooring location and refuge for vessels in distress. Upon further consideration, Dominion would like to have this commitment removed from the approved RAP. Based on European experience with offshore wind farms, there are several safety and design factors that Dominion has considered in making this request. Dominion's rationale for removal of the mooring and refuge for vessels in distress commitment is detailed in Attachment 13, which was submitted to USCG for consideration on December 15, 2017.

SUMMARY OF ENVIRONMENTAL EFFECTS AND PROPOSED MITIGATION MEASURES

The Table in Attachment 1 summarizes the environmental impacts and avoidance, minimization, and mitigation measures associated specifically with the proposed Project updates as described in the preceding sections. Unless otherwise noted in Attachment 1, all environmental impacts and avoidance, minimization, and mitigation measures remain as described in Section 4.0 of the approved RAP.

If you have any questions or comments regarding this amendment to the approved RAP, please do not hesitate to contact Steve Pietryk, Senior Project Manager for Dominion Energy at 804-273-4073 or by email at steven.g.pietryk@dominionenergy.com.

Sincerely,

Mark Mitchell

Mark Mitchell

Vice President – Generation and Construction

Dominion Energy

Attachments:

- Attachment 1 – Summary of Environmental Effects and Proposed Mitigation Measures
- Attachment 2 –RAP Amendment Comment Response Matrix
- Attachment 3 – Amendment to Marine Archaeological Resources Assessment (CONFIDENTIAL)
- Attachment 4 – Permits, Approvals, and Consultations
- Attachment 5 – Amendment to Visual Impact Assessment
- Attachment 6 – Revised Foundation Typical Drawing (CONFIDENTIAL)
- Attachment 7 – Revised Drivability Assessment (CONFIDENTIAL)
- Attachment 8 – Revised Underwater Acoustic Modelling
- Attachment 9 – Representative HDD Drilling Fluid Material Safety Data Sheet
- Attachment 10 – Revised Terrestrial Archaeology Survey Report (CONFIDENTIAL)
- Attachment 11 – Amendment to Historic Properties Assessment
- Attachment 12 – Air Emissions Supplement and Revised Air Emissions Calculations and Methodology Report
- Attachment 13 – Vessels in Distress Requirement Waiver Request

cc: Al Christopher – DMME
Casey Reeves – BOEM
Mandy Tornabene – Dominion Energy
Steve Pietryk – Dominion Energy
Scott Lawton – Dominion Energy

Attachment 1

Summary of Environmental Effects and Proposed Mitigation Measures

Revised Table ES-1 Potential Impacts and Avoidance, Minimization, and Mitigation Measures

RAP Section	Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
4.1	Physical and Oceanographic Conditions	_Meteorological or Oceanographic Conditions_: No change. _Seafloor Sediments_: As detailed in this RAP amendment, the proposed decrease in the WTG Work Areas, and minor increase in operational impacts will result in approximately 206.5 ac (83.6 ha) of temporary impacts to seafloor sediments during construction and 24.2 ac (9.8 ha) of permanent impacts during operation. This represents a decrease of 89.4 ac (36.2 ha) of temporary and 0.56 ac (0.2 ha) of permanent seafloor sediment disturbance from what was originally described in Section 4.1.2.2 of the RAP. _Terrestrial Soils_: As shown in Revised Table 3.2-6, impacts to terrestrial soils based on this RAP Amendment will result in an increase in temporary construction disturbance of 4.2 ac (1.7 ha) which is an increase of 1.3 ac (0.5 ha) from what was originally described in Section 4.1.2.2 of the RAP.	_Meteorological or Oceanographic Conditions_: No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.1 of the approved RAP. _Seafloor Sediments_: No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.1 of the approved RAP. _Terrestrial Soils_: No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.1 of the approved RAP.
4.2	Water Quality	_Ground and Surface Water_: No change. _Marine Water Quality_: No change	_Ground and Surface Water_: No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.2 of the approved RAP. _Marine Water Quality_: No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.2 of the approved RAP.

4.3	Marine Biological Resources	*<u>Benthos and Fish</u>*: As detailed in this RAP Amendment, the proposed decrease in the WTG Work Areas, and the change of foundation type will result in approximately 206.5 ac (83.6 ha) of temporary impacts to sift bottom habitat during construction and will result in the permanent conversion of 24.2 ac (9.8 ha) of soft bottom habitat to hard bottom habitat during operation. This represents a decrease of 89.4 ac (36.2 ha) of temporary and 0.56 ac (0.2 ha) of permanent habitat alteration from what was originally evaluated in Section 4.3.2.1 of the approved RAP. However, as detailed in Section 4.3.2.1 of the approved RAP, epifaunal and infaunal species will likely recolonize the sediments temporally disturbed during construction through the mechanisms of larval recruitment. The foundation scour protection is also likely to provide some additional habitat that would be suitable for structure-oriented species and colonization by sessile benthic species. *<u>EMF</u>*: No change Underwater Noise: The size of the impact hammer has not changed, however the geometry of the foundation has changed and instead of four separate hammering events per IBGS foundation, each monopile foundation only requires one continuous hammering event. The duration of anticipated pile driving activity has been reduced from a total 1 week for each IBGS foundation to a total of approximately 1 to 2 hours per monopole foundation, such that the duration of exposure to acoustic harassment is significantly reduced. Due to a change in methodology for calculating Level A harassment (NOAA, 2016), the potential for Level A harassment will vary depending on marine species and hearing capabilities and the Level B harassment threshold distance will range from 4.275 km to 5.175 km unmitigated to 2 km to 2.5 km with a bubble curtain implemented, ranges that are reduced when compared to the previous application. *<u>Injury or Mortality from Entanglement or Vessel Collision</u>:* No change *<u>Loss of Habitat or Prey Availability</u>:* No change *<u>Impacts from Spills of Hazardous Material or Marine Debris</u>:* No change	No addition avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.3 of the approved RAP.
4.4	Terrestrial Biological Resources	As a result of new requirements being imposed by Camp Pendleton, temporary and permanent impact areas have been relocated and will result in approximately 4.0 to 4.4 ac (1.6 to 1.8 ha) of temporary impacts during construction and 0.1 ac (0.04 ha) of permanent impacts during operation. This represents an increase of 1.8 to 2.2 ac (0.7 to 0.9 ha) of temporary disturbance, and no change in operational impacts. However, all onshore construction activities will still occur along existing road rights-of-way and/or within previously disturbed areas. Therefore, impacts on terrestrial biological resources inclusive of the updates contained herein will be consistent with those described in Section 4.4.2 of the approved RAP.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.4 of the approved RAP.
4.5	Avian and Bat Species	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.5 of the approved RAP.

4.6	Threatened and Endangered Species and Species of Special Concern	*__Fish__:* As detailed in this RAP Amendment, the proposed decrease in the WTG Work Areas, and the change of foundation type will result in approximately 206.5 ac (83.6 ha) of temporary alteration of habitat during construction and will result in the permanent alteration of 24.2 ac (9.8 ha) of habitat during operation. This represents a decrease of 89.4 ac (36.2 ha) of temporary and 0.56 ac (0.2 ha) of permanent habitat alteration from what was originally evaluated in Section 4.6.2.1 of the approved RAP. However, as stated in Section 4.6.2.1 of the approved RAP, the only known listed fish species with the potential to occur within the Project Area is the Atlantic sturgeon; however, its likelihood of occurrence is low. As a result of the decrease in temporary and permanent alteration of habitat associated with proposed Project modifications, impacts to this species would not be measurably different from what has already been described in the approved RAP and would not likely lead to population-level effects. *__Marine mammals__*: See the response above in regard to Section 4.3 *__Sea Turtles__*: No change. *__Invertebrates__:* No change. *__Avian Species__*: No change. *__Terrestrial Mammals__*: No change. *__Terrestrial Reptiles__*: No change. *__Amphibians__*: No change. *__Vascular Plants__*: No change.	In addition to the avoidance, minimization, mitigation measures, and BMPs already described in Section 4.6 of the approved RAP.
4.7	Essential Fish Habitat (EFH)	*__Habitats__:* As detailed in this RAP Amendment, the proposed decrease in the WTG Work Areas, and the change of foundation type will result in approximately 206.5 ac (83.6 ha) of temporary alteration of habitat during construction and will result in the permanent alteration of 24.2 ac (9.8 ha) of habitat during operation. This represents a decrease of 89.4 ac (36.2 ha) of temporary and 0.56 ac (0.2 ha) of permanent habitat alteration from what was originally evaluated in Section 4.6.2.1 of the approved Please see impacts and mitigation for Fish in 4.6 above. *__TSS__:* No change *__Noise__:* Please see impacts and mitigation for marine Mammals in 4.6 above. *__EMF__:* No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.7 of the approved RAP.
4.8	Wetlands and Other Jurisdictional Waterbodies	As a result of new requirements being imposed by Camp Pendleton, temporary and permanent impact areas have been relocated and will result in approximately 4.0 to 4.4 ac (1.6 to 1.8 ha) of temporary impacts during construction and 0.1 ac (0.04 ha) of permanent impacts during operation. This represents an increase of 1.8 to 2.2 ac (0.7 to 0.9 ha) of temporary disturbance, and no change in operational impacts. The use of an HDD to install the Onshore Interconnection Cable and Fiber Optic Cable under the bottom of Lake Christine will not result in any impacts to the lake. All onshore construction activities will still occur along existing road rights-of-way and/or within previously disturbed areas as described in the approved RAP, and will still avoid wetlands.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.8 of the approved RAP.

		Therefore, impacts on terrestrial biological resources, inclusive of the updates contained herein, will be consistent with those described in Section 4.4.2 of the approved RAP.	
4.9	Cultural Resources	As a result of new requirements being imposed by Camp Pendleton, temporary and permanent impact areas have been relocated and will result in approximately 4.0 to 4.4 ac (1.6 to 1.8 ha) of temporary impacts during construction and 0.1 ac (0.04ha) of permanent impacts during operation. This represents an increase of 1.8 to 2.2 ac (0.7 to 0.9 ha) of temporary disturbance, and no change in operational impacts. All onshore construction activities will still occur along existing road rights-of-way and/or within previously disturbed areas as described in the approved RAP.	Approximately half of the proposed Onshore Interconnection Cable Route (2.1 ac [0.85 ha,]) was surveyed during terrestrial archaeological surveys performed in support of the Project in 2013. The remainder of the proposed route was previously surveyed by Camp Pendleton contractors (R.C. Goodwin & Associates, 2007 and the College of William and Mary, 2015). When boundary surveys have been completed and final engineering design is available, Dominion will work with Camp Pendleton and the Virginia Department of Historic Resources to determine whether additional archaeological surveys are required to ensure that no sensitive cultural resources are affected. In addition, Dominion will implement an unanticipated discovery plan that will provide guidance to contractors on procedures in the unlikely event that something is discovered during construction. See Attachment 3 – Amendment to Marine Archaeological Resources Assessment, Attachment 5 – Amendment to Visual Impact Assessment, Attachment 10 – Revised Terrestrial Archaeology Survey Report, and, Attachment 11 – Amendment to Historic Properties Assessment.
4.10	Visual Resources	<u>*Offshore Facilities*</u>: Quantify height increase - negligible The 8 ft to 34 ft (2 m to 10 m) increase in the turbine maximum height as shown in Revised Table 3.2-1 does not result in a measurable difference in the impacts on visual resources from what was described in Section 4.10.2 of the approved RAP.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.10 of the approved RAP. See Attachment 5 – Amendment to Visual Impact Assessment.
4.11	Socioeconomic Resources	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.11 of the approved RAP.
4.12	Military Maritime Uses	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.12 of the approved RAP.
4.13	Land Use	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.13 of the approved RAP.
4.14	Transportation	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.14 of the approved RAP.
4.15	Acoustic Environment	<u>*In-air Noise*</u>*:* No change. <u>*Underwater Noise*</u>: See the response above in regard to Section 4.3	In addition to the avoidance, minimization, and mitigation measures described in Section 4.15 of the approved RAP.

4.16	Air Quality	In support of revisions to the OCS Air Permit application to be submitted in Q1 2019 and a revised General Conformity analysis, Dominion has revised the air emissions calculations to account for modified installation strategy and vessel availability. The revised Air Emission Calculations and Methodologies have been included as Attachment 12 and replaces Appendix I of the Approved RAP. Total construction emissions decreased for all pollutants, by a substantial amount in most cases. Total operating emissions decreased by a modest amount for all pollutants.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.16 of the approved RAP.
4.17	Public Health and Safety	No change.	No additional avoidance, minimization, mitigation measures, or BMPs are suggested beyond those already described in Section 4.17 of the approved RAP.

Attachment 2

RAP Amendment Comment Response Matrix

§ 585.634 (a) (c) and (d) Requirements

Proposed Modifications Topic Areas	Modification Information	RAP Section Location	SME Assigned	Lessor Determination: Further Action Needed/Sufficient?	Lessee Response	Lessor Determination: Further Action Needed? Complete? Sufficient	Lessee Response
(1) Site Assessment Activities	No longer intent to install the three metocean instrumentation platforms; Instead a small wave and current buoy will be deployed approximately 2 months prior to construction; Buoy will be in place for less than one year.	Section 1.1	PCB EBRE	**Insufficient** This is a change from the approved RAP which states in 1.1 (¶ 3 page 1-1) (*In connection with VOWTAP, Dominion proposes to install three stand-alone metocean instrumentation platforms for the purpose of collecting oceanographic measurements in the Project area. This innovative data collection effort is evaluated in a separate Site Assessment Plan (SAP), and is therefore not further discussed in this document.*) A SAP was submitted and then withdrawn and was never approved. The current approved RAP does not contain buoy deployment for metocean testing. The current approved RAP only considers buoys along the cable and multiple buoys along the construction area as described in 4.14.1.2 (¶ 4 page 4-172) for navigation lighting. This would be the first approval of a small buoy specifically for the metocean activities. Metocean waverider buoy details are found in withdrawn VOWTAP SAP but should be included in the RAP modification request. Please submit additional information on these facilities and the location(s) intended for installation.	Dominion intends to deploy a metocean buoy approximately 2 months prior to offshore construction to monitor real time weather conditions in the project area prior to and during construction. The buoy will remain in place for the duration of construction and be decommissioned when construction has been completed. The approximately deployment of the buoy will be March 1 to October 1, 2020. Buoy specifications: • 0.5 m to 1.5 diameter • Impact resistant stainless steel hull • Powered by lead acid or lithium batteries charged by solar panels • Solar panels will be mounted on the top half of the buoy (a transmission antenna and a navigational flashing light may also be installed on the top half of the buoy) • The mooring will consist of an anchor weight of e.g. 800kg, and a mooring line consisting of a combination of ropes and chains, and possibly floats. Shackles and eyes will ensure what deployment and decommissioning will take place in the safest and simplest way possible. • The mooring radius scope (watch circle) is 55m for a standard wave buoy configuration. A buoy with positive buoyancy will be placed a couple of meters from the clump weight preventing entanglement and seabed sweeping. • The footprint of the clump weight on the seafloor is anticipated to be approximately 1 m2 • Anticipated vertical penetration into the seabed is expected to be no more than 1m. • Deployment will take place with an audited and certified vessel, cleared by the Ørsted vessel audit team. The vessel will be fitted with a crane to safely deploy (and collect) the wave		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
					buoy. The wave buoy will be deployed and commissioned by a third-party, one of Ørsted's suppliers. After completion of the installation, the wave buoy will be decommissioned. It is currently anticipated that deployment and decommissioning will be performed using a dynamically positioned vessel. • The buoy will be deployed approximately 500 m east of the turbine locations – in the general vicinity of the following coordinates - 75,485765 Longitude; 36,891659 Latitude (WGS84); Northing 4082963,205, Easting 456717,2748 NAD83 (2011) UTM18N; - based on 2013 survey information, approximate water depths at the deployment location are 25 Meter MLLW		
(2) Permits, Approvals, and Consultations	Many of the current permits may require updating or reassessment (see Attachment 2 – revised Table 1.3.1).	Section 1.3.1	Bigger Hooker X Warner Hoffman Reeb X Stillings X Slayton	**Insufficient** EFH Assessment will need to be updated (see EFH comments below). ESA consultation determination cannot be made until the acoustic analysis of pile driving is corrected and updated in the Acoustic Monitoring Report. (Additional clarification is outlined below in row (11) Underwater Acoustic Modelling.) Within *Attachment 2 Revised Table 1.3.1. Permits, Approvals, and Consultations* additional clarification is needed regarding compliance with CZMA – Dominion will need to coordinate directly with VA DEQ to inform them of the modifications to the project scope. Dominion must confirm with VA DEQ that the project is still consistent to the maximum extent practicable with the enforceable policies of Virginia's coastal management plan. Please copy BOEM on all correspondence.	The underwater acoustic modelling has been updated and is included as Attachment 8 to the amendment. Dominion has also committed to use of a double bubble curtain during pile driving activities to minimize acoustic impacts. An assessment of effect of the double bubble curtain has been included in the revised Underwater Acoustic Modelling Report. Dominion submitted a letter to VDEQ on April 24, 2018 requesting concurrence that a supplemental Federal Consistency Certification will not be required for the Project modifications. Dominion will provide a copy of the response when received, to BOEM. Dominion is currently in the process of compiling additional Information in response to a request from DEQ on May 9, 2018.		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
(3) Certification Verification Agent Scope of Work	Some revisions to the CVA Scope of Work. ***Revised CVA SOW will be provided under separate cover when details are finalized.***	Section 1.6 and Appendix B	PCB ETRB BSEE Sid Falk Dan O'Connell	**Insufficient** See: "Attachment A" CVA Comments BOEM CVOW Mods	A comment response matrix, and clean and redline versions of the revised CVA SOW were provided to BOEM on March 15, 2018.		
(4) Wind Turbine Generator Specifications	Changes to the WTG specifications to include the following (see revised Table 3.2-1): -hub height -Turbine minimum height -Turbine height -Base height -Blade length -Blade width -Rotor speed WTG will be equipped with Power Boost technology which is software to enhancement that will enable the WTGs to generate up to 6.3 MW under certain operational conditions.	Section 3.2.1	All SMEs	**Sufficient**	No action.		
(5) Turbine Foundation	WTG will be supported by monopile and transition piece (MP/TP) instead of the Inward Battered Guide Structure (IBGS or Twisted Jacket) foundation.	Section 3.2.2	All SMEs	**Sufficient**	No action.		
(6) Turbine Foundation Installation Strategy	**Change in transport** – the MP/TP foundation will be carried out by Self-Propelled Jack –Up Vessel and transported to the Project site from Canadian pre-assembly feeder port in either Halifax, Nova Scotia or Saint John, New Brunswick on the deck of the Self-Propelled Jack-Up Vessel. **Change in Scour Protection** There is an increase in potential for scour protection; the MP/TP foundations will	Section 3.3.4.2	HookerX Dahar Reeb X ETRB: All SMEs	**Insufficient** See section (11) Underwater Acoustic Modelling pertaining to the acoustic modeling provided for pile driving. Note: Initial and periodic scour monitoring will be required to ascertain need for and effectiveness of scour protection measures.	The underwater acoustic modelling has been updated and is included as Attachment 8 to this amendment. Dominion has also committed to use of a double bubble curtain during pile driving activities to minimize acoustic impacts. An assessment of effect of the double bubble curtain has been included in the revised Underwater Acoustic Modelling Report. Noted. Dominion is currently working with BOEM to explore opportunities for scour monitoring through the RODEO program.		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
	require scour protection. After installation of the foundations, an initial local scour survey will be conducted within 6 months. Note: ***The specific need, type and method of additional scour protection will be determined in consultation with relevant jurisdictional agencies prior to deployment.*** A **hydraulic hammer** will be positioned and the monopile driven to the design penetration depth of 98ft to 105ft (30m to 32m) (see revised drivability assessment in Attachment 4). The maximum expected hammer energy required for piling is 1,000kJ. **Note: The revised pile capacity analysis and pile capacity charts will be provided with the FDR.**						
(7) Export Cable Installation Methods - Communication Cable Crossings	Prior to commencement of Export Cable installation activities, a UXO/DMM investigation will be undertaken. Dominion may elect to shift and/or expand the width of the 200-ft (61m) ROW. ***If Dominion determines that a change is necessary, the ROW will not be moved or expanded beyond the limits of the previously surveyed 984ft (300m) corridor.*** The Export cable will cross over one fiber optic communication cable that was installed after the approval of the RAP. • Specific details of the crossing design will be agreed upon with the fiber optic cable	Section 3.3.4.3	PCB ETRB: Jennifer Miller	**Sufficient** Note: The export cable will currently cross two permitted telecom cables permitted by USACE and FCC installed across the project easement and likely up to 3-4 by 2020.	No action.		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
	owners, and in accordance with the related International Cable Protection Committee (IPCP) recommendations, 1 the crossing design will comprise placement of a "separation layer" of either rock placement or mattresses on which the Export Cable will be installed. A "protection layer", also consisting of rock placement or mattresses, will then be installed over the Export Cable. Additional protection may be provided, as needed, to the Export Cable by means of a cable protection system comprised of a number of articulated plastic or metal collars around the cable. Upon completion of the Export Cable laying activities, post-lay surveys will be conducted from the installation vessel to verify cable burial depth and installed location						

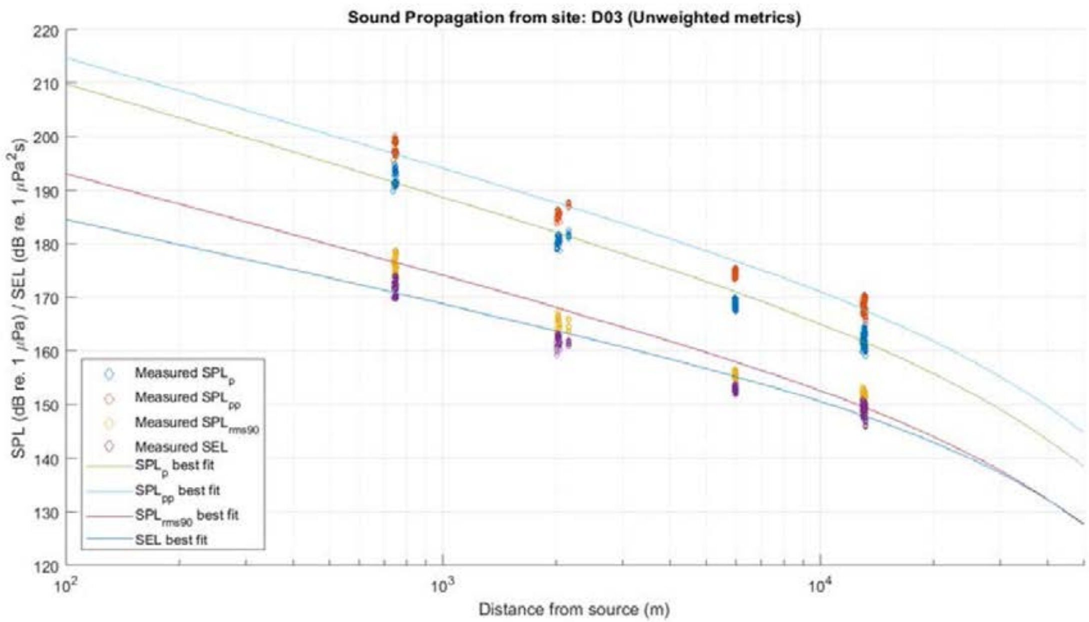
§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
(8) Onshore Interconnection Cable Route	Camp Pendleton is requiring a Modification to the Onshore Interconnection Cable Route which is required to support the construction and operation of the Onshore Interconnection Cable and Fiber Optic Cable. The onshore facility construction and operation footprint is shown in the revised Table 3.2-6.	Section 3.1.2, 3.2.5 and 3.3.2.2	PCB Hoffman Warner Bigger Stillings ETRB: Jennifer Miller	**Insufficient** See "Attachment B" Comments related to Section 106 Consultation BOEM CVOW Mods Provide a legible Figure 5 with a scale and .shp file for the Comparison of Onshore Route Approved in RAP and Proposed New Onshore Route. Note: The plan modification also states that the route is still being negotiated. BOEM requires notification if the planned cable route changes and/or installation methods change.	Figure 5 of the amendment has been updated and a shapefile of the modified cable route and alternatives has been provided with this submittal. Dominion will provide the final details of the easement when negotiations with Camp Pendleton have been completed. In response to comments included in Attachment B – comments related to Section 106 Consultation – and additional guidance provided by BOEM during the bi-weekly call on March 29, Dominion has revised the Terrestrial Archaeology Survey Report and prepared amendments to the Marine Archaeological Resources Assessment, The Historic Structures Assessment and the Visual Impact Assessment. The revised report and amendments have been provided as attachments to this amendment as follows: • Attachment 3 – Amendment to Marine Archaeological Resources Assessment • Attachment 5 – Amendment to Visual Impact Assessment • Attachment 10 – Revised Terrestrial Archaeology Survey Report • Attachment 11 – Amendment to Historic Properties Assessment		
(9) Offshore Deployment and Construction	Dominion is considering the use of helicopters for crew transfer during construction, if so Dominion will consult with FAA, U.S. Navy, Camp Pendleton, the USCG and any other relevant regulatory agencies and stakeholders.	Section 3.3.4	PCB ETRB Sid Falk Dan O'Connell BSEE	**Sufficient** Note: In the event that non-emergency extractions are used for routine crew transport, all applicable aviation and safety regulations for marking, lighting, landing pad design, aircraft choice, air traffic control, PPE, etc. will be adhered to. BSEE safety and aviation personnel should be alerted ASAP when this decision is made to coordinate requirements.	No action.		
(10) Project Construction Schedule	Update project schedule (see revised Table 3.4-1)	Section 3.4	PCB All SMEs	**Sufficient**	No action.		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
(11) Underwater Acoustic Modelling	The geometry of the foundation has changed and instead of four separate hammering events per foundation, each monopile foundation only require continuous hammering event. ***Note: A revised acoustic impact analysis has been prepared, utilizing the new technical guidance from NOAA for the method of defining the Level A harassment threshold. The revised Underwater Acoustic Modelling Report is provided in Attachment 5and replaces Appendix M-2 of the approved RAP.***	Section 4.15.2	Reeb Hooker	**Insufficient** Acoustic modeling for fish is currently insufficient. Table 9 in acoustic modelling report needs to include several additional thresholds for fish (information to be provided in "Attachment C Comments related to Fish Acoustic Criteria). The following information is required in order to assess the potential acoustic impacts of the proposed pile driving activities on marine protected species: Page 52 Section 3.1 of Acoustic modeling report: Per NMFS Guidance, in order to assess the potential impacts of impulsive sounds, SELcum and PK reference values are both required to be calculated since these are dual metric acoustic thresholds for impulsive sounds. It is not an either/or scenario as the text explains. Although the dBpeak may dominate the two criteria for a single strike, the energy from cumulative strikes needs to be added up appropriately since after approximately 10 strikes, the SELcum energy will supersede the dBpeak energy, therefore Table 2 dBpeak threshold values for Level A harassment alone, are not sufficient. Page 59-60 Section 4.3 Table 5 of Acoustic modelling report: References need to be provided for where the source level information for wind turbine operation, impact pile driving, cable lay operations and DP vessels was derived in order to assess the appropriateness of these data.	The underwater acoustic modelling has been updated and is included as Attachment 8 to the amendment. Dominion has also committed to use of a double bubble curtain during pile driving activities to minimize acoustic impacts. An assessment of effect of the double bubble curtain has been included in the revised Underwater Acoustic Modelling Report. The technical report has been updated to include distances to SELcum thresholds. The pile driving analysis was updated to reference the following study which was deemed most representative of the foundation type and water depths at the CVOW site: *NIRAS Consulting, Ltd 2017. Walney Extension Noise Monitoring Survey Report. Completed on behalf of DONG Energy Walney Extension (UK) Ltd.* The cable lay and wind turbine installation vessel proxy source level were chosen to be consistent with the original VOWTAP hydroacoustic modeling report and deemed representative by Orsted for the vessels planned for use for the present CVOW construction activities. Dominion will		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
					conduct field verifications of actual impact pile driving and DP vessel thruster noise during installation of the CVOW monopile foundations and the Inter-Array and Export Cables for model validation purposes and to further determine the effectiveness of the mitigation measures employed.		
				Page 65 Section 5.3 of Acoustic modeling report: Clarify how many days will be required to install each foundation 2 or 4 days? How many blows/strikes are anticipated using a 1000 kJ hammer?	Each foundation will take one day to install. The drivability assessment predicts an upper bound estimate of 1,333 blows for the first foundation (position A01) and 2,470 blows for the second position (position A02) at a rate of 30 blows per minute. The number of blows would be reduced if all were to occur at the 1000 kJ impact force but use of this hammer force is expected for final pile seating, only.		
				Page 66 Section 5.4 of Acoustic modeling report: References need to be provided for proxy sources and measurement data for operational noise.	The operational noise proxy source is: Institut für technische und angewandte Physik GmbH (2005). Ermittlung der Schalldruck-Spitzenpegel aus Messungen der Unterwassergeräusche von Offshore-WEA und Offshore- Rammarbeiten. Additional reference was made in the report to *Nedwell, J.R., Langworthy, J., and Howell, D. 2004. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise. Subacoustech Report Reference: 544R0424, November 2004, to COWRIE.* Previous assessments indicate that operational underwater noise from wind turbines will be low level. Though not all are public documents, these technical reports indicate		

§ 585.634 (a) (c) and (d) Requirements							
Proposed Modifications Topic Areas	**Modification Information**	**RAP Section Location**	**SME Assigned**	**Lessor Determination: Further Action Needed/Sufficient?**	**Lessee Response**	**Lessor Determination: Further Action Needed? Complete? Sufficient**	**Lessee Response**
				Page 17 Table 4.15 of RAP Amendment and Page 66 Table 9 of Acoustic modeling report: As explained above, NMFS Guidance requires the use of dual criteria SELcum and dBpeak in order to determine the PTS thresholds for impulsive sounds, these dBpeak PTS Onset results are lower than anticipated (Koschinski and Ludemann, 2013). It is unclear whether the NMFS spreadsheet, as discussed in the NMFS acoustic guidance, was used to calculate impact radii to PTS thresholds.	operational source noise levels 10 – 20 dB above background noise levels in the immediate area. Predictions of peak levels in the acoustic nearfield can be challenging. Therefore, the distance to thresholds were derived directly from the Walney Extension pile driving FV report referenced previously and normalized to the project site and expected impact hammer force. Please note that in the plot provided after the matrix, the PEAK sound level is shown in blue.		
(12) Construction and Operations Air Emissions	The revised calculations will be used to support the general conformity determination and OCS Air Permit filing, as well as BOEM's NEPA review. ***Note: A revised Air Emission Calculations and Methodologies Report will be provided under separate cover.***	Section 4.16	Slayton	**Sufficient**	No action.		
(13) Vessels in Distress	Dominion committed to making the WTG foundation available as a mooring location and refuge for vessels in destress. Note: After further consideration, Dominion would like to remove this committed from the approved RAP, reasoning for this change is outlined in Attachment 6 which was submitted to USCG for consideration on December 15, 2017.	Section 4.18.7	PCB ETRB	**Sufficient**	No action.		

Additional information in resposne to comment 11 above



Sound transmission loss curve fit for all relevant metrics, based on recorded pile strikes during installation at D03, adjusted to maximum hammer energy (3500 kJ).

Attachment 3

Amendment to Marine Archaeological Assessment
(RAP Appendix N)

CONFIDENTIAL – Provided Under Separate Cover

Attachment 4

Permits. Approvals, and Consultations

(RAP Table 1.3.1)

Revised Table 1.3.1. Permits, Approvals, and Consultations

Permit, Approval, or Consultation	Regulatory Authority	Filing Date/Status	Approval/Anticipated Approval Date	Status
FEDERAL				
OCS Lands Lease pursuant to the OSCLA (43 USC §§1331 et seq.) and BOEM implementing regulations (30 CFR Part 585)	BOEM	Q4 2013	Q1 2015	BOEM published request for competitive interest in Federal Register on December 21, 2012. On December 6, 2013 BOEM issued DMME a determination of no competitive interest for the proposed Research Lease. On March 23, 2015, BOEM issued the Research Lease.
Individual Permit pursuant to Section 10 Rivers and Harbors Act (33 USC § 403) & Section 404 CWA (33 USC §1344)	USACE Norfolk District (VA)	Q1 2019	Q4 2019	Pre-application consultation was initiated in March 2013. Permit authorization was received on December 4, 2014. Dominion will coordinate with the USACE to amend the permit as necessary prior to construction.
Review pursuant to NEPA (42 USC §§4321 *et seq.*) and BOEM regulations (30 CFR §§585.646,585. 648(b))	BOEM, USACE, and DOE	Q4 2017	Q3 2018	Scoping with primary federal permitting agencies has been ongoing since March 2013. BOEM Issued the draft EA in December 2014, and subsequently issued the final revised EA and FONSI on July 22, 2015. Dominion is submitting this RAP Amendment to BOEM to provide the necessary information for them to determine where the proposed project modifications may result in the need for reanalysis of certain resources under NEPA. In the event that BOEM determines reanalysis is needed due to the proposed Project modifications, Dominion will continue to coordinate with BOEM to ensure that all required information has been provided.
Consultation and Incidental Take Authorization (IHA) pursuant to the Marine Mammal Protection Act (MMPA) (16 USC §§1361 *et seq.*)	National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries)	Q3 2019	Q1 2020	Pre-application consultation was initiated in March, 2013. Dominion plans to submit the IHA in Q2/Q3 2019 prior to construction of the CVOW.

Permit, Approval, or Consultation	Regulatory Authority	Filing Date/Status	Approval/Anticipated Approval Date	Status
Consultation pursuant to Section 7 of the ESA (16 USC §§*1531 et seq*.)	NOAA Fisheries, USFWS	Completed	Q2 2015	Pre-application consultation was initiated in March, 2013. The Biological Opinion was issued in March 2016. Dominion is submitting this RAP Amendment to BOEM to provide the necessary information for them to determine where the proposed project modifications may result in the need to reopen Section 7 consultation. In the event that BOEM determines additional Section 7 consultations are needed due to the proposed Project modifications, Dominion will continue to coordinate with BOEM to ensure that all required information has been provided.
Essential Fish Habitat (EFH) Consultation pursuant to the MSFCMA (16 USC §§1801 *et seq.*)	NOAA Fisheries	Completed	Q2 2015	Pre-application consultation was initiated in March, 2013. The Biological Opinion was issued in March 2016. Dominion is submitting this RAP Amendment to BOEM to provide the necessary information for them to determine where the proposed project modifications may result in the need to reopen EFH consultation. In the event that BOEM determines additional EFH consultations are needed due to the proposed Project modifications, Dominion will continue to coordinate with BOEM to ensure that all required information has been provided.
Consultation pursuant to the Migratory Bird Treaty Act (MBTA) (16 USC §§703 *et seq*.)	USFWS	Completed	Q2 2015	Pre-application consultation was initiated in March 2013. Consultation as completed in March 2016. Dominion is submitting this RAP Amendment to BOEM to provide the necessary information for them to determine where the proposed project modifications may result in the need to reopen MBTA consultation. In the event that BOEM determines additional MBTA consultations are needed due to the proposed Project modifications, Dominion will continue to coordinate with BOEM to ensure that all required information has been provided.

Permit, Approval, or Consultation	Regulatory Authority	Filing Date/Status	Approval/Anticipated Approval Date	Status
Consultation pursuant to Section 106 of the NHPA (16 USC §§470 *et seq.*)	VDHR	Completed	Q2 2015	Pre-application consultation was initiated in March 2013. BOEM issued a finding of no adverse effect in April 2015. Dominion is submitting this RAP Amendment to BOEM to provide the necessary information for them to determine where the proposed project modifications may result in the need to reopen Section 106 consultation. In the event that BOEM determines additional Section 106 consultations are needed due to the proposed Project modifications, Dominion will continue to coordinate with BOEM to ensure that all required information has been provided.
Approval for Private Aids to Navigation (33 CFR 66)	USCG	4 months prior to Construction	3 weeks prior to Construction	Proposed lighting and marking was developed in consultation with the USCG was provided in Section 4.14.1 and Appendix R of the approved RAP. The proposed Project modifications will not result in any changes to proposed lighting and marking of the WTGs.
STATE				
Concurrence with Federal Consistency Certification pursuant to Section 307 of the CZMA (16 USC §1451 *et seq.*)	VDEQ , BOEM	Q2 2014	Q3 2014	Federal Consistency Certification was received on 08/07/2014. Dominion submitted the Federal Consistency Certification Conformance Statement on 10/24/2014. Dominion submitted a letter to VDEQ in April 2018 requesting concurrence that a supplemental Federal Consistency Certification will not be required for the Project modifications. Dominion is currently in the process of compiling additional Information in response to a request from DEQ on May 9, 2018. The proposed Project modifications will not result in any changes to Coastal Zone Consistency.

Permit, Approval, or Consultation	Regulatory Authority	Filing Date/Status	Approval/Anticipated Approval Date	Status
Submerged Land (VMRC) Permit (Code of Virginia § 28.2-1200 thru 28.2-1213; 4 VAC 20)	VMRC	Q1 2019	Q2 2019	Pre-application consultation was initiated in March, 2013. The permit was unanimously approved by VMRC at the public hearing held in March, 2015. The final permit was received on March 30, 2014, but processing was put on hold due to the time sensitive nature of the permit (only valid for 5 years from issuance). Based on direction provided by VMRC, Dominion submitted the signed permit with a cover letter outlining the proposed Project modifications and requesting a 3 year extension to VMRC in January 2018. The final, executed VMRC permit was issued on February 28, 2018 with an expiration date of March 31, 2021.
Water Quality Certification under Section 401 of the CWA (33 USC §1341); 9 VAC 25-660 *et seq*.	VDEQ	Q2 2014	Q2 2015	Pre-application consultation was initiated in March, 2013. VDEQ issued a waiver and no permit required letter for the Virginia Water Protection Permit in May 2015. Dominion will coordinate with VDEQ to provide the necessary information for them to determine whether a Virginia Water Protection Permit will be required due to the proposed Project modifications. Dominion does not anticipate that the proposed Project modifications will result in a change to the original determination.

Permit, Approval, or Consultation	Regulatory Authority	Filing Date/Status	Approval/Anticipated Approval Date	Status
Conformity Determination Air pursuant to the Clean Air Act (CAA) (42 USC §§ 7401 *et seq.*; 9VAC5 CHAPTER 30; 40 CFR Parts 50 to 99)	VDEQ	Q1 2018	Q2 2018	Pre-application consultation was initiated in March 2013. VDEQ provided documentation that the CVOW would not require a formal general conformity determination since it was well below the conformity threshold level in December 2014. At the time of the approved RAP, the Hampton Roads area was designated as an ozone maintenance area with respect to the 1997 ozone NAAQS, and was designated to be in attainment with respect to the 2008 ozone NAAQS. The 1997 ozone NAAQS was revoked by EPA, effective April 6, 2015 (see 80 FR 12264), and, therefore, the Hampton Roads area has ceased to be a maintenance area and is exempt from General Conformity requirements altogether.
OCS Air Permit (40 CFR Part 55; VDEQ 9 VAC 5-80 *et seq.*)	VDEQ	Q1 2019	Q1 2020	Pre-application consultation was initiated in October 2013. The application was submitted to VDEQ in October 2014. The application was deemed complete and sufficient in December 2014, but processing was put on hold due to the time sensitive nature of the permit (only valid for 18 months from issuance). The WTG towers will no longer be equipped with emergency generator engines and, therefore, these towers will not be OCS sources during operation of the Project. Instead, a single emergency generator may be located at the onshore interconnection station, and will be subject to the applicable VDEQ requirements for emergency engine permitting.
Construction Stormwater General Permit Authorization (VAR10; 9 VAC 25-880)	VDEQ	Q2 2019	Q1 2020	Dominion plans to submit the application at least 180 days prior to construction when details are finalized. Application will include a stormwater pollution prevention plan, stormwater management plan, erosion and sediment control plan, registration checklist and registration statement.

Attachment 5

Amendment to Visual Impact Assessment
(RAP Appendix Q)

May 10, 2018

Mr. James Bennett
Director, Office of Renewable Energy Programs
Bureau of Ocean Energy Management
U. S. Department of the Interior
45600 Woodland Road
Sterling, VA 20166

Subject: Amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Visual Impact Assessment Report (Research Activities Plan [RAP] Appendix Q)

Dear Mr. Bennett:

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion, formerly d/b/a Dominion Virginia Power) on behalf of the Virginia Department of Mines, Minerals, and Energy (DMME) is pleased to submit this amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Visual Impact Assessment Report (VIA). The VIA was originally submitted as Appendix Q to the Research Activities Plan (RAP) in December 2013. As part of the RAP approval process, BOEM undertook consultations under Section 106 of the National Historic Preservation Act (NHPA) (54 United States Code [U.S.C.] §300101), and it's implementing regulations (36 Code of Federal Regulations [CFR] 800). As a result of the Section 106 consultations, BOEM prepared a finding of No Adverse Effect (36 CFR 800.5(b)) in April 2015. The Final VOWTAP RAP subsequently received approval from BOEM on March 23, 2016.

Due to advances in technology since the Project's approval in March 2016, several modifications to the RAP were required to support the Project's current requirements for construction and operation. In accordance with 30 CFR 585.634(c), Dominion submitted a RAP amendment on December 27, 2017 to request BOEM's approval of the proposed modifications to the approved RAP in order to support a Project in service date of 2020. As requested by BOEM in their comments to the RAP amendment provided on February 16, 2018, and further discussed on March 29, Dominion has prepared this amendment to the VIA to support BOEM's evaluation of the Project modifications under Section 106 of the NHPA. This amendment includes updates to the project description, visual impact analysis, and conclusions, based on Project modifications.

PROJECT DESCRIPTION

This section describes the proposed Project location and infrastructure currently under consideration for the CVOW.

Wind Turbines

The CVOW facilities will include two, 6 MW wind turbine generators (WTG), to be located within Federal Lease Block 6111 Aliquot H, approximately 27 mi [24 nm or 43 km] offshore of Virginia Beach, Virginia (Figure 1). The maximum height of each turbine is proposed to range from 591 to 617 feet (ft) (180 to 188 meters [m]), measured from mean sea level (MSL) to rotor tip. This height range is 7 ft to 33 ft (2 to 10 m) taller than the WTG presented in Section 3.2.1 of the approved RAP. The turbines will be sited approximately 3,445 ft (1,050 m) apart in a north-south orientation. In compliance with Federal Aviation Administration (FAA) and U.S. Coast Guard (USCG) regulations, the WTGs will have nighttime lighting. FAA lighting will consist of L-864 medium intensity aeronautical lights with a flash rate of 20 flashes per minute (FPM) atop each WTG nacelle. USCG lighting will consist of two (2) quick flashing, amber lights with 4 nm (7.4 km) 360-degree visibility placed on the foundation of each WTG at a height of not more than 50 ft (15 m) above the highest astronomical tide.

The two turbines will be interconnected with a submarine inter-array cable, referred to as the Inter-Array Cable. Because the voltage of the Inter-Array Cable will be the same as the onshore grid connection voltage (34.5 kilovolts [kV]), no offshore substation is required for the Project, as noted in the approved RAP. The energy produced by the CVOW will be conveyed to shore via an additional 34.5-kV submarine transmission cable, referred to as the Export Cable.

Onshore Facilities

Due to new, previously unknown conflicts with military activities, Camp Pendleton is requiring a modification to the previously approved Onshore Interconnection Cable Route (cable route) which is required to support the construction and operation of both the Onshore Interconnection Cable and Fiber Optic Cable. The modified Onshore Interconnection Cable Route is a combination of segments that were previously evaluated in the alternatives analysis of the approved RAP, as well as some additional areas that have recently been identified as potential alternatives. In addition, the Switch Cabinet where the offshore Export Cable transitions to the Onshore Interconnection Cable may be relocated up to 20 ft (6 m) to the north or east of its original location due to conflicts with the location of a proposed hygiene facility to be constructed in the existing parking lot. Regardless of which segments are selected for the final Onshore Interconnection Cable Route and the final location of the switch cabinet, the final location of the Switch Cabinet will still be located within the existing parking lot and the Onshore Interconnection Cable Route will still be located entirely within the boundaries of Camp Pendleton. The Export Cable landing location and Interconnection Station location will remain the same as what was approved in the RAP, and therefore have not been further analyzed in this Historic Properties Survey Report Amendment. Figure 2 below (Original Figure 3 of Appendix Q of the approved RAP) has been updated to show the modified Onshore Interconnection Cable Route and Switch Cabinet alternatives.

The modified Onshore Interconnection Cable Route will originate at the proposed Switch Cabinet located within an existing parking lot at the end of Rifle Range Road and adjacent to Camp Pendleton Beach, as described above. The modified Onshore Interconnection Cable Route then extends in a northwest direction through the Camp Pendleton rifle range for approximately 900 ft (274 m) to the northwest corner of the rifle range, just south of the Camp Pendleton canine training area. The modified cable route then extends in a generally northern direction for approximately 335 ft (102 m) to a gravel turnaround area, which will serve as an equipment laydown and staging area for the horizontal directional drill (HDD) under Lake Christine. The HDD under Lake Christine will be approximately 935 ft (285 m) long and will run in a west/northwest direction to the cleared area on the western side of the lake. After the Lake Christine crossing, the cable route turns to the southwest, for approximately 350 ft (107 m) through a previously disturbed area.

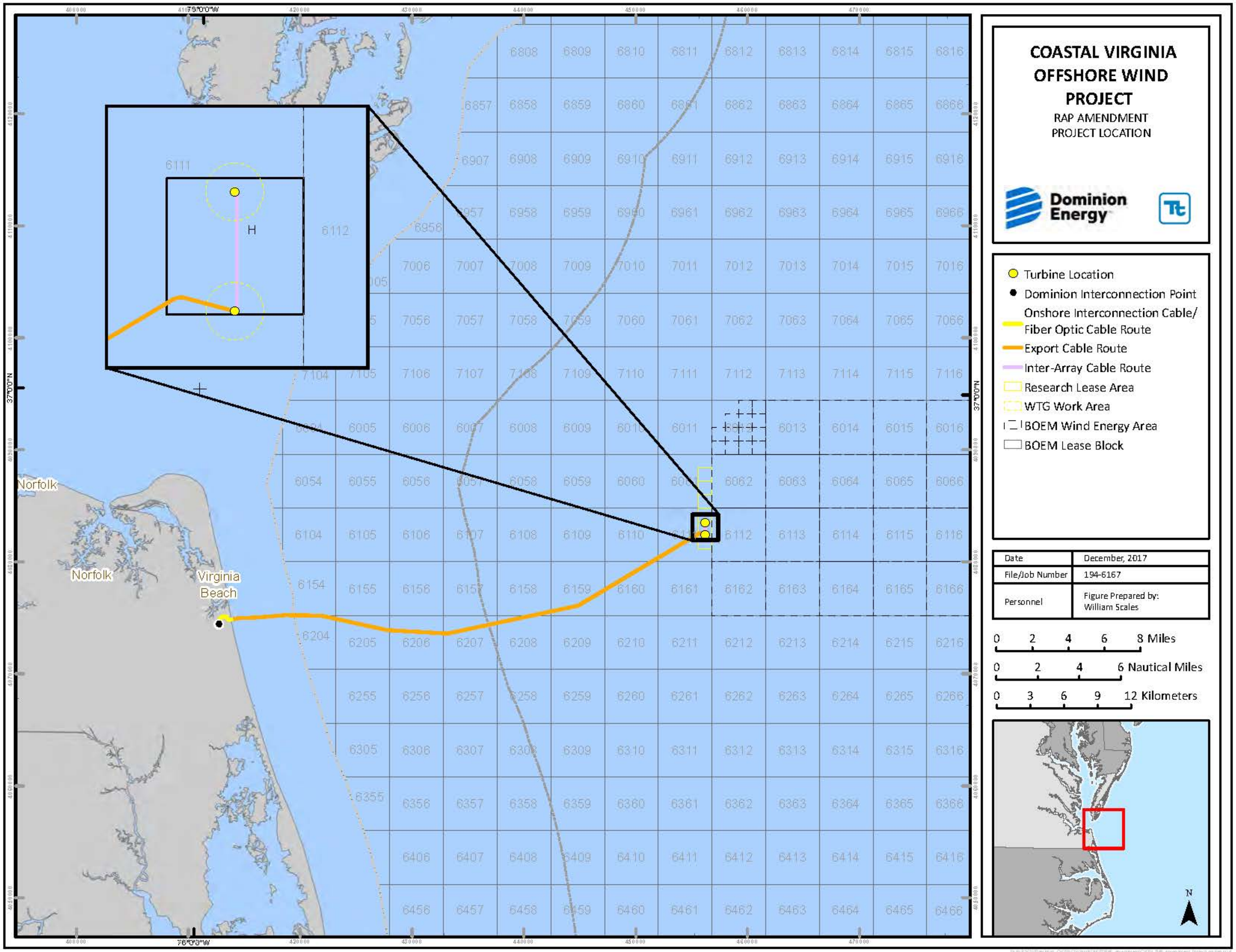


Figure 1. Project Location

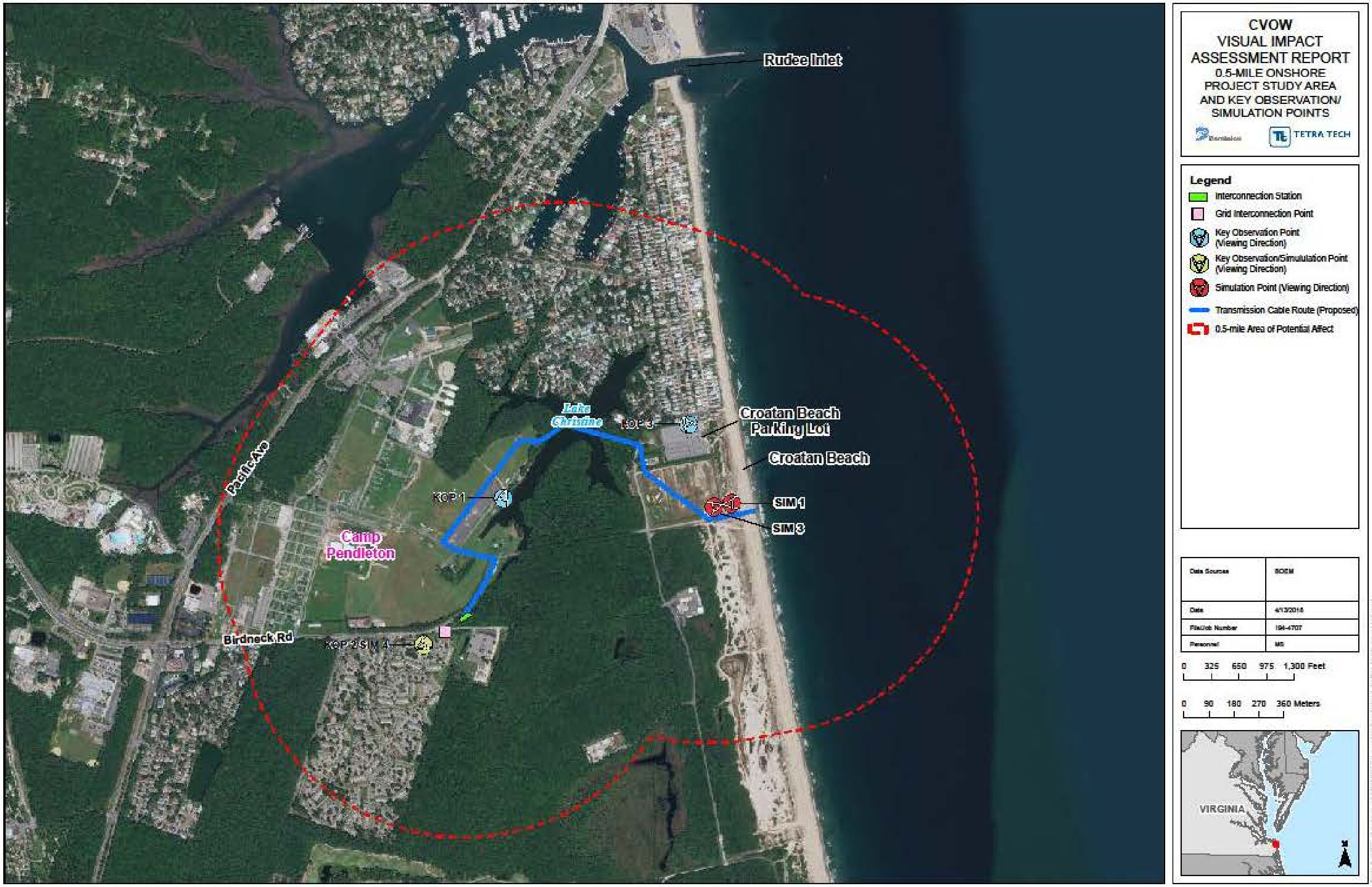


Figure 2. 0.5 Mile Onshore Project Study Area and Key Observation Simulation Points

Alternatively, Dominion may elect to locate the Onshore Interconnection Cable Route beginning at the Switch Cabinet extending in a west-south-west direction along Rifle Range Road for approximately 700 ft (213 m) until reaching the intersection of Rifle Range Road and Regulus Avenue. At the intersection of Rifle Range Road and Regulus Avenue, the Onshore Interconnection Cable Route extends in a general northerly direction for approximately 1000 ft (305 m) until reaching the gravel turnaround area, which will serve as an equipment laydown and staging area for the horizontal directional drill (HDD) under Lake Christine. The HDD under Lake Christine for this alternative will be approximately 1200 ft (366 m) long and will run in a generally west direction to a previously disturbed area located approximately 350 ft (107 m) southwest the cleared area on the western side of the lake.

From this point, there are two alternatives for the Onshore Interconnection Cable Route to be installed along the west side of Lake Christine. The first alternative, which would involve crossing an existing fiber optic cable at a perpendicular angle in two locations, extends west for approximately 230 ft (70 m) to the first perpendicular crossing of the existing fiber optic cable. The cable Route then runs southwest for approximately 1,500 ft (457 m) along the western boundary of a paved helicopter landing area until it reaches Jefferson Avenue. The cable route then runs in an east-southeast direction along Jefferson Avenue for approximately 670 ft (204 m) until the second perpendicular crossing of the existing fiber optic cable before reaching the intersection of Jefferson Avenue, Rifle Range Road, and the Gate 10 Access Road. The second alternative, which would not require a fiber optic cable crossing, would extend in a generally south-south-west direction for a distance of approximately 1550 ft (472 m) down the east side of Lake Road, approximately 30 ft (9 m) east of the shoulder, to a location approximately 30 ft (9 m) north of Jefferson Avenue. From this location, the Onshore Interconnection Cable route would extend in a generally westerly direction for a distance of approximately 370 ft (112 m), before turning to the south for a distance of approximately 50 ft (15 m) until reaching the intersection of Jefferson Avenue, Rifle Range Road and the Gate 10 Access Road.

From the intersection of Jefferson Avenue, Rifle Range Road and the Gate 10 Access Road, the cable route extends approximately 750 ft (229 m) down the center of an access road to the proposed Interconnection Station located just north of an entrance for Camp Pendleton at Gate No. 10 (Gate 10 Access Road) off South Birdneck Road. As described in the approved RAP, the cable route then continues from the Interconnection Station on the Gate 10 Access Road approximately 207 ft (63 m) to interconnect with Dominion's existing electrical infrastructure located on the south side of South Birdneck Road. The total length from the Switch Cabinet at Camp Pendleton Beach to Dominion's existing electrical infrastructure ranges from approximately 1.1 mi (1.8 km) to1.2 mi (1.9 km). Determination of the final Onshore Interconnection Cable Route and the Switch Cabinet location will be dependent on the outcome of ongoing easement negotiations between Dominion and Camp Pendleton. Dominion will provide a copy of the final easement to BOEM when it is finalized.

Between the Switch Cabinet at Camp Pendleton Beach and the Interconnection Station on the Gate 10 Access Road, the Onshore Interconnection Cable and Fiber Optic Cable will be installed via a series of HDD segments, as approved in the RAP. No direct burial or trenching is proposed for the onshore cables, which is also consistent with what was included in the approved RAP. However, due to the longer route, the Onshore Interconnection Cable and Fiber Optic Cable will be installed in 13 segments, instead of the 12 segments detailed in the approved RAP. Each HDD segment will range from approximately 230 ft (70 m) to 500 ft (152 m) in length, with the exception of the Lake Christine crossing, which will range from approximately 935 ft (285 m) to 1200 ft (366 m) in length.

The modified cable route will require the use of up to 14 splice pits, which is an increase of 1 pit relative to the approved RAP. The size of each splice pit remains the same and will require the excavation of a 4.0 ft by 6.0 ft by

2.0 ft (1.2 m by 1.8 m by 0.6 m) splice pit. As installation conditions allow, longer HDD segments may be feasible such that fewer splice pits may be required. The splice pits and associated excavated soils will be located within the proposed construction right-of-way and will not require expanded workspaces. Upon completion of cable splicing activities, the excavated material will be returned to the splice pits, compacted, and returned to pre-construction conditions. The splice pit will serve as the location where the cable drilling will either be initiated and/or received. No drilling muds will be required to complete the installation of the Onshore Interconnection Cable or Fiber Optic Cable. All activities will occur along the paved roadways and within the existing cleared areas along the route.

From the proposed Interconnection Station at the Gate 10 Access Road, the Interconnection Cable and Fiber Optic Cable will be installed with one final HDD for an additional 207 ft (63 m) to interconnect with Dominion's existing electrical infrastructure located on the southern side of South Birdneck Road, as described in the approved RAP.

To support the construction and operation of the Onshore Interconnection Cable and Fiber Optic Cable, Dominion proposes a 30 ft (9.1 m) temporary construction right-of-way along the entirety of the route for installation of the cable. Upon completion of construction, 15 ft (4.6 m) will be retained as a permanent easement for access during operation. The Onshore Interconnection Cable and Fiber Optic Cable will be installed in separate boreholes approximately 3 ft (0.9 m) apart and buried to a minimum depth of 3.3 ft (1 m) to be consistent with local utility standards. As an option, the fiber optic cable could be installed in conduit allowing fewer splices. The conduit would be installed by HDD and the fiber optic cable pulled back through the conduit.

PROJECT STUDY AREA

A 25-mi (40-km) Project Study Area was established in the original VIA (Appendix Q, Section 4.1 of the approved RAP). The study area was based on the offshore components of the Project and the results of a study prepared for BOEM, *Preliminary Assessment of Offshore Wind Turbine Visibility and Visual Impact Threshold Distances*. This study found that small to moderately sized wind facilities (wind farms with turbine hub [nacelle] heights ranging from approximately 219 feet to 295 feet (66.8 m to 90 m) above MSL "were noticeable to casual observers at distances of almost 18 mi (29 km); and were visible with extended or concentrated viewing at distances beyond 25 mi (40 km)" [Sullivan et al. n.d]. The currently proposed WTGs for the Project will be 341 to 364 ft (104 to 111 m) from MSL to the nacelle, approximately 3 to 26 ft (0.9 to 8 m) higher than the WTG as presented in Section 3.2.1 of the approved RAP, and 46 to 69 ft (14.02 to 21.03 m) higher than the turbines observed in the BOEM study. At locations beyond the identified 25-mi (40-km) Project Study Area, it is not anticipated that the difference in height between the WTG as presented in Section 3.2.1 of the approved RAP and the currently proposed WTGs (approximately 3 to 26 ft [0.9 to 8 m]) would be noticeable to the casual observer. Therefore, no changes to the 25-mile Project Study Area were made as a result of the current Project modifications.

Additionally, a 0.5-mi (0.8-km) Project Study Area was used for assessing visual effects for aboveground onshore facilities (i.e., Switch Cabinets, Interconnection Station, and preferred and alternative Onshore Interconnection Cable and Fiber Optic Cable routes) in the original VIA (Section 4.1 of Appendix Q). The 0.5-mi (0.8-km) buffer was determined based upon the scale of the onshore components and the wooded vegetation coverage of the surrounding landscape. Since the location of the aboveground onshore facilities have not changed and the modified cable will be installed underground, no changes to the 0.5-mi (0.8-km) Project Study Area were made as a result of current Project modifications.

VISUAL ANALYSIS AND CONCLUSIONS

It is not anticipated that Project modifications as described above will result in major changes to visual impacts originally described in Section 5 of Appendix Q of the RAP.

Offshore Facilities

The overall construction period would decrease by approximately one month. On a short-term basis during the construction period for the currently proposed offshore Project components, viewers onshore would be able to observe marine traffic associated with Project construction. Currently proposed modifications to the WTGs would not affect the anticipated volume of Project-related vessel traffic, since there are still only two WTGs proposed. As noted in Section 5.5 of Appendix Q of the approved RAP, based on the small volume of Project- related vessel traffic relative to baseline marine traffic, it is not likely that many viewers would perceive a change.

On a long-term basis, during operation of the Project, viewers along the Virginia Beach coastline may have limited visibility of a portion of the WTGs, but the WTGs would likely not be noticeable to the casual observer. The maximum additional height of the proposed WTG is 33 ft (10 m) taller than the WTG presented in Section 3.2.1 of the approved RAP. This change in turbine height would equate to a change of 0.0038 inch (0.0965 mm) to the turbines shown in Simulations 1 through 5 in Appendix Q, Attachment B of the approved RAP, which were originally created to be true to scale when viewed at a distance of 18 in (457 mm).

In Section 5.3 of Appendix Q, it noted that superior viewing locations are not common along the Virginia Beach coastline. However, since Appendix Q was originally submitted as part of the RAP in 2015, hotels have been built along the Virginia Beach coastline that are taller than those that existed in 2015. Viewers with a superior viewing position from the upper levels of these new hotels, would have unobstructed views toward the offshore Project Area. A photographic simulation was created from the Hilton Virginia Beach Hotel rooftop pool and included with this amendment as Simulation 6. Simulation 6 was created so that it is true to scale when viewed at a distance of 20 in (508 mm). At a distance of 27 mi (43 km) and a viewing elevation of 185 ft (56.3 m), 71 ft (21.6 m) of the WTGs would be obscured (i.e. below the horizon line). Although a majority of the WTGs would be above the visible horizon, weak contrast would be created due to the distance of the WTGs from the viewer and the WTGs would be seen in the context of existing vessels within the bay and along the coast. The WTGs may potentially attract a viewer's attention but would not dominate the characteristic landscape.

Visual impacts as described in Section 5.3 of Appendix Q would not change for viewers associated with Chesapeake Bay Bridge Tunnel/U.S. 13 (CBBT) and sensitive viewers located away from the coast, including residents, recreational uses associated with First Landing State Park, and along travel routes, as a result of Project modifications. For viewers associated with the CBBT, at a distance of 35 mi (56 km) from the offshore Project Area, the WTGs would be completely below the horizon line and would not be visible. Sensitive viewers located away from the coast, would not have views of the offshore Project Area, because they would be completely screened by urban development and vegetation.

Onshore Facilities

On a short-term basis during the construction period for onshore Project components, visual impacts would be similar to those described in Section 5.5 of Appendix Q of the approved RAP. Viewers would be able to observe construction equipment, construction laydown areas and crews. Varying degrees of visual contrast would occur when equipment and construction crews are present; however, contrast would be short-term since equipment and support facilities will be removed once construction in a specific location is complete.

As noted in the updated Project Description, the termination points for the modified Onshore Interconnection Cable Route have not changed, and as a result, the Interconnection Station and cable landing location have not moved. Since no modifications are proposed to the Interconnection Station and cable landing location, and the slight relocation of the Switch Cabinet within the exiting parking lot will be obscured by the hygiene facility, visual impacts as noted in Section 5.3.1 - Key Travel Routes, Section 5.3.2 - Recreation Areas, and 5.3.2.4 – Residences of Appendix Q, would remain the same.

Attachment 6

Revised Foundation Typical Drawing

(RAP Appendix D-1)

CONFIDENTIAL – Provided Under Separate Cover

Attachment 7

Revised Drivability Assessment
(Appendix F of RAP Appendix F-2)

CONFIDENTIAL – Provided Under Separate Cover

Attachment 8

Revised Underwater Acoustic Modelling
(RAP Appendix M-2)

Coastal Virginia Offshore Wind Project (CVOW)

UNDERWATER ACOUSTIC MODELING REPORT

Dominion Energy

5000 Dominion Boulevard

Glen Allen, VA 23060

Submitted May 2018

EXECUTIVE SUMMARY

The construction and operation of offshore wind turbines generates underwater sound that can potentially have an environmental impact on the marine life in the area. An underwater noise propagation study has been performed to be used to assess the potential environmental impacts on marine mammals and fish for the proposed Coastal Virginia Offshore Wind Project to help inform Section 7 consultations.

Underwater sound emissions were modeled to cover the range of offshore construction scenarios. Modeling for the purpose of estimating the distances to regulatory thresholds from individual piling events is intended to help indicate the realistic worst-case scenarios for the specific hearing sensitive marine species. This modelling included calculating the maximum received sound levels across the entire water column with depth. In addition, a number of wind turbine foundation and cable lay installation scenarios were reviewed. Modeling results are presented with reference to sensitive marine mammal and fish receptors. Careful consideration was given to bathymetric features and sediment type as the environmental parameters that, if varied, will have the greatest effect on sound propagation.

The initial noise propagation study was performed based on the available knowledge for impact assessments for offshore wind turbine installation at the commencement of the study, which involved the extrapolation of data. This update to the initial noise propagation study was performed to extract the relevant model input parameters from an offshore construction field verification study involving the same prototype foundation design and pile driving mechanism with the installation occurring in a similar offshore setting as the CVOW project. This new information served to form the basis of subsequent calculations. This technical study has also been updated to address NMFS Guidance to more accurately assess the potential impacts of impulsive sounds. Both SELcum and Peak thresholds are presented since these are considered dual metric acoustic thresholds for impulsive sounds. However, the potential for the onset of auditory injury from prolonged exposure is subject to many uncertainties regarding species-specific as well as individual response mechanisms.

For pile driving, the study was revised to represent the full range of hammer energies that would be experienced throughout a typical piling sequence. The levels modeled comprise 600 kJ (representative initial piling) to 1,000 kJ (worst case) using the updated source terms and frequency spectrum. The propagation model used to estimate the potential ranges of impact was based on an energy flux approach which calculates the sound energy transmitted through the water column. The resulting sound contour isopleths have been projected as SEL, as a function of range for the worst-case pile driving location based on the drivability report, and are provided in Appendix A. The regulatory assessment impact threshold limits are given in Section 3 and modeling results and distances to these thresholds are summarized in Section 5. The updated technical analysis also includes the evaluation of bubble curtain systems as a potential mitigation strategy to reduce sound.

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LIST OF ACRONYMS

Acronym	Definition
µPa	micropascal
BBC	Big bubble curtain
CRM	Coastal Relief Model
cSEL	cumulative sound exposure level
dB	decibel
dBA	A-weighted decibel
Dominion	Virginia Electric and Power Company, a wholly owned subsidiary of Dominion Resources, Inc.
DP	dynamic positioning
ESA	Endangered Species Act
FEED	Front End Engineering Design
GAP	General Activities Plan
GEODAS	Geophysical Data System
HF	high frequency cetaceans
Hz	hertz
IBGS	Inward Battered Guide Structure
kHz	kilohertz
kJ	kilojoule
LF	low frequency cetaceans
MF	mid-frequency cetaceans
MMPA	Marine Mammal Protection Act
MW	megawatt
m^3	cubic meter
NAD	North American Datum
NGDC	National Geophysical Data Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer continental shelf
PE	Parabolic Equation
PTS	permanent threshold shift
RAM	Range-dependent acoustic model
RAMGeo	RAM modified for range-dependent sediment layers
R_{max}	maximum radial distance
R_{mean}	average radial distance
SEL	sound exposure level
SELcum	cumulative sound exposure level
SPL	sound pressure level
SSP	sound speed profile
TL	transmission loss
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VOWTAP	Virginia Offshore Wind Technology Advancement Project

WFA	weighting factor adjustment
WTG	wind turbine generator

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1 INTRODUCTION

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion, formerly d/b/a Dominion Virginia Power) is proposing the Coastal Virginia Offshore Wind Project (CVOW or Project [formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP]), a 12 megawatt (MW), two turbine offshore wind demonstration project located approximately 24 nautical miles (27 statute miles, 43 kilometers) offshore of the City of Virginia Beach, Virginia (Figure 1). Other offshore Project facilities include a 34.5 kilovolt (kV) Inter-Array Cable that will interconnect the two CVOW wind turbine generators (WTGs), and a 34.5 kV Export Cable that will convey electricity from the offshore WTGs to a landfall site located in Virginia Beach, Virginia (Figure 1).

Dominion is aware that construction and operation of the Project has the potential to cause acoustic harassment to marine species, in particular marine mammals, sea turtles, and fish populations. This updated technical appendix presents the acoustic modeling methodologies, as applied, to estimate the expected underwater noise levels generated during construction and operation of the proposed Project, including impact pile driving of wind turbine foundations, which is expected to generate the highest underwater sound levels. This acoustic analysis included the following steps completed in accordance with established protocols and best engineering practices:

- **Establish existing conditions** – Review literature and measurement data completed within the study area to assess the general underwater acoustic environment.
- **Source level development and acoustic modeling** – Determination of representative scenarios to describe the resultant underwater sound levels for specific construction and operational activities. Use of a computer-based model simulation to forecast exclusion zones for marine mammals.
- **Data interpretation** – Results used by marine biologists and fisheries experts to assess potential impacts and determine species-specific mitigation measures.
- **Noise mitigation analysis** – A preliminary review of candidate noise mitigation strategies to meet permitting requirements and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) regulations, with an emphasis on pile driving activities.
- **Compliance assessment** – To provide a demonstration of the feasibility of the Project to be constructed and operated in compliance with all applicable requirements and be adequately protective of all marine aquatic life.

The spatial distribution of received noise has been analyzed encompassing three construction scenarios, four unique cable lay construction locations, two pile driver hammer energies, and an estimation of underwater sound levels during future wind turbine operation. These modeling scenarios were developed in direct cooperation with the Project's engineering team to ensure an accurate representation of the activities and anticipated construction methods. Underwater noise levels were modeled with the widely-used and publicly available Range Dependent Acoustic Model (RAMGeo), based on the U.S. Navy's Standard Split-Step Fourier Parabolic Equation. The underwater acoustic propagation model accounted for the variation of the bathymetry, geoacoustic properties of the sea bottom, and seasonal variations of the sound speed profile in the water column, notionally bracketing the directional upper and lower propagation bounds (longest and shortest propagation distances) in terms of the acoustic footprint. The acoustic source levels for the construction and operational activities were estimated using best practices based on realistic proxies, suitably scaled where appropriate. The pile diameter and associated impact force in addition to the type, size, and propulsion power of typical vessels that may be utilized were considered in these estimations.

This study also included an extensive background literature review in order to obtain relevant information on similar offshore construction noise measurements data from offshore wind farm projects currently in operation for the purposes of model validation. The underwater noise modeling analysis includes an overview of applicable regulatory criteria and scientific based thresholds, and a detailed discussion of the acoustic analysis methodology and the model input parameters incorporated. Modeling results of the underwater acoustic analysis are presented as sound contour isopleths for the maximum over depth received sound level as a function of range. This technical report has been updated to address the NOAA Fisheries Technical Guidance for Assessing the Effect of Anthropogenic Sound on Marine Mammals which was finalized in July of 2016, as well as harassment criteria and interim thresholds for fish and sea turtles. Information provided is intended to form the basis for the assessment of potential biologically significant impacts.

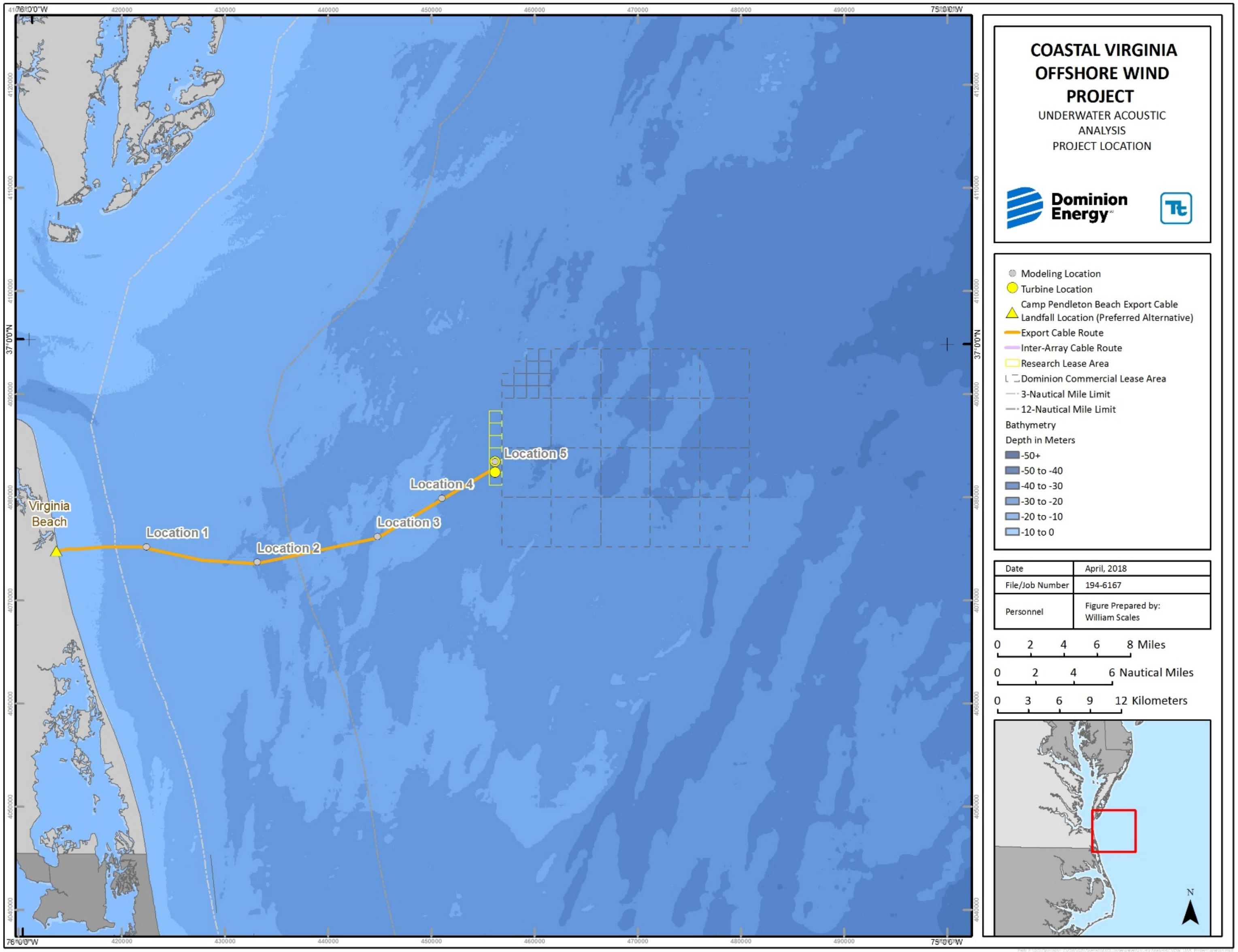

Figure 1. Overview of Project Area

2 EXISTING CONDITIONS

Underwater sounds, if they are intense enough, may cause behavioral responses, injury, or even death from concussion (Richardson et al. 1995). However, actual thresholds for behavioral responses to sounds in the natural environment depend on the range and levels of ambient noise that are persistently present. As is routine when conducting noise surveys in air, the significance of any noise as an annoyance can be related to the extent to which it exceeds background levels. Therefore, the prediction of possible masking effects, and the behavior of marine life, will also be influenced by the anticipated background noise levels. The propagation modeling considers the contribution of the Project in isolation; therefore, existing conditions and potential masking effects are not accounted for. In addition, review of the modeling results alone does not provide an indication of when marine life will acclimatize to certain sound levels.

The existing underwater acoustic environment can be described as a combination of many possible noise sources of both natural and man-made origins. Noise from natural sources is generated by physical or biological processes. Examples of physical noise sources are tectonic seismic activity, wind and waves; examples of biological noise sources are the vocalizations of marine mammals and fish. There can be a strong minute-to-minute, hour-to-hour, or seasonal variability in sounds from biological sources. Shallow water has been defined for the purposes of this hydroacoustic analysis as a water column less than 200 m deep. Research has shown that ambient noise is 5-10 dB higher in shallower water, which is linked to the influence of surface agitation and reflection by the bottom and may also be dependent on localized conditions of sea state and wind speed, varying both spatially and temporally. The ambient noise for frequencies above 1 kilohertz (kHz) is due largely to waves, wind, and heavy precipitation; however, it may be evident at frequencies down to 100-300 Hz during otherwise quiet times (Simmonds et al. 2004). Surface ocean wave interaction and breaking waves with spray have been identified as important sources of noise. Wind induced bubble oscillations and cavitation are also near-surface noise sources, major storms can give rise to noise in the 10-50 kHz band which can propagate to long ranges with the same mechanism and directionality as distant shipping. At areas within distances of 8-10 km of the shoreline, surf noise will be prominent in the frequencies ranging up to a few hundred hertz (Richardson et al. 1995), even during calm wind conditions.

Man-made noise sources can consist of contributions related to industrial development, offshore oil industry activities, naval operations, and marine research but the most predominant contributing noise source is generated by commercial ships and recreational watercraft. Noise from such ships dominates coastal waters and emanates from the ships' propellers and other dynamic positioning propulsion devices such as thrusters. The sound generated from main engines, gearboxes, generators transmitted through the hull of the vessel into the water column is considered a secondary sound source to that of vessel propulsion systems, as is the use of sonar and depth sounders which occur at generally high frequencies and attenuate rapidly. Other potential ship-related sources include vortex shedding from the hull and noise associated with the wake, noise generated by pipes open to, and discharging into the sea. Most shipping contributes in a frequency range of less than 1 kHz. In general, older vessels produce more noise than newer ones and larger vessels produce more than smaller ones, but this is not always the case. Although, typically, shipping vessels produce frequencies below 1 kHz, small leisure craft may generate sound with frequency components from

1 kHz, up to the 50 kHz range due to ppropeller cavitation at elevated speeds, which may generate noise at somewhat higher frequencies (Simmonds et al. 2004).

In addition to these sound sources, a considerable amount of background noise may be caused by biological activities. Aquatic animals make sounds for communication, echolocation, prey manipulation, and also as by-products of other activities such as feeding. Biological sound production usually follows seasonal and diurnal patterns, dictated by variations in the activities and abundance of the vocal animals. The frequency content of underwater biological sounds ranges from less than 10 Hz to beyond 150 kHz. Source levels show a great variation, ranging from below 50 dB to more than 230 dB_{RMS} re 1 µPa at 1 m. Likewise there is a significant variation in other source characteristics such as the duration, temporal amplitude, frequency patterns and the rate at which sounds are repeated (Wahlberg 2012). With all of the complexities involved, the capacity for acoustic models to estimate background levels is limited, so for that reason the acoustic modeling analysis presented is restricted to future Project construction and operational scenarios only.

2.1 Underwater Acoustic Concepts and Terminology

The sound level estimates presented in this modeling study are expressed in terms of several metrics and apply the use of averaging times to allow for interpretation relative to potential biological impacts on marine life. This section provides an overview of basic acoustical terms, descriptors, and concepts that should help frame the discussion of acoustics in this document. The majority of the information in the following sections is to provide further insight into how data and modeling results have been presented in accordance with regulatory reporting requirements and established criteria.

Reference Levels

Sound levels are reported on a logarithmic scale expressed in units of decibels (dB) and are reported in terms of linear (or unweighted) decibels. A decibel is defined as the ratio between a measured value and a reference value of 1 micropascal (µPa). A logarithmic scale is formed by taking 20 times the logarithm (base 10) of the ratio of two pressures: the measured sound pressure divided by a reference sound pressure. When evaluating sound propagation in the underwater environment, in comparison to the in-air environment (see Appendix M-1, In-Air Acoustic Modeling Report), many differences must be noted. The reference for underwater sound pressure is 1 µPa; however, in-air sound uses a reference of 20 µPa. Due to the difference in acoustic impedance, a sound wave that has the same intensity in air and in water will in water have a pressure that is 60 times larger than in air, with a displacement amplitude that will be 60 times less. Assuming pressure is maintained as a constant, the displacement amplitude in water will be 3580 times less than in air. To help demonstrate this relationship, Table 1 provides the corresponding values of sound pressure in air and in water having the same intensities at a frequency of 1 kiloHertz (kHz) as it relates to human-perceived loudness. This somewhat simplistic comparison does not account for the frequency dependent hearing capabilities of various species (e.g., marine species) or individual hearing response mechanisms.

Table 1. Sound Pressure Levels and Comparison to Relative Human Loudness Thresholds

Pressure in Air re 20 µPa/Hz	Pressure in Water re 1µPa/Hz	Relative Loudness (human perception of different reference sound pressure levels in air)
0	62	Threshold of Hearing
58	120	Potentially Audible Depending on the Existing Acoustic Environment
120	182	Uncomfortably Loud
140	202	Threshold of Pain
160	222	Threshold of Direct Damage
Source: Kinsler and Frey 1962		

Sound Level Metrics

Sound is the result of mechanical vibration waves traveling through a fluid medium such as air or water. These vibration waves generate a time-varying pressure disturbance that oscillates above and below the ambient pressure. Statistical levels describe the temporal variation in sound levels. Underwater sound pressure levels may change from moment to moment; some are sharp impulses lasting one second or less, while others may rise and fall over much longer periods of time. Statistical levels provide a percentile distribution of the time-varying sound levels.

Underwater sounds are classified according to whether they are transient or continuous. Transient sounds are of short duration and occur singly, irregularly, or as a part of a repeating pattern. For instance, an explosion represents a single transient event, whereas the periodic pulses from a ship's sonar are patterned transients. Broadband short duration transients are called pulses. Continuous sounds, which occur without pauses, may be further classified as periodic, such as the sound from rotating machinery or pumps, or aperiodic, such as the sound of a ship transiting. Shipping is considered a short-term continuous sound. These sounds normally increase in level with higher engine loads or as vessels approach an observation location and then diminish as they move away. Fixed-location continuous sounds are associated with an operational offshore wind turbine. The intensity of continuous noise is generally given in terms of the root mean square (RMS) sound pressure level (SPL). The RMS SPL is calculated by taking the square root of the average of the square of the pressure waveform over the duration of the time period. The RMS is also known as the quadratic mean and is a statistical measure of the magnitude of a varying quantity. Given a measurement of the time varying sound pressure p(t) from a given noise source at some location, the RMS SPL is computed according to the following formula:

$$\text{dB}_{\text{RMS}}\ \text{SPL} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right)$$

Where T is the measurement period. Pulses are defined as brief, broadband, atonal, transients. These sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures. Pile driving using an impact hammer during construction is an example of underwater noise that is characterized as pulsed sound. The Peak SPL metric is commonly quoted for impulsive sounds and is used to characterize the maximum instantaneous sound pressure level attained by an impulse, p(t):

$$\text{Peak SPL} = 10\log_{10}\left[\frac{\max\left(\left|p^2(t)\right|\right)}{p_0^2}\right]$$

Where p(t) is the instantaneous pulse pressure as a function of time, measured over the pulse duration 0 ≤ t ≤ T. At high intensities, the peak SPL can be a valid criterion for assessing whether a sound is potentially injurious but does not take into account the pulse duration or bandwidth of a signal, therefore it is not a good indicator of loudness. The peak pressure level of the sound pulse generated by impact piling will decay at a slightly higher rate compared to the energy in the pulse (the SEL is proportional to pulse energy) due to temporal dilation of the pulse that results from multiple reflections from the seabed and the sea surface as the sound pulse propagates. For pulsed noise, the RMS SPL level is measured over the pulse duration according to the following equation:

$$\text{dBrms}_{90}\ \text{SPL} = 10\log_{10}\left(\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt \Big/ p_0^2\right)$$

For impulsive noise, the time interval (T_{90}) is defined as the "90% energy pulse duration" which is the interval over which the pulse energy curve rises from 5% to 95% of the total energy rather than a fixed time window. In addition, because the window length is used as a divisor, pulses that are more spread out in time have a lower RMS SPL for the same total acoustic energy.

The sound exposure level (SEL; dB re 1 μPa^2·s) is a measure of the total acoustic energy contained in one or more acoustic events. The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T_{100}):

$$\text{SEL} = 10\log_{10}\left(\int_{T_{100}} p^2(t)dt \Big/ T_0\, p_0^2\right)$$

where T_0 is a reference time interval of 1 s. The SEL represents the total acoustic energy received at a given location. Unless otherwise stated, sound exposure levels for pulsed noise sources (*i.e.*, impact hammer pile driving) presented in this report refer to a single pulse.

SEL can be calculated as a cumulative metric over periods with multiple acoustic events. In the case of impulsive sources like impact piling, SEL describes the summation of energy for the entire impulse normalized to one second and can be expanded to represent the summation of energy from multiple pulses. The latter is written SEL_{cum} denoting that it represents the cumulative sound exposure. The sound exposure level is often used in the assessment of marine mammal and fish behavior over an 24 hour time period.

The cumulative SEL (dB re 1 μPa^2·s) can be computed by summing (in linear units) the SELs of the *N* individual events:

$$\text{SEL}_{cum} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{\text{SEL}_i}{10}}\right)$$

Spectral Levels

The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Acoustic modeling was completed for one-third octave band center frequencies in the range of 10 Hz to 8 kHz. One-third octaves are a series of electronic filters used to separate sound into discrete frequency bands, making it possible to know how sound energy is distributed as a function of frequency. Corresponding broadband sound levels sum the acoustic energy across all frequencies. These analyses quantitatively describe the frequency dependent sound environment for specific events or activities. The advantage of one-third octave band modeling is that it can resolve the frequency dependent propagation characteristics of a particular environment and can be summed to efficiently compute the overall broadband sound pressure level for any given receiver position within the water column.

Underwater sound levels may also be weighted according to marine mammal functional hearing groups using audiograms based on hearing sensitivities of species in these groups: low frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, and pinnipeds. This is commonly referred to as M-weighting. M-weighting is applied to adjust the expected acoustic impact on a per-frequency basis. Weighting functions for low-frequency cetaceans (LF), mid-frequency cetaceans (MF) and high frequency cetaceans (HF) are presented below in Figure 2. The M-weighting functions are therefore very useful when determining the behavioral responses of marine mammals to any noise.

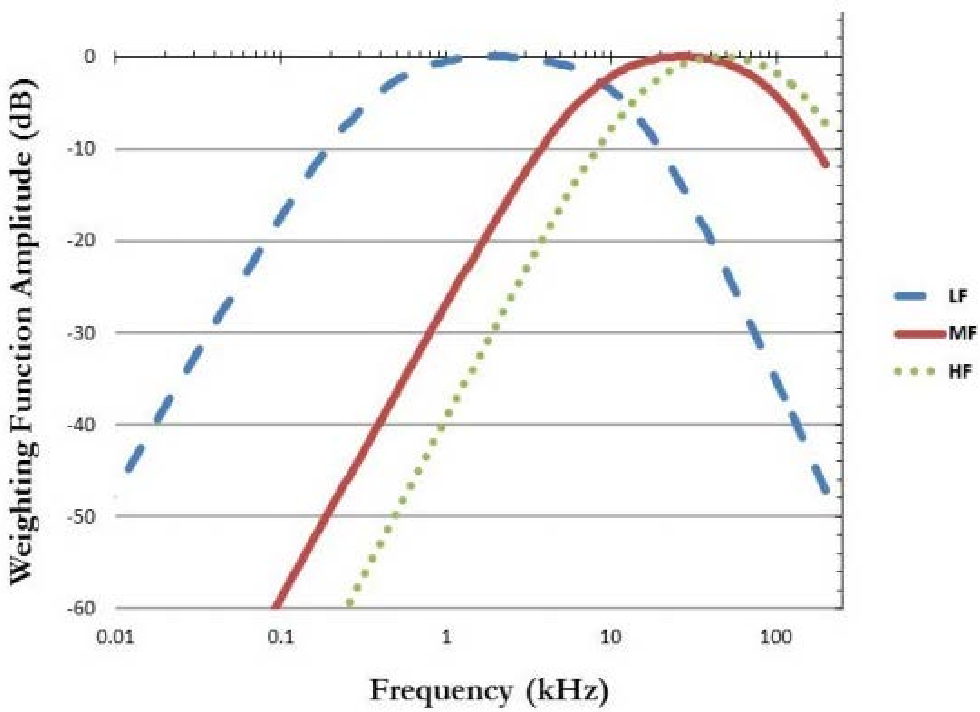

Figure 2. Auditory M-weighting functions for low-frequency (LF), mid-frequency (MF) and high-frequency (HF) cetaceans. (NOAA 2016)

Seawater Absorption

Absorption in the underwater environment involves a process of conversion of acoustic energy into heat and thereby represents a true loss of acoustic energy to the water. The primary causes of absorption have been attributed to several processes, including viscosity, thermal conductivity, and chemical reactions involving ions in the seawater. The viscosity of the medium causes sound energy to be converted into heat by internal friction. Some sound energy is converted into heat because sound waves alternately raise and lower the temperatures. Suspended particles are set to oscillating by the sound waves and in this process some of the sound energy is dissipated in the form of heat. This is especially the case if the particles are air bubbles. While each of these factors offers its own unique contribution to the total absorption loss, all of them are caused by the repeated pressure fluctuations in the medium as the sound waves are propagated. In these processes, the area over which the signal is spread remains the same, but the energy in the signal, and therefore the intensity, is decreased.

The absorption of sound energy by water contributes to the attenuation losses linearly with range and is given by an attenuation coefficient in units of decibels per kilometer (dB/km). This absorption coefficient is computed from empirical equations and increases with the square of frequency. For example, for typical open-ocean values (temperature of 10°C, pH of 8.0, and a salinity of 35 practical salinity units [psu]), the equations presented by Francois and Garrison (1982a, b) yield the following values for seawater absorption: 0.001 dB/km at 100 Hz, 0.06 dB/km at 1 kilohertz (kHz), 0.96 dB/km at 10 kHz, and 33.6 dB/km at 100 kHz. Thus, low frequencies are favored for long-range propagation.

Spatial Effects and Spreading

Transmission loss (TL) underwater is the accumulated decrease in acoustic intensity as an acoustic pressure wave propagates outwards from a source. The intensity of the source is reduced with increasing distance due to spreading. Spreading can be categorized into two models, spherical spreading and cylindrical spreading models. Three fundamental equations can be used to describe spreading losses. The first equation used for noise modeling covers TL for short ranges near the source, where sound energy spreads outward unimpeded by interactions at the sea surface or sea floor until the entire channel depth is ensonified. The following equation is used when r, the horizontal separation distance between sound source and receiver, is up to 1 times H, which is sometimes conservatively assumed as the average water depth. The equation also includes a range and frequency dependent absorption term, α.

$$TL = 20 \log r + \alpha r$$

The intermediate (or transition zone) is defined as H ≤ r ≤ 8H where modified cylindrical spreading occurs accompanied by mode stripping effects (Richardson et al. 1995). The TL equation representing this intermediate range is given below:

$$TL = 15 \log r + \alpha r$$

For underwater transmission in shallow water where the water depth is greater than five-times the sound wavelength, the 15 log r spreading loss factor in the above equation may extend beyond the range of 8H. Long range TL occurs where r > 8H. Due to the boundaries of the sea surface and sea floor, sound energy is not able to propagate uniformly in all directions from a source indefinitely; therefore, long range TL is represented as cylindrical spreading, limited by the channel boundaries. Cylindrical spreading propagation is applied using the equation given below:

$$TL = 10\log r + \alpha r$$

These equations are based on free-field conditions that assume uniform sound spreading in an infinite, homogeneous ocean and neglect specific environmental effects, such as water column refraction and bottom reflections. Such factors are important in consideration of underwater sound propagation carried out over extended calculation distances, and thus strongly affect the accuracy of this methodology. The acoustic far-field is defined as the distance from a source, which is greater than the acoustic wavelength at a frequency of interest. Since the wavelength varies with frequency, the separation distance will vary with frequency with the lower frequencies having the longer wavelength, as measured in meters. The geometric far-field roughly begins at the distance from a source of sound which is greater than roughly four times the largest physical dimension of the area sound source(s). When in the geometric far-field, the sources have all essentially merged into one, so that measurements made even further away will be no different in terms of source contribution. The effects of source geometry and multiple sources operating concurrently, in the geometric far-field, are expected to be negligible. However, in the acoustic nearfield, under a practical spreading model, the ability to accurately calculate high level sound fields is limited.

Scattering and Reflection

Scattering of sound from the surface and bottom boundaries and from other objects is difficult to quantify and is site specific, but is extremely important in characterizing and understanding the received sound field. Reflection, refraction and diffraction from gas bubbles and other inhomogeneities in the propagating medium serve to scatter sound and will affect TL and occur even in relatively calm waters. If boundaries are present, whether they are "real" like the surface of the sea or "internal" like changes in the physical characteristics of the water, they affect sound propagation. The acoustic intensity received depends on the losses due to the path length as well as the amount of energy reflected from each interface. Multiple reflections may occur as the sound reflects alternately from the bottom and the sea surface. It is also very likely that some reflections or refractions may actually overlap others and cause constructive and destructive interference patterns.

Changes in direction of the sound due to changes of sound velocity are known as refraction. The speed of sound is not constant with depth and range but depends on the temperature, pressure and salinity. Of the three factors, the largest impact on sound velocity is temperature. The change in the direction of the sound wave with changes in velocity can produce many complex sound paths. It may produce locations in the ocean that a sound ray sent out from a particular transducer cannot penetrate. These are called shadow zones. It may also produce sound channels that can trap the sound and allow a signal to travel great distances with minimal loss in energy.

Frequency dependence due to destructive interference contributes to the weakening of the sound signal. Since the inhomogeneities in water are very small compared to the wavelength of the signal, this attenuation-effect will mostly contribute when the signals encounter changes in bathymetries and propagate through the sea floor and the subsurface. For variable bathymetries, the calculation complexity increases, as individual portions of the signal are scattered differently. However, if the acoustic wavelength is much greater than the scale of the seabed non-uniformities, as is most often the case for low-frequency sounds, then the effect of scattering on propagation loss become somewhat less important than other factors. Also, scattering loss occurring at the surface due to wave action will increase at higher sea states. For reflection from the sea-surface, it is assumed that the surface is smooth (i.e., reflection coefficient with a magnitude of -1). While a rough sea surface would increase scattering (and hence transmission loss) at higher frequencies, the scale of surface roughness is insufficient to have a significant effect on sound propagation at the lower frequencies where most of the energy is generated.

Cut-off Frequency

Sound propagation in shallow water is essentially a normal mode where a sound wave moves sinusoidally and has its own frequency and the sound channel is an acoustic waveguide. Each mode is a standing wave in the vertical direction that propagates in the horizontal direction at a frequency dependent speed. Each mode has a cutoff frequency, below which no sound propagation is possible. The cutoff frequency is determined based on the type of bottom material and water column depth. This limiting frequency (f_c) can also be calculated if the speed of sound in the sediment ($C_{sediment}$) is known (Hastings 2008) and seasonal temperature variation of the speed of sound of the seawater (C_{water}) is known using the following equation:

$$f_c = \frac{C_{water}}{4h} / \sqrt{1 - (C_{water})^2/(C_{sediment})^2}$$

Where:
f_c = critical frequency
C_{water} = speed of sound of water
$C_{sediment}$ = speed of sound in sediment
h = water depth in the direction of sound propagation

In the Project Area, the speed of sound in the sediment is higher than in water, where it is approximated at 1500 m/s. Values for speed of sound in sediment will range from 1605 m/s in sand-silt sediment to 1750 m/s in predominantly sandy areas. Sound traveling in shallower regions of the Project Area will be subject to a higher cutoff frequency and a stronger attenuation than sound propagating as opposed to areas with greater water depths. Figure 3 graphically presents the cut-off frequency for different bottom material types. As shown in this plot, at a water depth of 25 m and a bottom condition consisting of predominantly of fine sand which is consistent with the WTG site locations. The approximate cutoff frequency would be expected to occur at approximately 50 Hz, with even higher attenuation rates occurring along the nearshore cable route. Significant sound energy would attenuate rapidly as sound sources occurring in shallower water are subject to much stronger attenuation below this frequency than what would occur in deeper ocean regions.

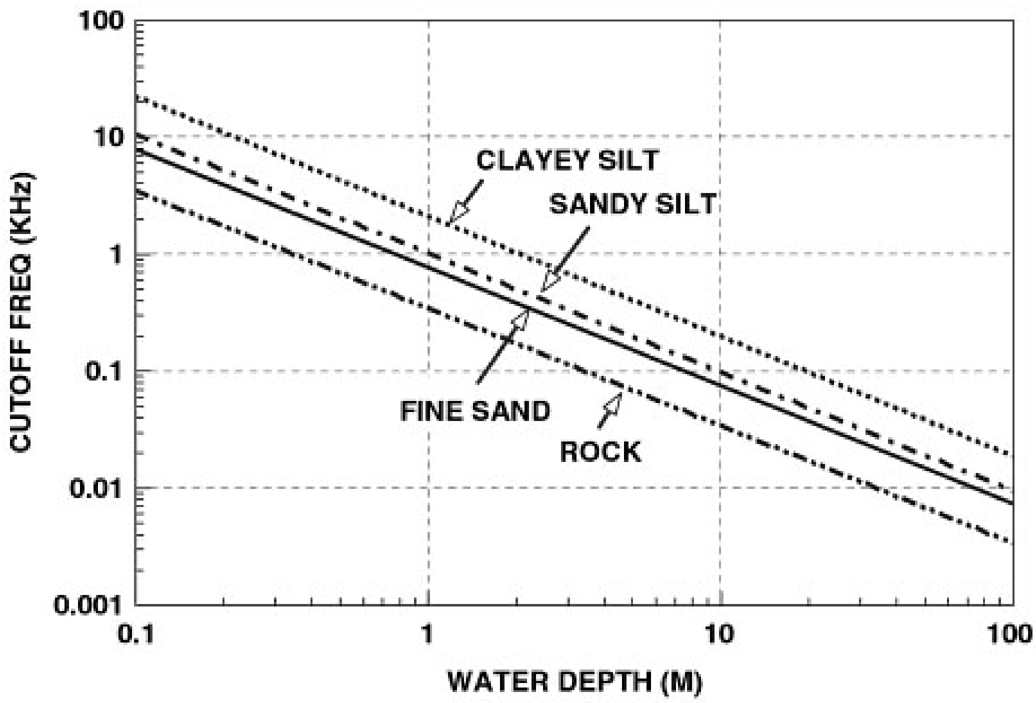

Figure 3. Cut-off Frequencies for Different Bottom Materials

Reference: Au, W. and M. Hastings. 2008. Principles of Marine Bioacoustics. Springer Science & Business Media, New York, New York .

3 REGULATORY CRITERIA AND SCIENTIFIC GUIDELINES

The potential harmful effects of high-level underwater sound can be summarized as lethal, physical injury and hearing impairment. In general, biological damage as a result of sound is either related to a large pressure change (barotrauma) or to the total quantity of sound energy received on a cumulative basis. Other ways in which sound or noise can be detrimental to the marine mammals and fish is by causing behavioral disturbance and auditory masking. A regulatory and literature review was conducted to obtain and summarize the latest impact criteria in order to accurately assess the potential for adverse impact on marine mammals, sea turtles and fishery resources.

3.1 MMPA Thresholds for Lethal and/or Injurious Auditory Effects

The potential effects of underwater noise resulting in takes on marine mammals are federally managed by NOAA under the Marine Mammal Protection Act (MMPA) to minimize the potential for both harm and harassment. Under the MMPA, Level A harassment is statutorily defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild; however, the actionable sound pressure level is not identified in the statute. Level B harassment is defined as any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

In July of 2016, National Marine Fisheries Service (NMFS) finalized the Technical Guidance for Assessing the Effect of Anthropogenic Sound on *Marine Mammals*. Under this new NMFS guidance, Level A harassment is said to occur as a result of exposure to high noise levels and the onset of permanent hearing sensitivity loss, known as a permanent threshold shift (PTS). This revision to earlier NMFS guidelines is based on findings published by the Noise Criteria Group (Southall et al., 2007). For transient and continuous sounds, it was concluded that the potential for injury is not just related to the level of the underwater sound and the hearing bandwidth of the animal, but is also influenced by the duration of exposure. The evaluation of the onset of PTS provides additional species-specific insight on the potential for affect that is not captured by evaluations completed using the previous NMFS Level A harassment alone.

The NMFS guidance classifies impact pile driving as an "impulsive" sound source, which characterizes these activities as more injurious than "non-impulsive" sources, due to high peak sound pressures and rapid rise times. The higher risk of damage does not stem from the duration of exposure, but rather the "critical level", where the short duration high peak pressures can be less than the ear's integration time, leading to potential damage to an animal's hearing before it can perceive the onset mechanical fatigue.

Frequency weighting provides a sound level referenced to an animal's hearing ability either for individual species or classes of species, and therefore a measure of the potential of the sound to cause an effect. The measure that is obtained represents the perceived level of the sound for that animal. This is an important consideration because even apparently loud underwater sound may not effect an animal if it is at frequencies outside the animal's hearing range. In the NMFS final Guidance document, there are five hearing groups: Low-frequency (LF) cetaceans (baleen whales), Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales), High-frequency (HF) cetaceans (true porpoises, Kogia, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*), Phocid pinnipeds (true seals), and Otariid pinnipeds (sea lions and fur seals). It should be noted that Otariid pinnipeds do not occur within the Study Area.

Table 2 Summary of Generalized Hearing Ranges and PTS Thresholds of Marine Mammals (NMFS, 2016)

Functional Hearing Group	PTS Onset Impulsive	PTS Onset Non-Impulsive	Functional Hearing Range
LF cetaceans (baleen whales)	219 dB_{peak} & 183 dB SEL_{cum}	199 dB SEL_{cum}	7 Hz to 35 kHz
MF cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	230 dB_{peak} & 185 dB SEL_{cum}	198 dB SEL_{cum}	150 Hz to 160 kHz
HF cetaceans (true porpoises, Kogia, river dolphins, cephalorhynchid, Lagenorhynchus cruciger & L. australis)	202 dB_{peak} & 155 dB SEL_{cum}	173 dB SEL_{cum}	275 Hz to 160 kHz
Phocid pinnipeds (underwater) (true seals)	218 dB_{peak} & 185 dB SEL_{cum}	201 dB SEL_{cum}	50 Hz to 86 kHz
Otariid pinnipeds (underwater) (sea lions and fur seals)	232 dB_{peak} & 203 dB SEL_{cum}	219 dB SEL_{cum}	60 Hz to 39 kHz

Notes: The peak SPL is un-weighted (i.e., flat weighted), whereas the cumulative SEL criterion is M-weighted for the given marine mammal functional hearing group. Peak sound pressure (dBpeak) has a reference value of 1 µPa, and cumulative sound exposure level (SELcum) has a reference value of 1 micropascal squared-seconds (1µPa2s). The recommended accumulation period is 24 hours.

PTS is considered "Level A harassment" under the MMPA. However, NOAA NMFS (2016a) does not address "Level B harassment." Because the new guidance does not address "Level B harassment," NOAA Fisheries uses an interim sound threshold guideline of 160 dB rms re 1µPa for pulsed sound and 120 dB rms re 1µPa received level for continuous sound. Within this zone, the sound produced by the proposed project may periodically approach or exceed ambient sound levels (i.e., threshold of perception or zone of audibility); however, actual perceptibility will be dependent on the hearing thresholds of the species under consideration and the inherent masking effects of ambient sound levels.

Marine mammal responses to sound can be highly variable, depending on the individual hearing sensitivity of the animal, the behavioral or motivational state at the time of exposure, past exposure to the noise which may have caused habituation or sensitization, demographic factors, habitat characteristics, environmental factors that affect sound transmission, and non-acoustic characteristics of the sound source, such as whether it is stationary or moving (NRC 2003). There is much intra-category and intra-species variability in behavioral response. Therefore, the criteria for use in assessing the spatial extent of marine mammal disturbance due to a continuous and multiple pulse sound should be viewed as probabilistic and precautionary.

In addition, according to the NMFS Guidance SEL_{cum} is recommended for use with non-impulsive sounds (page 1 of Guidance) and thus is not an appropriate metric to capture all the effects of impulsive sounds from monopole installation. This is stated directly on page 30 of the guidance: "*Thus, SEL_{cum} is not an appropriate metric to capture all the effects of impulsive sounds (i.e., often violates EEH; NIOSH 1998), which is why instantaneous PK level has also been chosen as part of NMFS' dual metric acoustic thresholds for impulsive sounds.*" The use of (cumulative) SEL as further stated in the new NOAA Guidelines "*is a simplifying assumption to accommodate sounds of various SPLs, durations, and duty cycles. …. this approach assumes exposures with equal SEL result in equal effects, regardless of the duration or duty cycle of the sound*". The guidance goes on to say "*It is well-known that the equal energy rule will* ***over-estimate*** *the effects of intermittent noise*….(Ward, 1997). [page 67]". NOAA NMFS (2016a).

3.2 Fish and Sea Turtle Species

The hearing capabilities and sensitivities of fish vary from species to species, but are believed to form three functional hearing groups, e.g., fishes with swim bladders mechanically linked to the ears, fishes with swim bladders not linked to the ears, and fishes without swim bladders. Fish species with a reduced or no swim bladder tend to have a relatively low auditory sensitivity, fish having a fully functional swim bladder tend to be more sensitive, and fish with a close coupling between the swim bladder and the inner ear are most sensitive. In addition, while some fish are sensitive to sound pressure, all fish are capable of detecting particle motion or the rate of displacement of fluid particles by acoustic pressure. The existing body of literature relating to the impacts of sound on marine species can be divided into three categories: (1) pathological, (2) physiological, and (3) behavioral. Pathological effects include lethal and sub-lethal physical damage; physiological effects include primary and secondary stress responses; and behavioral effects include changes in exhibited behaviors. Fish behavior in response to noise is not well understood. Sound pressure levels that may deter some species, may attract others. Behavioral changes might be a direct reaction to a detected sound or a result of anthropogenic sound masking natural sounds that fishes make use of in their normal behavior. Risk of injury or mortality resulting from noise is generally related to the effects of rapid pressure changes, such that the sound intensity is an important factor for the degree of hearing loss, as is the frequency, the exposure duration, and the length of the recovery time.

While impact pile driving activity has been linked to fish mortality, there are insufficient data to indicate the percentage of fish killed, whether some species are more susceptible to sound than others, and the exacting distance at which fish are killed (Hastings and Popper 2005). It is possible that fish outside a designated zone of influence are damaged, and that ultimately this damage would lead to death later. Moreover, there are numerous complicating factors with pile driving that might impact fish.

An interagency work group, including the U.S. Fish and Wildlife Service (USFWS) and the NMFS, has reviewed the best available scientific information and developed criteria for assessing the potential of pile driving activities to cause injury to fish (FHWG 2008). The workgroup established dual sound criteria for injury, measured 33 feet away from the pile, of 206 dB re 1µPa Peak and 187 dB accumulated sound exposure level (dB SELcum; re: 1µPa^2 sec) and 183 dB accumulated SEL for fish less than 2 grams.

The NOAA Fisheries also currently recognizes a 150 dB_{RMS} level as the threshold for disturbance to salmon, bull trout and Atlantic sturgeon. Based on their assessment, sound pressure levels in excess of 150 dB re 1 µPa are expected to cause temporary behavioral changes, such as elicitation of a startle response or avoidance of an area. Those levels are not expected to cause direct permanent injury. That is not to say that exposure to noise levels of 150 dB_{RMS} will always result in behavioral modifications, but that there is the potential, upon exposure to noise at this level, to experience some behavioral response (e.g., temporary startle to avoidance of an ensonified area). In summary, based on the best available information on other fish species, underwater noise at or above the levels presented in Table 3 have the potential to cause injury or behavioral modifications for fish.

The hearing capabilities of sea turtles are poorly known, and there is limited information on the effects of noise on sea turtles. Some studies have demonstrated that sea turtles have fairly limited capacity to detect sound, although all results are based on a limited number of individuals and must be interpreted cautiously. NOAA Fisheries has not yet established acoustic thresholds for effects to sea turtles. It is predicted that protection of sea turtles from noise associated with pile driving would be addressed through consideration and mitigation for thresholds established for fish and marine mammals. A 180 dB_{RMS} exclusion zone is expected to prevent mortalities, injuries, and most auditory impacts and has recently been adopted on similar offshore energy projects.

Table 3 Acoustic Criteria and Metrics for Fishes and Sea Turtles

Fish Group	Injury[1]		Physiological	Behavior
	SEL_{cum} dB re 1 µPa^{2}s	dB Peak dB re 1 µPa	dB rms dB re1 µPa	dB rms dB re 1 µPa
Small fish (mass <2 g)	183 [a]	206 [a]	--	150 [b]
Large fish (mass ≥2 g)	187 [a]	206 [a]	--	150 [b]
Sea turtles	--	--	180 [b]	166 [b]

Reference: U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM). Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities, Literature Synthesis, 2012

a = Stadler and Woodbury, 2009.b = GARFO, 2016.

4 ACOUSTIC MODELING METHODOLOGY

Acoustic modeling was conducted for primary-noise generating activities occurring during Project construction and operation. The following subsections describe the modeling program used, the modeling scenarios, and acoustic model input values.

4.1 Sound Propagation Model

The underwater acoustic propagation modeling for this updated study was performed using a modified version of the RAM parabolic-equation (PE) model (Collins 1993, 1996). RAM was developed at the US Naval Research Laboratory and has been extensively benchmarked and is widely used as a reference model in the underwater acoustics community. RAMGeo is a version of RAM source code modified to handle sediment layers that are range dependent and parallel to the bathymetry and computes acoustic fields in 3-D by modeling transmission loss along evenly distributed radial traverses covering a 360 º swath from the source (so-called N×2-D modeling). This methodology consists of a set of algorithms that calculates transmission loss based on a number of factors including the distance between the source and receiver along with basic ocean parameters (e.g., depth, bathymetry, geoacoustic properties of sediment type, and the ocean's temperature-depth sound speed profile).

The extremely efficient PE code copes naturally with range-dependent environments and overcomes the principle limitation of the PE method, which is the lack of accuracy for energy propagating at large angles to the horizontal (Duncan and Maggi, 2006). Use of the PE method allows for a one-way wave equation that can be solved by a range-marching technique with a proper starting field (i.e., near-field underwater sound pressure level). The forward propagating field is obtained at a given range from the field at a previous range after having also accounted for boundary conditions at the top and bottom of the domain, in other words the solution (i.e., the underwater received sound pressure level) is marched in range.

The PE algorithm assumes that outgoing reflected and refracted sound energy dominates scattered sound energy and computes the solution for the outgoing (one-way) wave equation. At low frequencies, the contribution of scattered energy is very small compared to the outgoing sound field. An uncoupled azimuthal approximation is used to provide gridded 2-D TL values in range and depth with a geo-referenced dataset to automatically retrieve the bathymetry and acoustic environment parameters along each propagation transect radiating from the sound source.

The received sound field within each vertical radial plane is sampled at various ranges from the source with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The received sound level at a given location along a given transect is taken as the maximum value that occurs over all samples within the water column below. The TL values produced by the model are used to attenuate the spectral acoustic output levels of the sound source to generate received sound levels along a transect. These values are then summed across frequencies to provide broadband received levels.M-weighting was applied for multiple hearing groups, including low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, phocid pinnipeds in water, and otariid pinnipeds in water, to weight the importance of received sound levels according to marine mammal hearing sensitivity, in accordance with the 2016 NOAA

Technical Guidance (NMFS 2016). Marine mammal weighting calculations and contour isopleth were further visualized using the dBSea software package version 2.2.4, developed by Marshall Day Acoustics.

4.2 Modeling Environment

The accuracy of underwater noise modeling results is largely dependent on the referenced sound source data and the accuracy of the intrinsically dynamic data inputs used to describe the medium between the path and receiver, including sea surface conditions, water column, and sea bottom. The exact information required can never be obtained for all possible modeling situations, particularly for long-range acoustic modeling of temporally varying sound sources where uncertainties in model inputs increase at greater propagation distances from the source. Model input variables incorporated into the calculations are further described as follows.

4.2.1 Bathymetry

For geometrically shallow water, sound propagation is dominated by boundary effects. Bathymetry data represent the 3D nature of the subaqueous land surface and was obtained from the National Geophysical Data Center (NGDC) US Coastal Relief Model (NOAA Satellite and Information Service 2005); the horizontal resolution of this data set is 3 arc-seconds. NGDC's 3 arc-second U.S. Coastal Relief Model (CRM) provides the first comprehensive view of the U.S. coastal zone, integrating offshore bathymetry with land topography into a seamless representation of the coast. The CRM spans the U.S. East and West Coasts, the northern coast of the Gulf of Mexico, Puerto Rico, and Hawaii, reaching out to, and in places even beyond, the continental slope. The Geophysical Data System (GEODAS) is an interactive database management system developed by the NGDC for use in the assimilation, storage and retrieval of geophysical data. GEODAS software manages several types of data including marine trackline geophysical data, hydrographic survey data, aeromagnetic survey data, and gridded bathymetry/topography.

The datasets, originally with a horizontal resolution of 20 m, were linearly interpolated on a regular grid and extended 40 km from the WTG locations. The bathymetric data was sampled by creating a fan of 90 radials at a given angular spacing. This grid was then used to determine depth points along each modeling radial transect. The underwater acoustic modeling takes place over these radial planes in set increments depending on the acoustic wavelength and the sampled depth. These radial transects were used for modeling both the construction and operation of the Project, with each radial centered on the given Project sound source or activity. Figure 1 presents the bathymetries within the Project Area.

4.2.2 Sediment

Sediment type (e.g., hard rock, sand, mud) directly impacts the speed of sound as it is a part of the medium in which the sound propagates. Sediment information for the Project study area was obtained from the U.S. Geological Survey (USGS) Continental Margin Mapping Program, which includes an extensive east coast sediment study. For the immediate project site, the geoacoustic properties were defined up to a maximum depth of 110 meters with information from the CVOW geotechnical study. The layers used in the modeling and the main geoacoustic properties is provided in Table 4 with the bottom type in the Project Area defined as predominantly sand.

Table 4. Overview of seabed geoacoustic profile used for the modelling (Cp = compressed wave speed, **αs (dB/λ)** = compressional attenuation, p = density).

Seabed Layer (m)	Material	Geoacoustic Properties
0 to 4	Silty fine SAND	Cp = 1650 m/s αs (dB/λ) = 1.1 dB/ λ p = 1,800
4 to 12	Sandy lean CLAY	Cp = 1560 m/s αs (dB/λ) = 0.2 dB/ λ p = 1,600
12 to 24	Fat CLAY (with shell fragments and sand pockets)	Cp = 1470 m/s αs (dB/λ) = 0.08 dB/ λ p = 1,200
24 to 52	Silty fine to medium SAND	Cp = 1650 m/s αs (dB/λ) = 1.1 dB/ λ p = 1,800
52 to 60	Sandy lean CLAY (with shell fragments)	Cp = 1560 m/s αs (dB/λ) = 0.2 dB/λ p = 1,560
60 to 72	Lean CLAY (with sand)	Cp = 1470 m/s αs (dB/λ) = 0.08 dB/ λ p = 1,200
72 to 85	Silty fine SAND	Cp = 1700 m/s αs (dB/λ) = 1.0 dB/ λ p = 1,605
85 to 110	Fat CLAY	Cp = 1470 m/s αs (dB/λ) = 0.08 dB/ λ p = 1,200

Reference: Hamilton 1976, Hamilton 1982, Hamilton and Bachman 1982, APL 1994.

4.2.3 Seasonal Sound Speed Profiles

The speed of sound in sea water depends on the temperature T [°C], salinity S [ppt], and depth D [m] and can be described using sound speed profiles (SSPs). Oftentimes, a homogeneous or mixed layer of constant velocity is present in the first few meters. It corresponds to the mixing of superficial water through surface agitation. There can also be other features such as a surface channel, which corresponds to sound velocity increasing from the surface down. This channel is often due to a shallow isothermal layer appearing in winter conditions, but can also be caused by water that is very cold at the surface. In a negative sound gradient, the sound speed decreases with depth, which results in sound refracting downwards which may result in increased bottom losses with distance from the source. In a positive sound gradient as predominantly present in the winter season, sound speed increases with depth and the sound is, therefore, refracted upwards, which can aid in long distance sound propagation. The construction timeframe is expected to run from May through mid-July. For the majority of construction modeling scenarios the May SSP (Figure 4) was chosen due to it exhibiting worst case characteristics in terms of long range propagation effects. For the wind turbine operational scenario, the February SSP (Figure 5) was worst case on an annual basis, with May temperatures colder at the bottom and February temperatures colder at the surface, as shown on the corresponding plots.

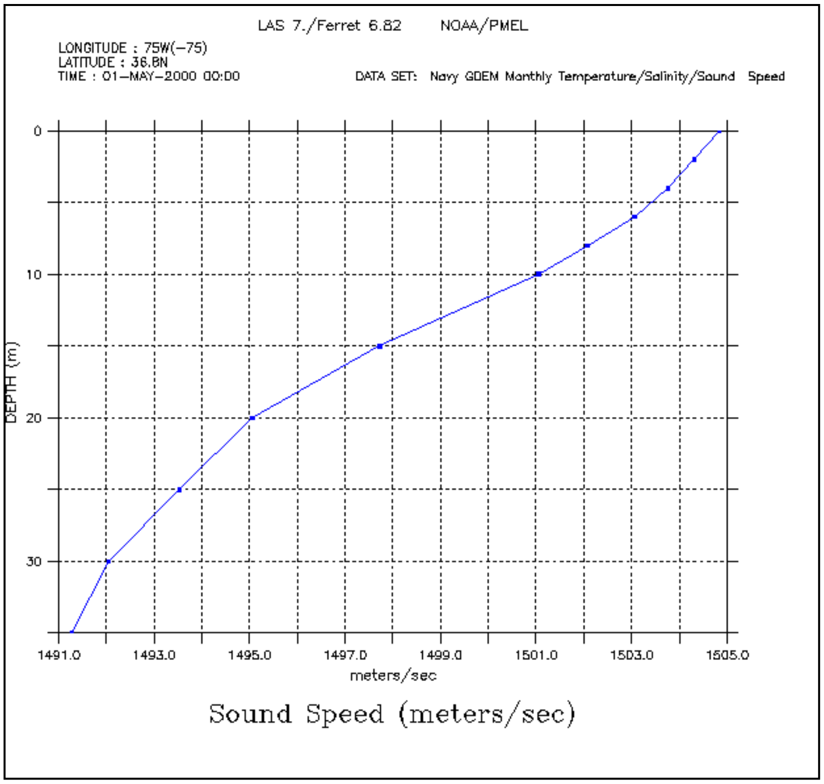

Figure 4. Average May Sound Speed Profile as a Function of Depth

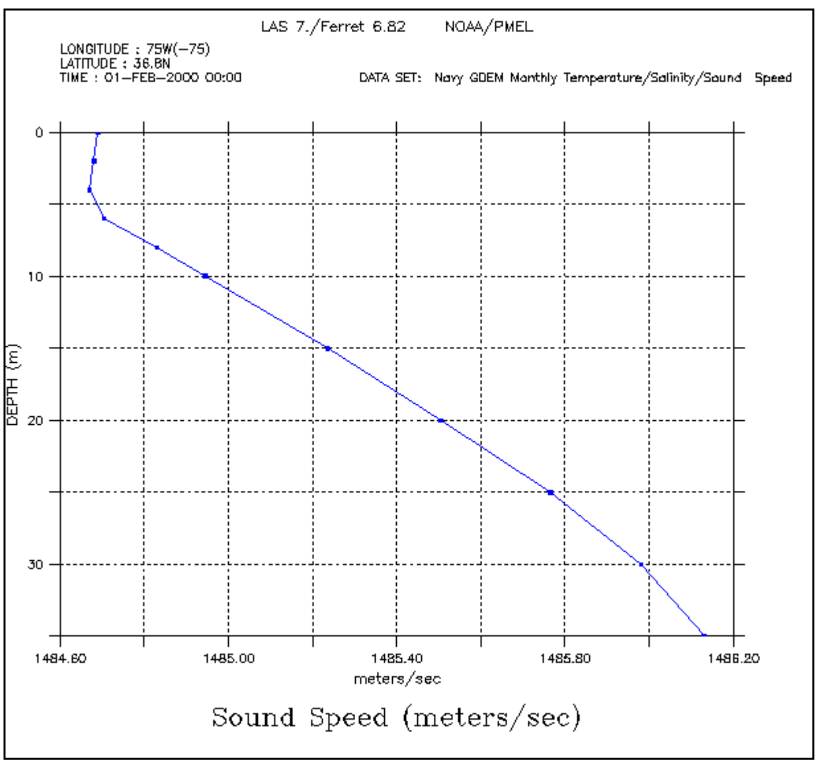

Figure 5. Average February Sound Speed Profile as a Function of Depth

4.3 Acoustic Modeling Scenarios

The representative acoustic modeling scenarios were derived from descriptions of the expected construction activities and operational conditions through consultations between the Project design and engineering teams. The subsections that follow provide more detailed information about the parameters used to model the noise sources associated with each scenario. Sound source level data were unavailable for several vessels and activities identified at the time of writing. Therefore, a literature review was conducted in order to identify source level measurements from comparable equipment performing similar activities. Proxy source levels for each of the modeling scenarios presented in this report were derived from literature, engineering guidelines, and underwater source measurements of similar equipment and activities.

Reasonable and appropriate source level information was derived for wind turbine operation, impact pile driving, cable lay operations, and Dynamically Positioned (DP) vessels expected to be used in support of the WTG installation. The source level descriptions and source depth assumptions are key inputs to the acoustic propagation model. The source level is stated as a spectral level as a function of frequency – e.g. in one-third octave bands and summed as an overall broadband level. The level of an acoustic source is a measure of the acoustic emission at the source. It is related to the radiant intensity and acoustic power of the source, but it is rarely described in these terms. By convention, underwater acoustic source levels are routinely defined as the acoustic pressure at 1m distance from idealized point source, i.e. dB re 1 μPa at 1m by extrapolating back to a reference range of one meter from the source using a version of the simplified free field modeling (see Section 2.1). Extrapolating back to 1 meter to derive an apparent sound source level is particularly prone to error due to the fact that the assumptions used in this derivation are not typically stated. In this particular shallow water environment, the reliance on a simplistic geometric spreading model to use back-propagation to calculate a source's apparent source level is near impossible due to the due to the variability in factors such as bathymetry and sediment properties. This has recently been considered in detail within the specific domain of Environmental Impact Assessments (Farcas et al. 2016), with similar conclusions. Received levels, if appropriately documented (Merchant et al. 2015; Robinson et al. 2014), should however be most useful when comparing different construction and operational scenarios.

However, since most of the data are presented in this way, this format has been maintained here, with the calculation of the apparent source normalized to the CVOW project site based on far-field measurements completed at similar sites. A summary of construction and operational scenarios incorporated into the underwater acoustic modeling analysis is provided in Table 5. The basis for these source levels are provided below.

Table 5. Underwater Noise Modeling Scenarios

Scenario	Description	Geographic Coordinate System NAD83 UTM10N	Apparent Source Level	Water Depth at Source
Scenario 1	Cable Lay Operations Position 1	422417, 4075190	177 dBrms	15 m
Scenario 2	Cable Lay Operations Position 2	433145, 4073712	177 dBrms	21 m
Scenario 3	Cable Lay Operations Position 3	444782, 4076187	177 dBrms	19 m

Scenario	Description	Geographic Coordinate System NAD83 UTM10N	Apparent Source Level	Water Depth at Source
Scenario 4	Cable Lay Operations Position 4	451021, 4079909	177 dBrms	20 m
Scenario 5	WTG Installation	456196, 4083479 456196, 4082429	184 dBrms	25 m
Scenario 6	Impact Pile Driving – 600 kJ Hammer Energy	456196, 4083479 456196, 4082429	211 $dBrms_{90}$ 220 SEL 231 Peak	25 m
Scenario 7	Impact Pile Driving – 1,000 kJ Hammer Energy	456196, 4083479 456196, 4082429	213 $dBrms_{90}$ 222 SEL 233 Peak	25 m
Scenario 8	Operational Wind Turbine	456196, 4083479 456196, 4082429	140 to 150 dBrms	25 m

4.3.1 Cable Lay Operations

Specialist vessels specifically designed for laying and burying cables on the seabed will be used. The cable will be buried along the cable route by the use of a jet plow or plow. Throughout the cable lay process, a DP enabled cable lay vessel maintains its position (fixed location or predetermined track) by means of its propellers and thrusters using a Global Positioning System, which describes the ship's position by sending information to an onboard computer that controls the thrusters. DP vessels possess the ability to operate with positioning accuracy, safety, and reliability without the need for anchors, anchor handling tugs and mooring lines. The underwater noise produced by subsea trenching operations depend on the equipment used and the nature of the seabed sediments, but will be predominantly generated by vessel thruster use.

Thruster sound source levels may vary in part due to technologies employed and are not necessarily dependent on either vessel size, propulsion power or the activity engaged. Cable installation contractors have not yet been identified for Project construction; therefore, data on any vessel specific thrusters is not available at this time. The sound source level assumption employed in the underwater acoustic analysis was 177 dB and a vessel draft of 7 meters for placing source depth. For the purposes of the underwater acoustic modeling analysis, it was assumed that cable laying activities will be continuous and may occur on a 24-hour schedule. Thruster noise is generated by cavitation and has a relatively flat spectrum shape due to the large number of random bursts caused by various sized bubbles collapsing. The discrete spectral "blade rate" component occurs at multiples of the rate at which any irregularity in the flow pattern or in the impeller itself is intercepted by the impeller blades (Fischer 2000).

4.3.2 Heavy Lift Vessel and WTG Installation

Installation of the WTG structures will involve the use of supply and service vessels including an offshore heavy lift jack up vessel, operation support vessel, a high speed heavy cargo vessel, and a specialized wind turbine installation vessel, many of which are equipped with thrusters. Thrusters are propellers located below the water line and may either be mounted in tunnels running crosswise through the vessel's hull or hung below the vessel's hull. Thrusters can generate elevated underwater noise and are used intermittently. Broadband linear source values were estimated to range from 177 to 183 dB assuming full engine loads occurring during short term pushing, pulling, or lifting operations. To allow the vessels to remain on station. For the purposes of providing the acoustic modeling analysis, the apparent sound source level was adjusted up to 184 dB to account for cumulative effects of multiple support vessels operating concurrently.

4.3.3 Pile Driving

In most cases, foundations for massive offshore wind turbine structures are constructed by driving piles into the seabed with hydraulic hammers. The pile driver operates by lifting a hammer inside the driver and dropping it onto a steel anvil. The anvil transmits the impulse into the top of the pile and the pile is forced into the sediment. Repeated blows drive the monopile to the desired depth, the vertical travel of the pile decreasing with each blow as greater soil resistance is built up from the contact between the pile surface and the sediment. Each blow typically results in a travel of several centimeters. During this time, the hammer strikes the pile approximately once every two seconds.

Predicting underwater noise levels during offshore pile driving is of great interest to foundation installation contractors who must comply with stringent noise emission thresholds. The CVOW monopile will have a 7.8 m diameter at the seafloor and 6 m diameter flange. The length of the monopile ranges from 62.5 to 64 meters. Only one monopile will be driven at a time. The acoustic energy is created upon impact and travels into the water along different paths: 1. from the top of the pile where the hammer hits, through the air, into the water; 2. from the top of the pile, down the pile, radiating into the air while travelling down the pile, from air into water; 3. from the top of the pile, down the pile, radiating directly into the water from the length of pile below the waterline; and 4. down the pile radiating into the seafloor, travelling through the seafloor and radiating back into the water.

Near the pile, acoustic energy arrives from different paths with different associated phase and time lags which creates a pattern of destructive and constructive interference. The sound radiating from the pile itself was simulated using a vertical array of discrete point sources to accurately characterize vertical directivity effects in the near-field zone. Further away from the pile, the water and seafloor borne energy are the dominant pathways. The underwater noise generated by a pile-driving strike depends primarily on the following factors:

1. The impact energy and type of pile driving hammer,
2. Pile diameter and type of the pile,
3. Water depth, and
4. Subsurface hardness in which the pile is being driven.

The acoustic energy radiated into the aquatic environment by a struck pile is directly correlated to the kinetic energy that the impact hammer imparts to it. Engineering considerations about pile penetration and load bearing capacity dictate that the impact hammer energy must be matched to the pile and to the resistance of the underlying substrate (Parola 1970). Greater hammer impact energy is required for larger diameter piles to achieve the desired load bearing capacity. The water depth also has a strong influence. As more of the surface area is exposed at greater water column depths, a higher percentage of sound energy may be introduced directly into the aquatic environment.

Tables 6 presents underwater sound measurement data collected for impact pile driving of cylindrical steel piles with similar diameter, water column depths, seafloor characteristics, and impact forces, in the context of an offshore oceanic environment. These data show that the noise level increases by 10 $\log_{10}$ (E_2/E_1) as the blow energy is increased from E_1 to E_2 which was lower than previously reported in other study documents (Schultz-von et al. 2006; Stephen P. Robinson et al. 2007). The normalization methodology also accounts for variations in depth and distance and is described by the following equation for the expected maximum impact force necessary to install the 7.8 meter diameter pile:

$$L_{normalized} = L_{measured} + 10\log_{10}\left(\frac{25}{H_1}\right) + 15\log_{10}\left(\frac{R_1}{500}\right) + 10\log_{10}\left(\frac{600}{E_1}\right)$$

Where: L = sound pressure level
H_1= depth at which the original pile driving measurement was completed
R_1 = distance at which the original measurement was taken
E_1 = impact hammer force for the original measurement
E_2 = estimated maximum hammer force 600 kJ

Measured underwater noise data from pile driving of a 7.8 meter diameter pile for the Walney Extension Offshore Wind Farm was referenced with additional adjustments to the normalization function. The last two columns of Table 6 present the key sound metrics that were used in the determination of biological significance, rms_{90} SPL normalized to a distance of 500 meters and applied in subsequent modeling calculations. Pile driving sound is characterized as impulsive, which has somewhat unique features in comparison to other sounds. Impulsive sounds can have moderate average, but very high instantaneous pressure peaks, which might be harmful to the auditory system. For the purposes of assessing compliance with the NOAA Fisheries cause and effect for impulsive sound, the reporting of sound generated during impact pile driving must employ a RMS SPL "averaged over the duration of the pulse". A typical pile driving impulse duration is approximately 125 milliseconds with principal energy contained within the first 30 to 40 milliseconds. The measured peak sound level represents the maximum of these high instantaneous pressure peaks. As shown in Table 6, the normalized $RMS_{90\%}$ range from 182 to 184 dB at a reference distance of 500 meters for the expected pile driver hammer energy of 600 kJ to 1000 kJ.

Table 6. Normalization of Underwater Pile Driving Measurement Results

Measurement Site	Pile Diameter m	Measured Depth H1 m	Measured Distance R1 m	Impact Energy E1 kJ	MEASURED SPL dB re 1 µPa		$RMS_{90\%}$ re 1 µPa NORMALIZED TO 500 m	
					Peak	$RMS_{90\%}$	Impact Force 600 kJ	Impact Force 1000 kJ
Walney Extension	7.8	28	730	600	192	179	182	184
$RMS_{90\%}$ values estimated using a 125 millisecond pulse duration. Reference: Niras Consulting Ltd, 2017								

The SEL is the level of a sound energy averaged over a stated 1-second duration with the same sound energy as occurring during the pressure pulse. The normalized SELs the range from 173 to 175 dB at a reference distance of 500 meters for the expected pile driver hammer energy of 600 kJ to 1000 kJ. If the strikes are all equal force, the SEL_{cum} can be computed from the single-strike SEL based on the total number of strikes using the following equation:

Cumulative SEL (SEL_{cum}) = Received SEL + 10 * log(# number of strikes)

That is, the SEL_{cum} increases by 10 dB with every tenfold increase of the number of strikes. In actuality, the pile driving would initially start at the lower range of impact force, and ramp up to a maximum impact force to reach final design penetration and seat the piles. The calculation has assumed this expected impact force of 600 kJ would occur over an entire piling sequence, with the 1000 kJ force occurring for a comparatively shorter duration at the very end of the installation to adequately seat the monopile, if necessary.

4.3.4 WTG Operation

When the WTGs are operational, the main source of underwater noise will be from the working of the gears in the nacelle at the top of the tower (Nedwell et al. 2004). This noise/vibration is transmitted into the sea by the structure of the tower itself, and manifests as low frequency noise. Other transmission pathways are via the tower and the seabed, or through the air and air/water interface, but those pathways are unlikely to be as important as the pathway directly through the tower (Nedwell et al. 2004). A review of other published studies indicate that source levels from operating offshore WTGs that have monopile foundations show peak frequencies occurring predominantly below 500 Hz, and that the apparent source level range from 140 to 153 dB re 1μPa at 1m (Nedwell et al. 2004). Similar measurements by Nedwell indicate that the steady state background in an offshore oceanic environment also occurs within this frequency range, which implies masking effects. The available field data showed that although the absolute level of turbine noise increases with increasing wind speed, the noise level relative to background noise (i.e., from wave action, entrained bubbles) remained relatively constant.

5 ACOUSTIC MODELING RESULTS

By employing field verified underwater measurement data, resultant sound levels are representative of vessels and equipment that are likely to be employed during Project activities. Acoustic modeling algorithms were applied to estimate received sound levels from various Project construction and operational phases to determine distances to biologically significant threshold levels as defined by NOAA Fisheries. Analysis methods accounted for the Project's shallow water environment, considering both spatial and seasonal factors in conjunction with estimations of source levels. The default weighting function adjustment (WFA) of 2 kHz for pile driving as described in the NMFS guidance document (NMFS, 2016) was not used. NMFS concedes that using the default WFAs will result in larger impact distances than more sophisticated modeling (NMFS 2016). The modeling software, dBsea (©Marshall-Day) was used to predict the underwater sound fields using more precise weighting functions (NMFS 2016) to compute SELcum rather than the default WFAs.

Acoustic modeling was conducted for the scenarios described in Section 4.3 and the results of those analyses are presented in the subsequent subsections. Maps of modeled un-weighted acoustic sound fields are provided in Appendix A, which present color-coded unweighted decibel isopleths projected onto scaled mapping. These sound contour maps show that the highest noise levels from impact pile driving are to be found where the sound is able to propagate away from the source in deeper water for the furthest distance, before being attenuated by bottom loss in shallower water. The results of the hydroacoustic modeling calculations are presented in two different formats. For Scenario 1 through 5 (Figure A-1 through A-5), each contour illustrates the received rms SPL in dB re 1 μPa, the maximum sound pressure level over the measurement period. For Scenarios 6 and 7 (Figure A-6 and A-7), sound level contour maps show the total sound energy contained in a single pile driving pulse in SEL dB re 1$\mu Pa^2 s$ in 10 dB increments, and Figure A-8 and A-9 showing the same pile driving scenarios with the implementation of mitigation in the form of a Big Bubble Curtain (BBC).

The expected acoustic fields for each of the modeled scenarios are presented as tabularized distances to the specific NOAA Fisheries Level A and Level B thresholds. The distances in the tables are given in meters from a given source location with R_{max} indicates the greatest maximum radial distance from the source to the specified threshold value. The R_{mean} indicates the average distance from source at which the sound level would be present, i.e. an average circular area that would encompass an area exposed to sound at or above that level, regardless of the actual geometrical shape of the noise footprint. Both RMS SPL and SELcum descriptors apply the maximum level over all sampled depths at the given radial transect. The resultant dataset will be used to estimate how many marine mammals and other species of concern would receive a specified amount of sound energy in a given time period and for use in developing monitoring and/or mitigation programs, as necessary.

5.1 Cable Lay Operations

The use of DP thrusters and jet plow activities were modeled at four locations along the cable lay route. The locations were chosen to provide analysis on different water depths and bathymetry profiles affect the area of impact. For the 180 dB_{RMS} threshold for sea turtles, it was concluded that the distance will be negligible. During operation, thrusters would generate noise which exceeds and Level B harassment threshold 120 dB_{RMS} to a maximum distance of over 20 kilometers.

The maximum distance to the 150 dB_{RMS} behavior threshold for the fish would be 350 meters from a DP vessel with thrusters operating at full power for the worst case cable lay position. Peak thresholds will not be exceeded to any appreciable distance. The SEL cumulative levels will vary as they are dependent on duty cycles which are difficult to predict. Distance to SELcum thresholds are expected to be substantially lower than the pile driving scenarios.

The modeled acoustic fields are presented as a radii of distances to the specific sound level thresholds and marine mammal hearing groups in Table 7 for the worst case Cable Lay position 1. A sound contour isopleth map of the modeled acoustic field in color-coded unweighted decibel isopleths projected onto scaled mapping is provided as Figures A-1 through A-4.

Table 7. Distances to Maximum-Over-Depth Sound Level for Cable Lay Operations Linear and M-weighted for the Four Functional Hearing Groups

SPL rms (dB re 1 μPa)	Unweighted	LF cetaceans	MF cetaceans	HF cetaceans	Phocid pinnipeds
	Range (m)				
180	N/A	N/A	N/A	N/A	N/A
170	80	N/A	N/A	N/A	N/A
160	125	75	N/A	N/A	N/A
150	350	120	N/A	N/A	N/A
140	2,625	150	N/A	N/A	75

130	8,800	1,250	N/A	N/A	125
120	23,000	4,000	N/A	N/A	325

5.2 Heavy Lift Vessel and Wind Turbine Installation

Vessels associated with WTG installation were also evaluated in terms of potential impacts to marine species. For sea turtles, the distance to the 180 dB_{RMS} threshold will be negligible, not measurable to any appreciable distance. Noise impacts to distances further out will vary based on differences in the bathymetry. The maximum distance to the Level B harassment threshold of 120 dB_{RMS} is 17 km.

The results of the modeling analysis indicate the maximum distances to the 150 dB_{RMS} behavior threshold for fish is 600 meters. Peak thresholds will not be exceeded to any appreciable distance. The SEL cumulative levels will vary as they are dependent on duty cycles which are difficult to predict. Distance to SELcum thresholds are expected to be substantially lower than the pile driving scenarios.

The modeled acoustic fields are presented as a radii of distances to the specific sound level thresholds and marine mammal hearing groups in Table 8. A sound contour isopleth map of the modeled acoustic field in color-coded unweighted decibel isopleths projected onto scaled mapping is provided in Appendix A.

Table 8. Distances to Maximum-Over-Depth Sound Level for Heavy Lift Vessel and Wind Turbine Installation Linear and M-weighted for the Four Functional Hearing Groups

dB SPL rms (dB re 1 µPa)	Unweighted	LF cetaceans	MF cetaceans	HF cetaceans	Phocid pinnipeds
	Range (m)				
180	50	N/A	N/A	N/A	N/A
170	100	N/A	N/A	N/A	N/A
160	125	80	N/A	N/A	N/A
150	600	125	N/A	N/A	50
140	2,850	300	N/A	N/A	100
130	7,250	1,450	N/A	N/A	130
120	17,000	4,600	50	N/A	500

5.3 Pile Driving

Pile driving activities will occur during daylight hours starting approximately 30 minutes after dawn and ending 30 minutes prior to dusk, unless a situation arises where ceasing the pile driving activity would compromise safety (both human health and environmental) and/or the integrity of the Project. Impact pile driving included the analysis for the 600 kJ and maximum 1000 kJ hammer energies, thereby describing the full range of sound levels expected throughout an entire piling sequence. Figures A-6 and A-7 in Appendix A provide sound contour isopleth mapping of the modeled acoustic fields in color-coded unweighted decibel isopleths projected onto scaled mapping for the two hammer energies. Soft-start mitigation procedures would be employed to reduce sound levels during the initial stages of driving a pile, which will reduce risk of impacts as the distance to thresholds would be significantly shorter as the cumulative SEL generally increases more rapidly at close range to the pile and less rapidly at greater ranges from the pile where the received sound levels are lower. The use of soft-start may also be effective in deterring aquatic life allowing movement to a safe distance prior to the full energy piling being reached by allowing time for a fleeing animal to reduce its exposure to the sound.

Assessment of proposed mitigation measures will consider the feasibility as well as the frequency range and expected noise reduction for the selected mitigation measure. Bubble curtains are commonly used to reduce acoustic energy emissions from high-amplitude sources and are generated by releasing air through multiple small holes drilled in a hose or manifold deployed on the seabed near the source. The resulting curtain of air bubbles in the water provides significant attenuation for sound waves propagating through the curtain.

The sound attenuating effect of the noise mitigation system BBC or air bubbles in water is caused by :(i) sound scattering on air bubbles (resonance effect) and (ii) (specular) reflection at the transition between water layer with and without bubbles (air water mixture; impedance leap). The noise reduction realized with the bubble curtain is estimated at 10 to 13 dB (Bellman 2014) for the SEL metric with potentially higher attenuation rates for the Peak metric. Figures A-8 and A-9 in Appendix A provide sound contour isopleth mapping of the modeled acoustic fields for the mitigated pile driving scenarios with a BBC.

Peak Sound Pressure Level

Table 9 presents the maximum (R_{max}) radial distances that correspond to the peak SPLs (dB re 1 µPa) for impact pile driving. The levels presented in Table 9 correspond to auditory injury and disturbance criteria for marine mammals and injury criteria for fish for both the unmitigated scenario and with the BBC. Peak thresholds are unweighted. Several of the Peak distances to thresholds do not change under the mitigated pile driving scenario, as these distances will fall within the expected bubble curtain containment area of 100 meters.

Table 9. Maximum Radii (m) That Correspond to the Peak SPLs for Impact Pile Driving

Peak SPL (dB re 1 µPa)	Criteria	R_{max}
202	PTS – HF cetaceans	325
205	Injury – Fish	200
218	PTS – Phocid pinnipeds	<100
219	PTS – LF cetaceans	<100
230	PTS – MFC cetaceans	<100
Big Bubble Curtain Mitigated		
202	PTS – HF cetaceans	<100
205	Injury – Fish	<100
218	PTS – Phocid pinnipeds	<100
219	PTS – LF cetaceans	<100
230	PTS – MFC cetaceans	<100

<u>Cumulative Sound Exposure Levels</u>

Each foundation is anticipated to require up to 1 day to complete the installation. The drivability assessment predicts an upper bound estimate of 1,333 blows for the first foundation (position A01) and 2,470 blows for the second position (position A02) at a rate of 30 blows per minute. The radii in Tables 10 and 11 correspond to marine mammal injury and disturbance criteria and fish injury and behavioral disturbance criteria for a 24-hour SEL_{cum}.

Table 10. Radii (m) of Unweighted and M-Weighted SEL_{cum} Contours for Impact Pile Driving – 600 kJ

SEL_{cum} (dB re 1 µPa^2 s)	Critera	Unweighted		LFC		MFC		HFC		PINN	
		R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}
155	PTS– HF cetaceans							1,625	1,450		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	6,100	5,200	4,300	3,900						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					250	250			1,000	850
187	Injury – Large fish (mass >2 g)	4,400	3,900								
Big Bubble Curtain Mitigated											
155	PTS– HF cetaceans							<200	<200		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	3,575	2,950	1,450	1,250						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					<200	<200			200	200
187	Injury – Large fish (mass >2 g)	2,625	2,050								

Table 11. Radii (m) of Unweighted and M-Weighted SEL_{cum} Contours for Impact Pile Driving – 1000 kJ

SEL_{cum} (dB re 1 µPa² s)	Critera	Unweighted		LFC		MFC		HFC		PINN	
		R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}	R_{max}	R_{mean}
155	PTS– HF cetaceans							2,100	1,800		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	6,900	6,000	5,100	4,600						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					300	300			1,200	1,000
187	Injury – Large fish (mass >2 g)	5,200	4,400								
Big Bubble Curtain Mitigated											
155	PTS– HF cetaceans							250	250		
183	Injury – Small fish (mass <2 g) PTS - LF cetaceans	3,150	2,500	1,750	1,500						
185	PTS - MF cetaceans PTS - Phocid pinnipeds					<200	<200			250	250
187	Injury – Large fish (mass >2 g)	2,050	1,700								

Sound Pressure Levels ($RMS_{90\%}$)

As shown in Tables 12 and 13, the resultant distances to the Level B Harassment of marine mammals threshold of 160 dB_{RMS90} ranges from 4 km to 5 km unmitigated and 2 km to 2.5 km with BBC. Hearing recovery time would be expected during significant gaps in piling. The 12 hour period represents the daylight time window that pile driving would occur and allows for overnight recovery time for the fish during the day after pile driving has stopped. The distances to the 150 dB_{RMS90} threshold for fisheries resources range from 8.75 km to 11.375 km unmitigated and 4.57 km to 5.67 km with the BBC. The distances to the 166 dB_{RMS90} threshold for sea turtles range from 2.7 km to 3.15 km unmitigated and 1.175 to 1.5 km with the BBC. The historical Level A threshold or 180 dB_{RMS90} for injury of marine mammals, which is still currently in use for sea turtles, ranges from 700 m to 800 m unmitigated and 280 m to 350 m with the BBC.

Table 12. Radii (m) of dB_{rms90} SPL Contours for Impact Pile Driving – 600 kJ

dB rms90 SPL (dB re 1 µPa)	Criteria	R_{max}	R_{mean}
150	Disturbance – Fish	9.725	8,750
160	Disturbance – Marine Mammals	4,380	4,275
166	Disturbance – Sea Turtles	2,700	2,650
180	Injury – Seaturtles (Marine Mammals - Historic)	700	680
Bubble Curtain Mitigated			
150	Disturbance – Fish	4,700	4,570
160	Disturbance – Marine Mammals	2,110	2,060
166	Disturbance – Sea Turtles	1,200	1,175
180	Injury – Seaturtles (Marine Mammals - Historic)	300	280

Table 13. Radii (m) of dB_{rms90} SPL Contours for Impact Pile Driving – 1000 kJ

dB rms90 SPL (dB re 1 µPa)	Criteria	R_{max}	R_{mean}
150	Disturbance – Fish	11,375	10,225
160	Disturbance – Marine Mammals	5,175	5,050
166	Disturbance – Sea Turtles	3,150	3,075
180	Injury – Seaturtles (Marine Mammals - Historic)	800	780
Bubble Curtain Mitigated			
150	Disturbance – Fish	5,670	5,120
160	Disturbance – Marine Mammals	2,520	2,450
166	Disturbance – Sea Turtles	1,500	1,460
180	Injury – Seaturtles (Marine Mammals - Historic)	350	330

5.4 Wind Turbine Operation

Underwater noise from the operation of the wind farm has also been modeled using proxy sources and based on actual measurement data, and shows that noise levels within the boundary of the Project are not likely to be significantly above ambient noise, but may increase the ambient noise slightly during periods of calm seas and low shipping traffic. It should be noted that a major contribution to the ambient noise would result from sea-state, which would be expected to increase as the turbines rotational speed increases with wind speed.

Acoustic modeling of underwater operational sound was performed for the design wind condition during normal operations. The predicted sound level from operation of a wind turbine has been estimated at only 130 dB at 20 m from the wind turbine foundation and attenuates to the 120 dB_{RMS} threshold level at a relatively short distance of 100 m. These levels are very close to the expected regularly reoccurring ambient noise. The WTGs are located approximately 3,450 ft (1,050 m) apart from one another; so no cumulative effects above 120 dB_{RMS} threshold will occur.

The operational effects of the Project are anticipated to be minimal, with no adverse effect to marine mammals and aquatic life. Underwater noise levels in this range may be perceptible to marine mammals that swim close to an operating wind turbine, but would not adversely affect them or their prey. Although the effect on fish response is more difficult to establish given the lack of information available in the scientific literature, there is indicative evidence that fish would be unlikely to show significant avoidance to the noise levels radiating from the turbine and received sound levels will be below the 150 dB_{RMS} behavioral threshold set for listed species. Vessels servicing the Project site will produce underwater sounds typical of existing vessel traffic in the area; therefore, the Project poses no unique or special risk to marine life.

6 CONCLUSION

Several activities during the construction phase will result in underwater noise above the background noise levels. The primary noise source will be the impact piling activity, whereas activities such as wind turbine and cable installation are expected to introduce significantly lower levels of noise.

Underwater sound levels produced during Project construction are not expected to be of sufficient duration to cause long term effects on marine mammals, sea turtles and fisheries within the Project Area. Temporary avoidance behavior due to Project related noise and vessel activity is likely to occur during the construction period. In addition, the implementation of mitigation and monitoring techniques, such as observation of time-of-year windows, the use of protected species observers during project construction activities that are known to generate high-intensity sound levels, and the establishment of exclusion and monitoring zones as well as ramp-up and shut-down procedures during pile driving events have proven to minimize impacts on marine species should they occur in the Project Area. Dominion will conduct field verifications of actual impact pile driving and DP vessel thruster noise during installation of the CVOW monopile foundations and the Inter-Array and Export Cables for model validation purposes and to further determine the effectiveness of the mitigation measures employed.

The assessment of underwater noise levels associated with the operational phase of the Project shows expected underwater noise levels to be well below thresholds established to be adequately protective of all marine life.

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Attachment A – Sound Contour Isopleth Figures

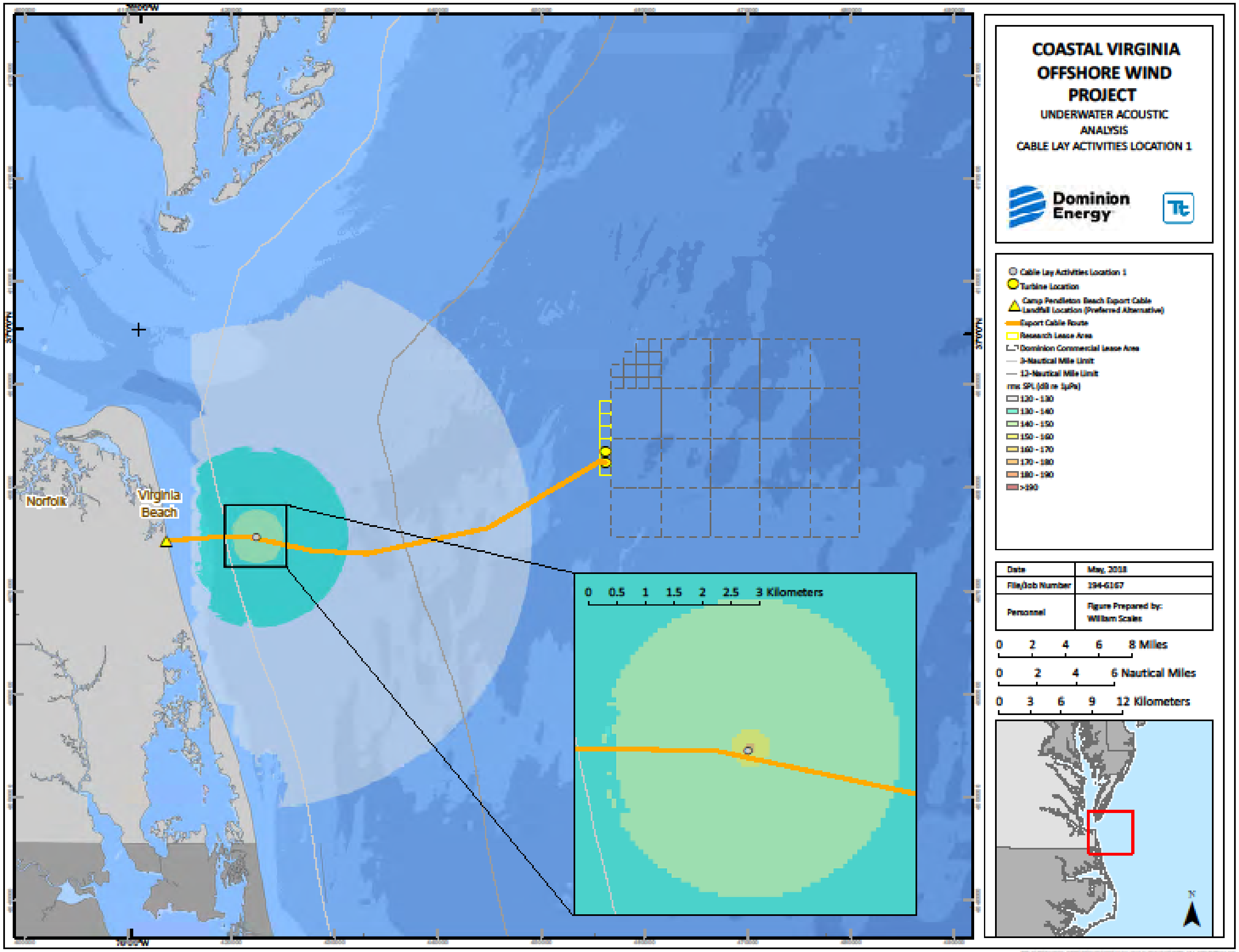

Figure A-1. Scenario 1: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Cable Lay Operations at Location 1

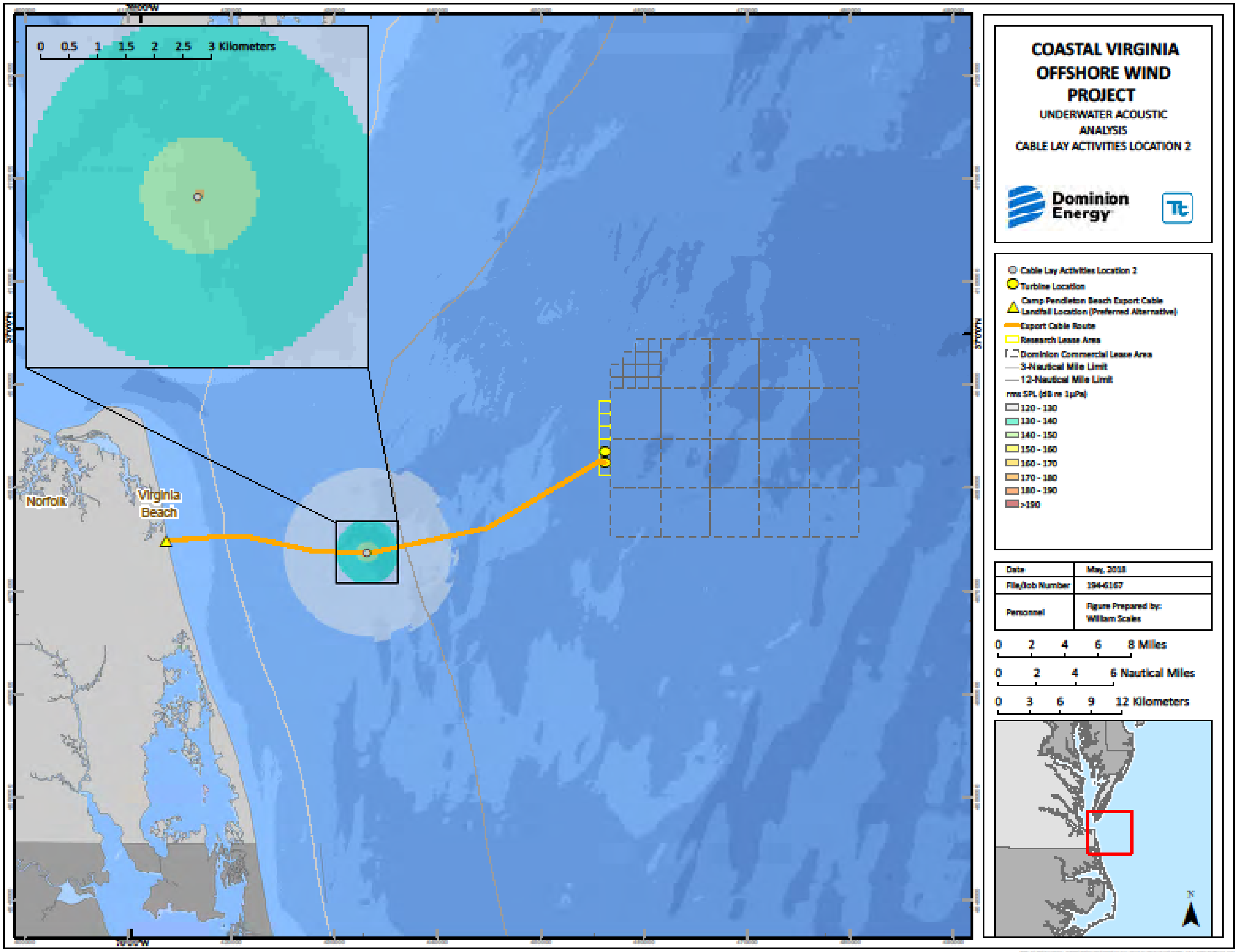

Figure A-2. Scenario 2: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Cable Lay Operations at Location 2

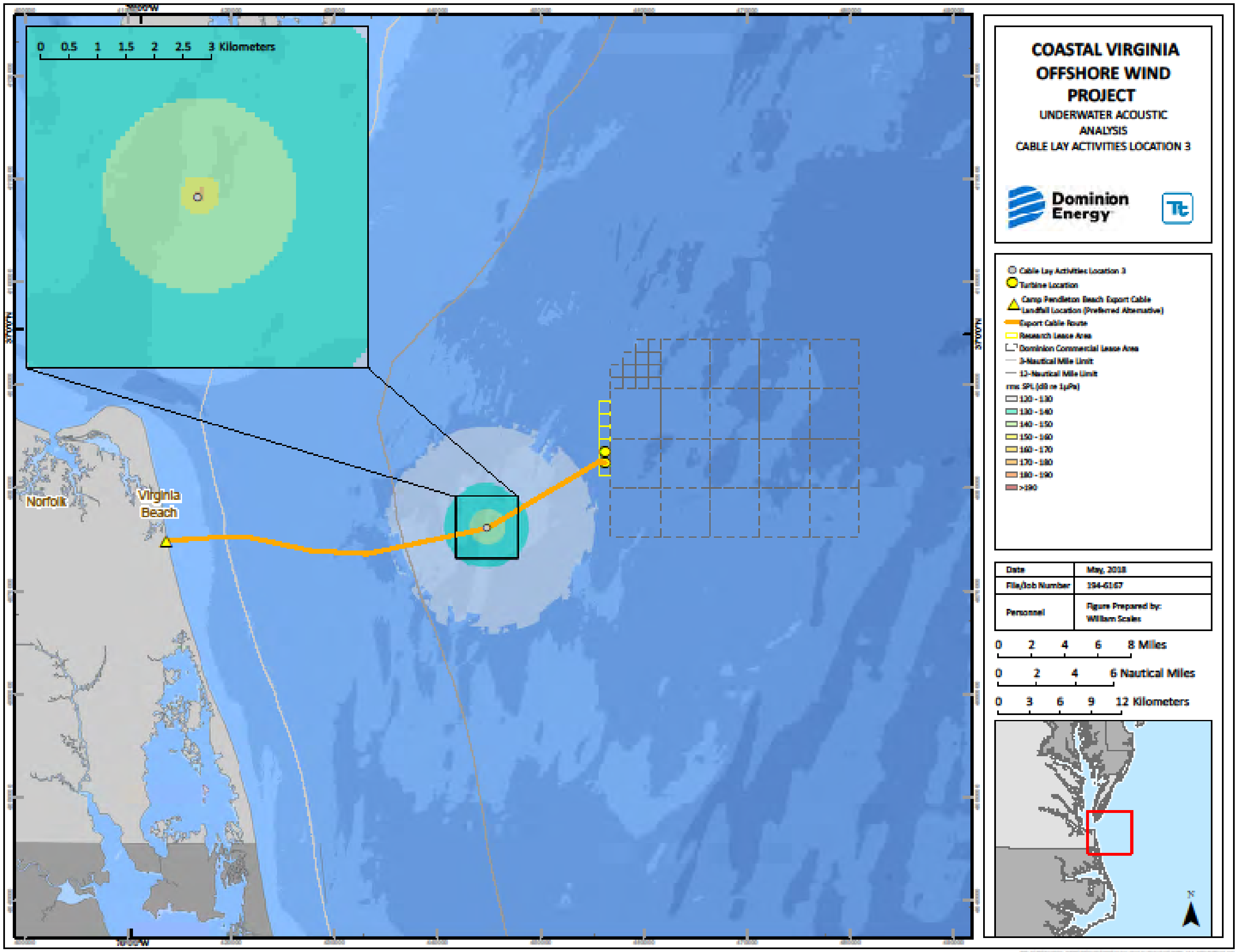

Figure A-3. Scenario 3: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Cable Lay Operations at Location 3

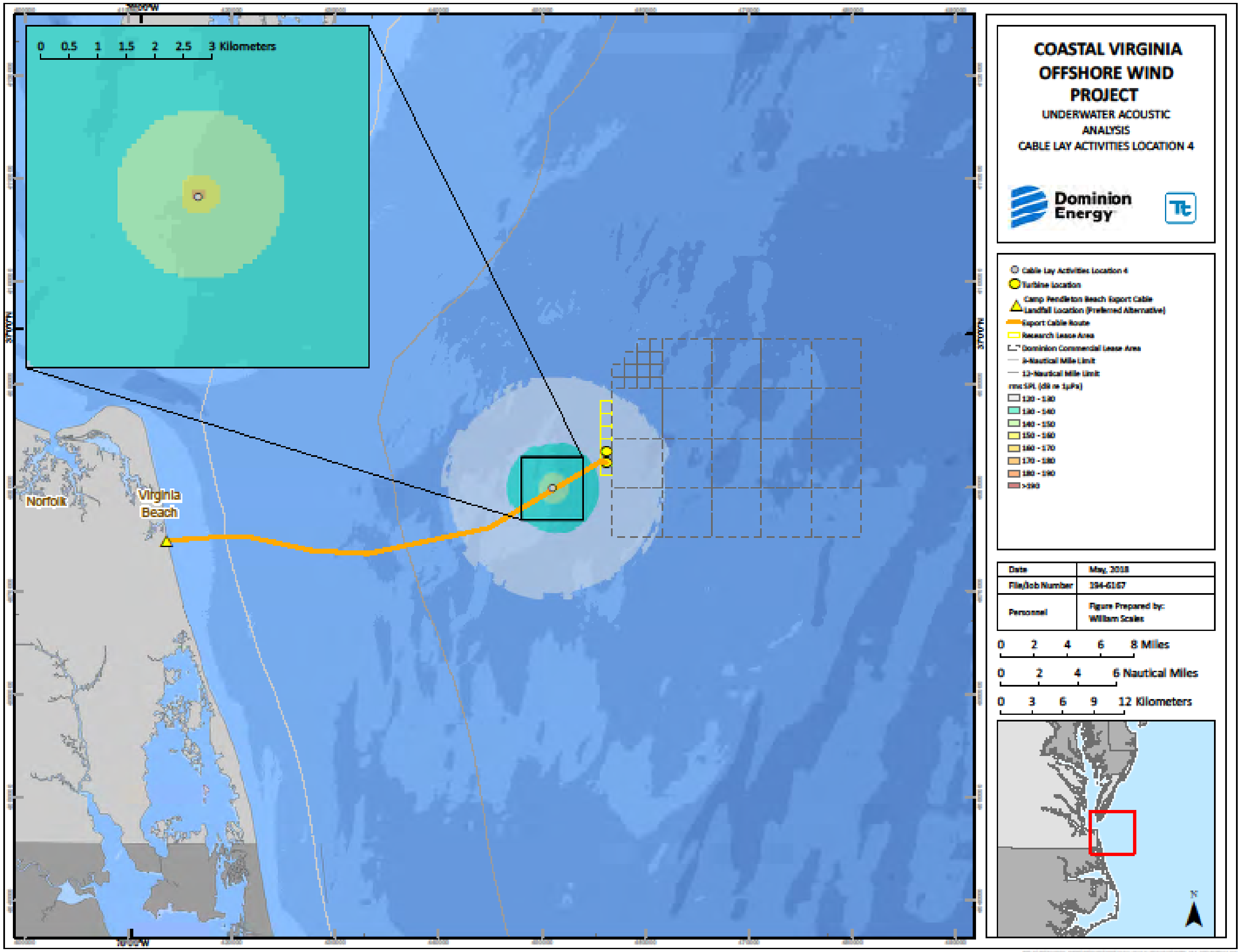

Figure A-4. Scenario 4: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Cable Lay Operations at Location 4

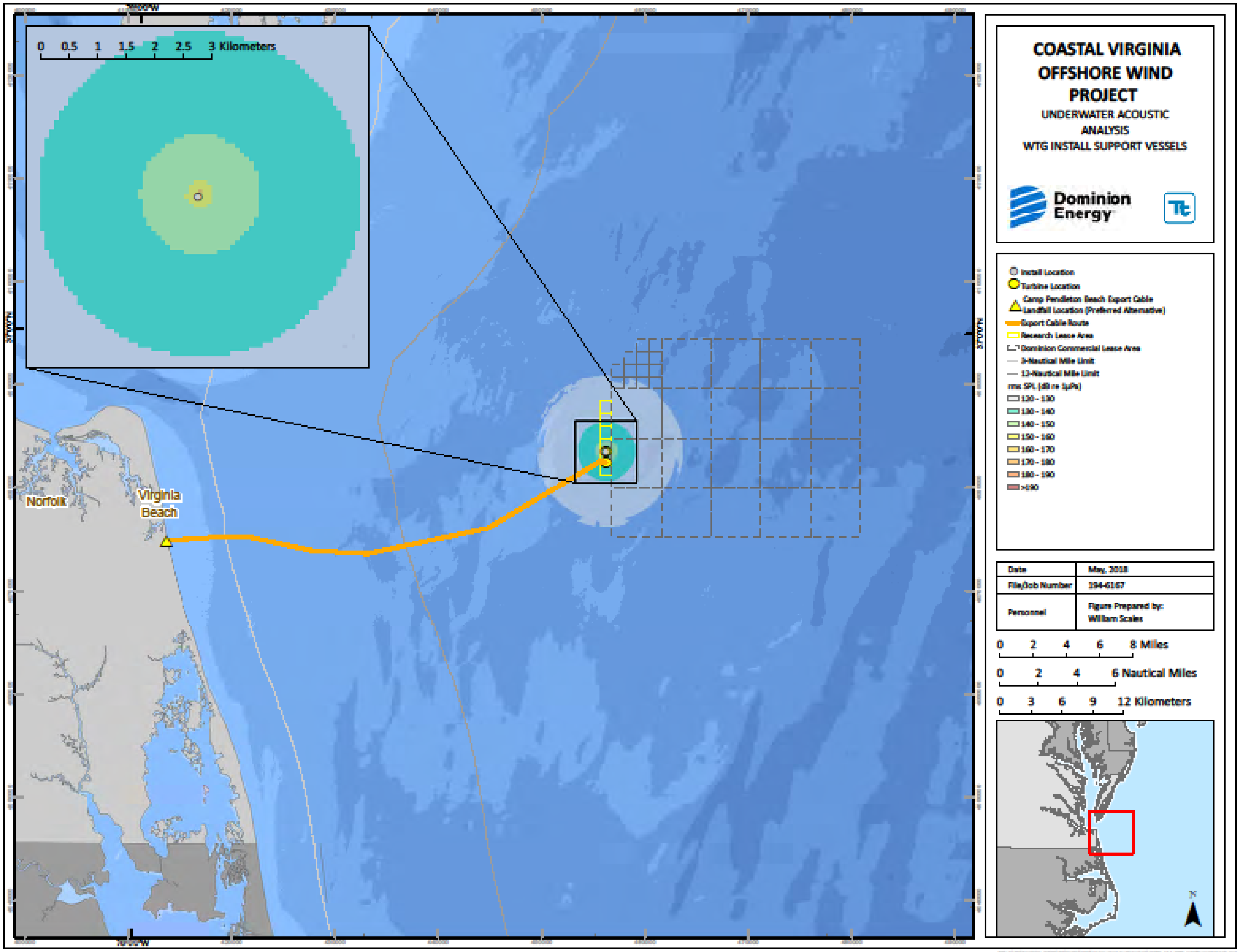

Figure A-5. Scenario 5: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Wind Turbine Installation at Project Site

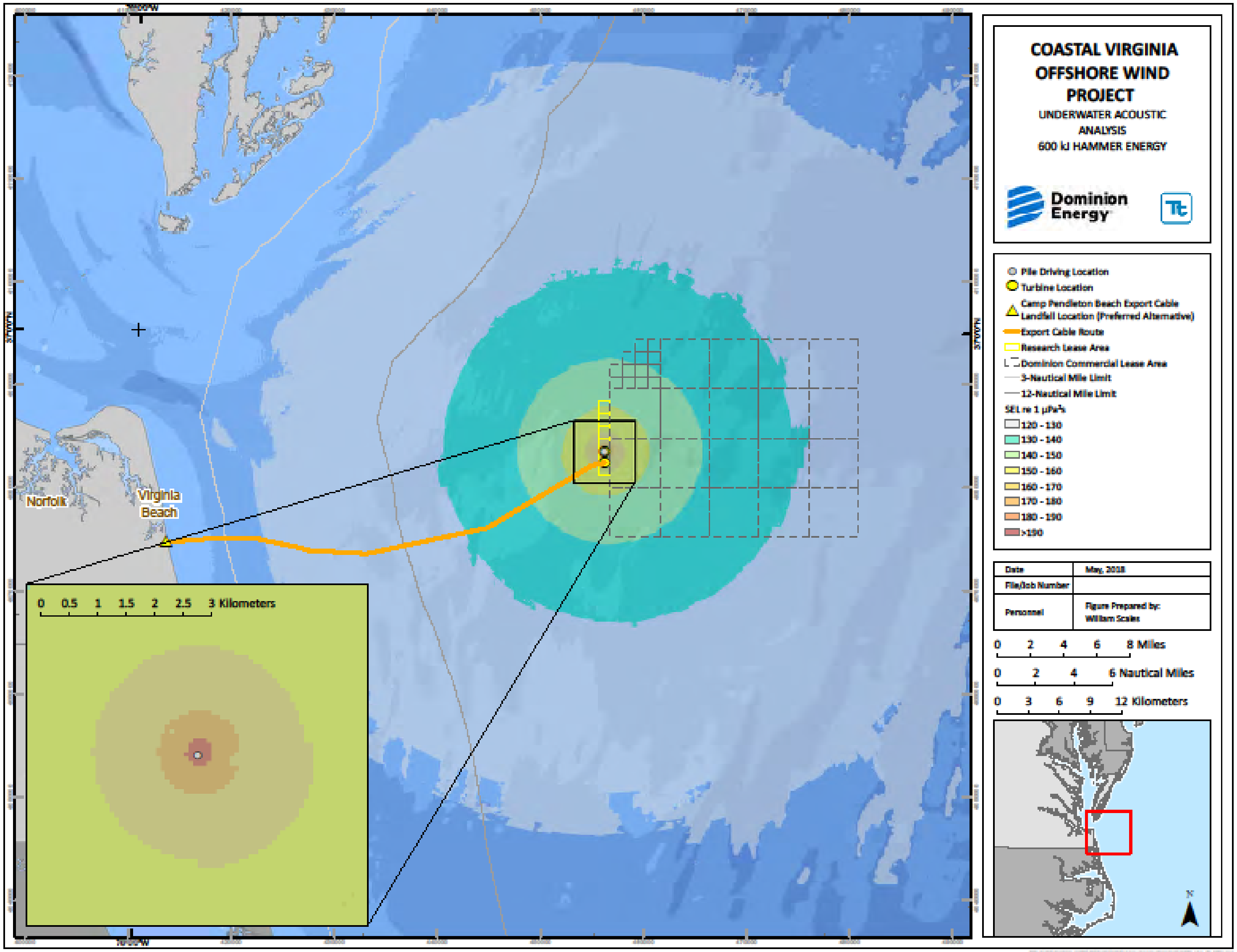

Figure A-6. Scenario 6: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Pile Driving at Expected Hammer Energy (600 kJ)

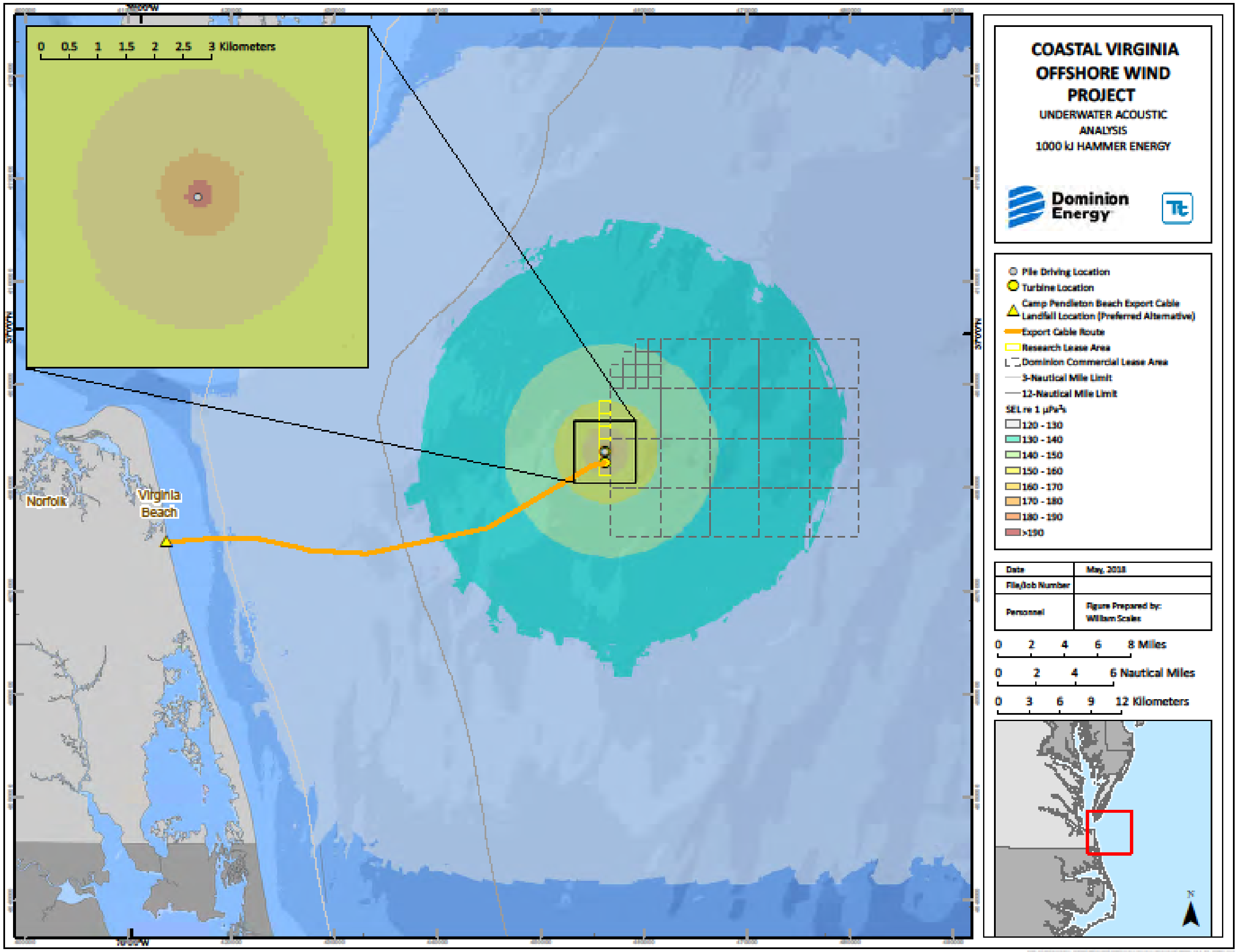

Figure A-7. Scenario 7: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Impact Pile Driving at Maximum Hammer Energy (1000 kJ)

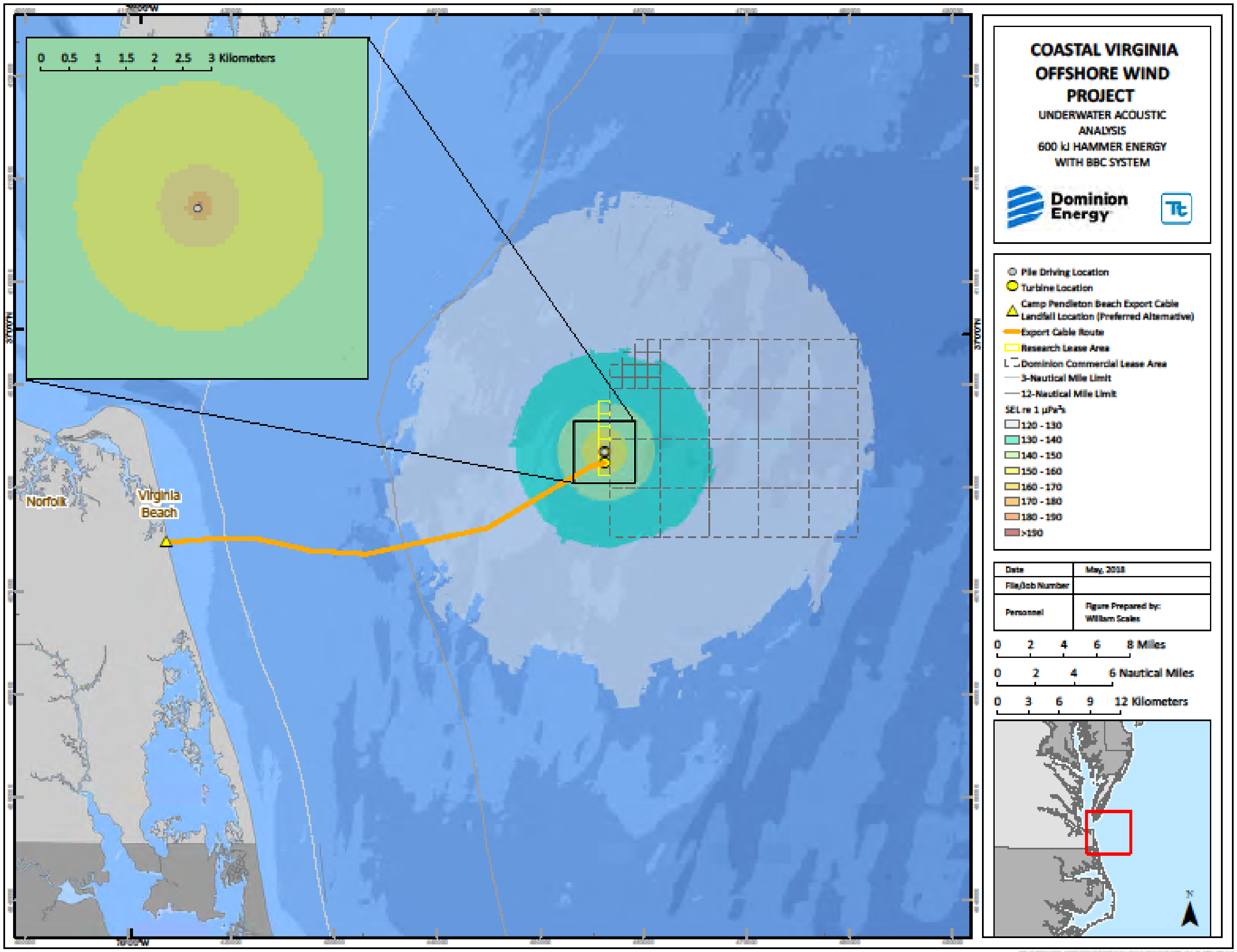

Figure A-8. Scenario 6: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Pile Driving at Expected Hammer Energy (600 kJ) with BBC

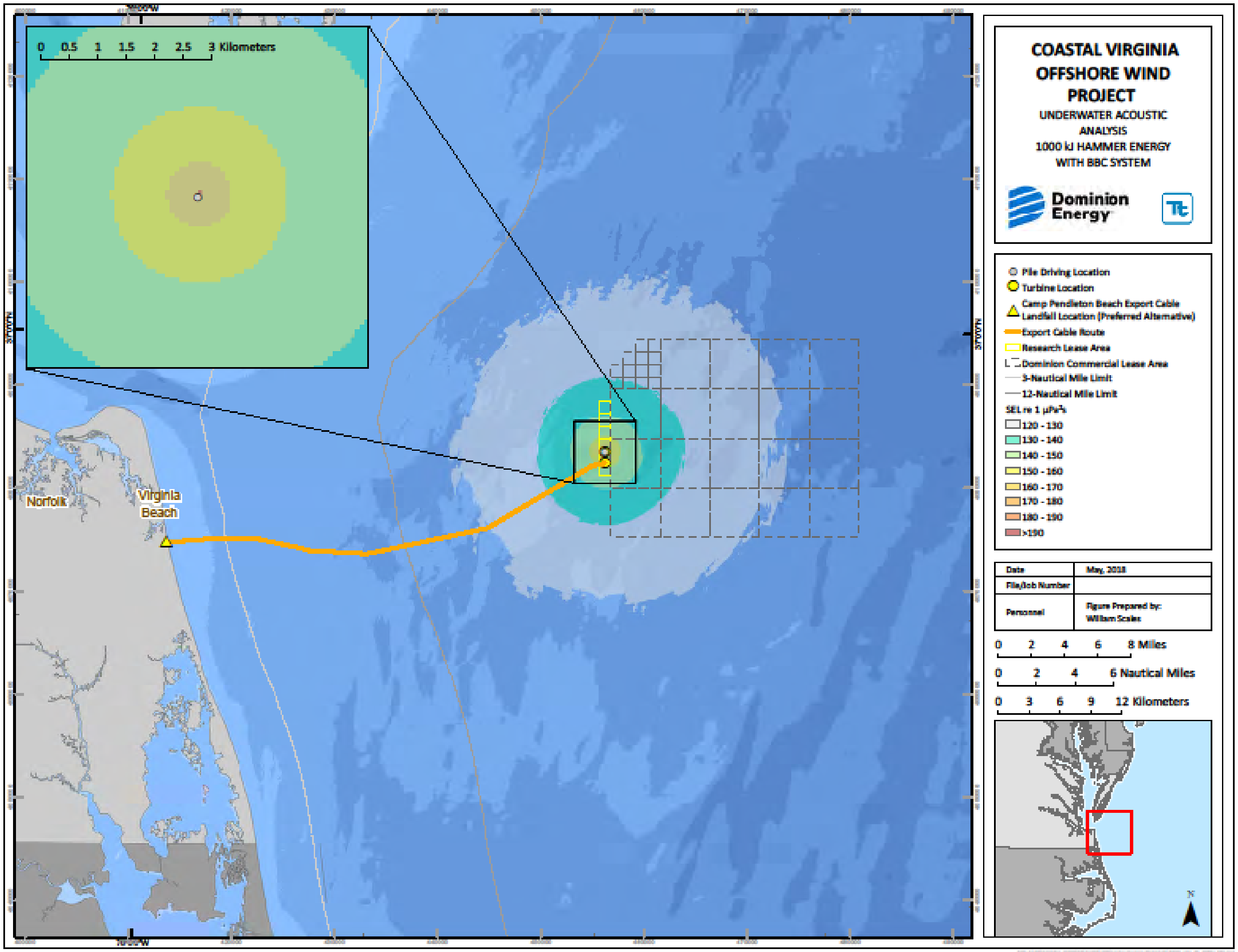

Figure A-9. Scenario 7: Received Sound Levels, Broadband (10 Hz–8 kHz) maximum-over-depth sound pressure levels for Impact Pile Driving at Maximum Hammer Energy (1000 kJ) with BBC

Attachment 9

Representative HDD Drilling Fluid Material Safety Data Sheet

BORE-GEL®

Boring Fluid System – U.S. Patent Number 5,723,416

Description

BORE-GEL® single-sack boring fluid system is specially formulated for use in horizontal directional drilling (HDD) applications. BORE-GEL fluid system is a proprietary blended product using high-quality Wyoming sodium bentonite. When BORE-GEL fluid system is mixed with fresh water, it develops an easy-to-pump slurry with desirable fluid properties for HDD.

Applications/Functions

The use of BORE-GEL fluid system promotes the following:

- Optimum gel strength for cuttings suspension and transport
- Pumpable slurry with minimal viscosity
- High reactive solids concentration for improved borehole stability in poorly consolidated/cemented sands and gravel formations
- Reduced filtration via a thin filter cake with low permeability
- Lubrication of pipe in microtunneling operations

Advantages

- Minimizes the number of boring fluid products required
- Easy to mix and fast to yield
- Low viscosity minimizes pump pressures
- Provides lubricity for pulling product line
- Can be used in Water Wells in unconsolidated formations or when additional gel strengths are required to compensate for low annular velocity
- NSF/ANSI Standard 60 certified

Typical Properties

Appearance	Tan to gray powder
pH (4% slurry or 15 lb/bbl)	10.2
Bulk density, lb/ft^3	68 to 72 (compacted)

Rev. 2/24/2011 · IDP 032

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BORE-GEL®**

Revision Date: 25-Feb-2010

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BORE-GEL®
Synonyms: None
Chemical Family: Mineral
Application: Viscosifier

Manufacturer/Supplier
Baroid Fluid Services
Product Service Line of Halliburton
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Bentonite	1302-78-9	60 - 100%	Not applicable	Not applicable
Crystalline silica, cristobalite	14464-46-1	0 - 1%	0.025 mg/m^3	$1/2 \times \frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, tridymite	15468-32-3	0 - 1%	0.05 mg/m^3	$1/2 \times \frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, quartz	14808-60-7	1 - 5%	0.025 mg/m^3	$\frac{10\ mg/m^3}{\%SiO2 + 2}$

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Health 0*, Flammability 0, Physical Hazard 0 , PPE: E

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 6 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Personal Protective Equipment	If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	Light brown or Gray
Odor:	Mild earthy
pH:	8-10
Specific Gravity @ 20 C (Water=1):	2.5
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	53 - 80
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Slightly soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.

Hazardous Decomposition Products Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Inhalation Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact May cause mechanical skin irritation.

Eye Contact May cause eye irritation.

Ingestion None known

Aggravated Medical Conditions Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity: Not determined

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect: Not determined

Carcinogenicity Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).

Genotoxicity: Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not determined

Ecotoxicological Information

Acute Fish Toxicity: TLM96: 10000 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method If practical, recover and reclaim, recycle, or reuse by the guidelines of an approved local reuse program. Should contaminated product become a waste, dispose of in a licensed industrial landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials Crystalline silica

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

Recommended Treatment

Add slowly and uniformly through a high-shear, jet-type mixer over one or more cycles of the volume of slurry. Continue to circulate and agitate the slurry until all unyielded bentonite is dispersed.

Approximate amounts of BORE-GEL® fluid system added to fresh water		
Boring Application	**lb/100 gal**	**kg/m^3**
Normal boring conditions	25 – 35	30 – 42
Poorly consolidated sand/gravel	35 – 60	42 – 72
Lubrication fluid for microtunneling	50 – 60	60 – 72

Packaging

BORE-GEL boring fluid system is packaged in a 50-lb (23-kg) multiwall paper bag.

Availability

BORE-GEL boring fluid system can be purchased through any Baroid Industrial Drilling Products Retailer. To locate the Baroid IDP retailer nearest you contact the Customer Service Department in Houston or your area IDP Sales Representative.

Baroid Industrial Drilling Products
Product Service Line, Halliburton
3000 N. Sam Houston Pkwy. E.
Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613

TRU-BORE®

Certified to NSF/ANSI 60

WYO-BEN®

Product Information

Description

TRU-BORE® is a highly concentrated bentonite based drilling fluid designed for difficult drilling operations in both vertical and horizontal borings. It is extremely effective high performance viscosifier for horizontal drilling applications to maintain hole integrity during pullback. It is non-toxic and environmentally safe. Its fast-hydrating formula allows contractors to mix fast and build viscosity quickly. **TRU-BORE®** stabilizes formations ranging from moderate clay soils to high concentrations of sand. By forming a thin tough filter cake, fluid loss to areas around the borehole is reduced. These factors, coupled with excellent gel strength values make **TRU-BORE®** the best risk management tool available today.

Characteristics

- Barrel Yield: 240 - 260
- Fluid Loss: 12 – cc.
- Mesh: 80% ± 2 passing 200 mesh
- PH 8.1 ± .2
- Moisture: 8% ± 1.5

Application

For every 100 gallons of make-up water, adding 15 to 25 pounds of **TRU-BORE®** will yield a viscosity of approximately 45 seconds on a Marsh Funnel. At a rate of 27 pounds per 100 gallons, viscosity can climb to 60 seconds.

CLAY
1½ bags for viscosity of 32-35 seconds, then add **UNI-DRILL®** liquid polymer to reach a viscosity of 42-45 seconds. (The addition of **UNI-DRILL®** keeps the clays from thickening the mud system even more.)
SAND
2¼ - 3 bags for viscosity of 55 ± seconds
UNKNOWN OR MEDIUM SOILS
1½ - 3 bags for viscosity of 45 seconds

Packaging

TRU-BORE® is packaged in 50 pound multi-walled paper bags, palletized 60 bags per pallet and shrink-wrapped.

4375/201302

WYO-BEN, INC., Billings, Montana 800.548.7055 406.652.6351 **www.wyoben.com**

WYO-BEN, INC.

SAFETY DATA SHEET

SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name:	**TRU-BORE®**
Chemical Family:	Mineral
Application:	Drilling Fluid
Manufacturer/Supplier:	Wyo-Ben, Inc. 1345 Discovery Drive Billings, MT 59102 USA Telephone: 800.548.7055 Facsimile: 406.656.0748
Emergency Phone Number	CHEMTREC® 1.800.424.9300

SECTION 2 — HAZARD IDENTIFICATION

Hazard Classification:	Carcinogenicity (Category 1A) Specific Target Organ Toxicity (Repeated Exposure) (Category 1)
Signal Word:	Danger
Hazard Statements:	May cause cancer. Causes damage to organs through prolonged or repeated exposure.

Hazard Symbol:

<u>Precautionary Statements</u>

Prevention:	Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Do not breath dust. Wash face, hands and any exposed skin thoroughly after handling. Do not eat, drink or smoke when using this product.
Response:	If exposed or concerned: Get medical advice/attention. Get medical attention/advice if you feel unwell.
Storage:	Store locked up.
Disposal:	Dispose of contents/container in accordance with local/regional/national/international regulations.
Hazards Not Otherwise Classified:	May cause eye and respiratory irritation.

SECTION 3 — COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	Percent
Crystalline Silica, quartz	14808-60-7	≤6%

SECTION 4 — FIRST AID MEASURES

Inhalation: If inhaled, remove to a dust free area. Get medical attention if respiratory irritation develops or if breathing becomes difficult. Inhalation may aggravate existing respiratory illness.

Eyes: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Skin: Wash with soap and water. Seek medical attention if irritation persists.

Ingestion: Do Not induce vomiting. First aid measures not normally required.

Notes to Physician: Treat symptomatically

SECTION 5 — FIRE FIGHTING MEASURES

Suitable Extinguishing Media: Product is non-combustible. All standard firefighting media may be used.

Unsuitable Extinguishing Media: None

Special Exposure Hazards: None known. Product is not combustible.

Special Protective Equipment and Precautions for Firefighters: None for product. Wear self-contained breathing apparatus (SCBA) and full protective gear. Caution: slippery when wet.

NFPA Ratings: Health 1, Flammability 0, Reactivity 0

SECTION 6 — ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures: Use appropriate protective equipment. Avoid creating and breathing dust.

Prevent further leakage or spillage if safe to do so.

Environmental Precautionary Measures: No special environmental precautions required

Procedure for Cleaning/Absorption: Prevent further leakage or spillage if safe to do so. Avoid generating dust. Collect using appropriate dustless method. Dispose in landfill according to local, state and federal regulations.

SECTION 7 — HANDLING AND STORAGE

Handling Precautions: This product contains quartz which may become airborne. Avoid breathing dust. Avoid creating dusty conditions. Promptly clean up spills to avoid breathing airborne dust. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH/MSHA European Standard En 149, or equivalent certified for silica bearing dust, respirator when using this product. Material is slippery when wet.

Storage Information: Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container.

SECTION 8 — EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

Substances	CAS Number	ACGIH TLV-TWA	OSHA PEL-TWA*
Crystalline Silica, quartz	14808-60-7	0.025 mg/m^3	$\frac{10\ mg/m^3}{\%SiO_2 + 2}$

* More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

Engineering Controls: Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits.

Personal Protective Equipment: If engineering controls and work practices cannot prevent excessive exposures, the selection and proper use of personal protective equipment should be determined by an industrial hygienist or other qualified professional based on the specific application of this product.

Respiratory Protection: Not normally needed. If significant exposures exceeding occupational exposure limit are possible use NIOSH/MSHA respirator approved for silica bearing dust.

Hand Protection: Standard work gloves.

Skin Protection: Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection: Wear safety glasses or goggles to protect against exposure.

Other Precautions: None known.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Powdered Solid

Color: Light tan to gray as dry powder

Odor: Odorless

pH: 8 – 10 (5% aqueous suspension)

Specific Gravity @ 20 C (Water=1): 2.45 – 2.55

Density @ 20 C (lbs/gallon): Not determined

Bulk Density @ 20 C (lbs/ft^3): 49 - 70

Boiling Point/Range (F/C): Not applicable

Freezing Point/Range (F/C): Not applicable

Vapor Pressure @ 20 C (mmHg): Not applicable

Vapor Density (Air=1): Not applicable

Percent Volatiles: Not applicable

Evaporation Rate (Butyl Acetate=1): Not applicable

Solubility in Water (g/100ml): Insoluble, forms colloidal suspension

Solubility in Solvents (g/100ml): Not applicable

VOCs (lbs/gallon): Not applicable

Viscosity, Dynamic @ 20 C (centipoise):	3.5 – 12.5 (6% aqueous suspension)
Viscosity, Kinematic @ 20 C (centistrokes):	Not determined
Partition Coefficient/n-Octanol/Water:	Not applicable
Molecular Weight (g/mole):	Not applicable
Flash Point/Range (F/C):	Not applicable
Flash Point Method:	Not applicable
Autoignition Temperature (F/C):	Not applicable
Flammability Limits in Air – Lower (%):	Not applicable
Flammability Limits in Air – Upper (%):	Not applicable

SECTION 10 — STABILITY AND REACTIVITY

Reactivity:	Nonreactive
Chemical Stability:	Stable
Possibility of Hazardous Reactions:	Will not occur.
Conditions to Avoid:	None
anticipated Incompatibility (Materials to Avoid):	None known
Hazardous Decomposition Products:	None
Additional Guidelines:	Not applicable

SECTION 11 — TOXICOLOGICAL INFORMATION

Principle Route of Exposure: Eye or skin contact, inhalation.

Symptoms Related to the Physical, Chemical and Toxicological Characteristics

Inhalation: Inhaled crystalline silica in the form or quartz from occupational sources is carcinogenic to humans (IARC, Group 1).

Skin Contact: May cause skin irritation due to drying.

Eye Contact: May cause mechanical eye irritation.

Ingestion: None known

Aggravated Medical Conditions: Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to respirable quartz-bearing dust.

Chronic Effects/Carcinogenicity: Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC, 1997) concludes that there is sufficient evidence in humans for carcinogenicity of inhaled crystalline silica from occupational sources (IARC Group 1), that carcinogenicity was not detected in all industrial circumstances studied and that carcinogenicity may depend on characteristics of the crystalline silica or on external factors affecting its biological activity. See IARC Monograph 68,

	Silica, Some Silicates and Organic Fibres (June 1997). The National Toxicology Program (NTP) classifies respirable crystalline silica as "Known to be a human carcinogen" (NTP 9th Report on Carcinogens, 2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).
Other Information:	See "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

<u>Toxicity Tests</u>

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not classified
Carcinogenicity:	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not classified
Reproductive/Developmental Toxicity:	Not classified

SECTION 12 — ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air):	Not determined
Persistence/Degradability:	Not determined
Bio-accumulation:	Not determined
Ecotoxicological Information	
Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information:	Not determined
Other Information:	Not applicable

SECTION 13 — DISPOSAL CONSIDERATIONS

Disposal Method:	If product should become a waste dispose in a licensed landfill according to federal, state and local regulations.
Contaminated Packaging:	Follow all applicable national or local regulations.

SECTION 14 — TRANSPORT INFORMATION

Land Transportation

DOT – Not regulated as dangerous goods

Canadian TDG – Not regulated as dangerous goods

ADR – Not regulated as dangerous goods

Air Transportation

ICAO/IATA – Not regulated as dangerous goods

Sea Transportation

IMDG – Not regulated as dangerous goods

Other Transportation Information

Labels: None

SECTION 15 — REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311, 312) Hazard Class	Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	This product contains crystalline silica (respirable) which is a substance known to the State of California to cause cancer.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory or are exempt.
WHMIS Hazard Class	This product contains crystalline silica (respirable) and is classified as a Class D, Division 2, Subdivision A substance.

SECTION 16 — OTHER INFORMATION

Prepared	03/18/2015
Last Revision	04/10/2018

DISCLAIMER

All information presented herein is believed to be accurate; however, it is the user's responsibility to determine in advance of need that the information is current and suitable for their circumstances. No warranty or guarantee, expressed or implied is made by WYO-BEN, INC. as to this information, or as to the safety, toxicity or effect of the use of this product.

Attachment 10

Revised Terrestrial Archaeology Survey Report
(RAP Appendix O)

CONFIDENTIAL – – Provided Under Separate Cover

Attachment 11

Amendment to Historic Properties Assessment
(RAP Appendix P)

May 10, 2018

Mr. James Bennett
Director, Office of Renewable Energy Programs
Bureau of Ocean Energy Management
U. S. Department of the Interior
45600 Woodland Road
Sterling, VA 20166

Subject: Amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Historic Properties Survey Report (Research Activities Plan [RAP] Appendix P)

Dear Mr. Bennett:

Virginia Electric and Power Company, d/b/a Dominion Energy Virginia (Dominion, formerly d/b/a Dominion Virginia Power) on behalf of the Virginia Department of Mines, Minerals, and Energy (DMME) is pleased to submit this amendment to the Coastal Virginia Offshore Wind Project (CVOW, formerly the Virginia Offshore Wind Technology Advancement Project or VOWTAP) Historic Properties Survey Report. The Historic Properties Survey Report was originally submitted as Appendix P to the Research Activities Plan (RAP) in December 2013. As part of the RAP approval process, BOEM undertook consultations under Section 106 of the National Historic Preservation Act (NHPA) (54 United States Code [U.S.C.] §300101), and it's implementing regulations (36 Code of Federal Regulations [CFR] 800). As a result of the Section 106 consultations, BOEM prepared a finding of No Adverse Effect (36 CFR 800.5(b)) in April 2015. The Final VOWTAP RAP subsequently received approval from BOEM on March 23, 2016.

Due to advances in technology since the Project's approval in March 2016, several modifications to the RAP were required to support the Project's current requirements for construction and operation. In accordance with 30 CFR 585.634(c), Dominion submitted a RAP amendment on December 27, 2017 to request BOEM's approval of the proposed modifications to the approved RAP in order to support a Project in service date of 2020. As requested by BOEM in their comments to the RAP amendment provided on February 16, 2018, and further discussed on March 29, Dominion has prepared this amendment to the Historic Properties Survey Report to support BOEM's evaluation of the Project modifications under Section 106 of the NHPA. This amendment includes updates to the project description, area of potential effects, survey findings, and recommendations, based on Project modifications.

PROJECT DESCRIPTION

This section describes the proposed Project location and infrastructure currently under consideration for the CVOW.

Wind Turbines

The CVOW facilities will include two, 6 MW wind turbine generators (WTG), to be located within Federal Lease Block 6111 Aliquot H, approximately 27 mi [24 nm or 43 km] offshore of Virginia Beach, Virginia (Figure 1). The maximum height of each turbine is proposed to range from 591 to 617 feet (ft) (180 to 188 meters [m]), measured from mean sea level (MSL) to rotor tip. This height range is 7 ft to 33 ft (2 to 10 m) taller than the WTG presented in Section 3.2.1 of the approved RAP. The turbines will be sited approximately 3,445 ft (1,050 m) apart in a north-south orientation. In compliance with Federal Aviation Administration (FAA) and U.S. Coast Guard (USCG) regulations, the WTGs will have nighttime lighting. FAA lighting will consist of L-864 medium intensity aeronautical lights with a flash rate of 20 flashes per minute (FPM) atop each WTG nacelle. USCG lighting will consist of two (2) quick flashing, amber lights with 4 nm (7.4 km) 360-degree visibility placed on the foundation of each WTG at a height of not more than 50 ft (15 m) above the highest astronomical tide.

The two turbines will be interconnected with a submarine inter-array cable, referred to as the Inter-Array Cable. Because the voltage of the Inter-Array Cable will be the same as the onshore grid connection voltage (34.5 kilovolts [kV]), no offshore substation is required for the Project, as noted in the approved RAP. The energy produced by the CVOW will be conveyed to shore via an additional 34.5-kV submarine transmission cable, referred to as the Export Cable.

Onshore Facilities

Due to new, previously unknown conflicts with military activities, Camp Pendleton is requiring a modification to the previously approved Onshore Interconnection Cable Route (cable route) which is required to support the construction and operation of both the Onshore Interconnection Cable and Fiber Optic Cable. The modified Onshore Interconnection Cable Route is a combination of segments that were previously evaluated in the alternatives analysis of the approved RAP, as well as some additional areas that have recently been identified as potential alternatives. In addition, the Switch Cabinet where the offshore Export Cable transitions to the Onshore Interconnection Cable may be relocated up to 20 ft (6 m) to the north or east of its original location due to conflicts with the location of a proposed hygiene facility to be constructed in the existing parking lot. Regardless of which segments are selected for the final Onshore Interconnection Cable Route and the final location of the switch cabinet, the final location of the Switch Cabinet will still be located within the existing parking lot and the Onshore Interconnection Cable Route will still be located entirely within the boundaries of Camp Pendleton. The Export Cable landing location and Interconnection Station location will remain the same as what was approved in the RAP, and therefore have not been further analyzed in this Historic Properties Survey Report Amendment. Figure 2 below (Original Figure 4 of Appendix P of the approved RAP) has been updated to show the modified Onshore Interconnection Cable Route and Switch Cabinet alternatives.

The modified Onshore Interconnection Cable Route will originate at the proposed Switch Cabinet located within an existing parking lot at the end of Rifle Range Road and adjacent to Camp Pendleton Beach, as described above. The modified Onshore Interconnection Cable Route then extends in a northwest direction through the Camp Pendleton rifle range for approximately 900 ft (274 m) to the northwest corner of the rifle range, just south of the Camp Pendleton canine training area. The modified cable route then extends in a generally northern direction for approximately 335 ft (102 m) to a gravel turnaround area, which will serve as an equipment laydown and staging

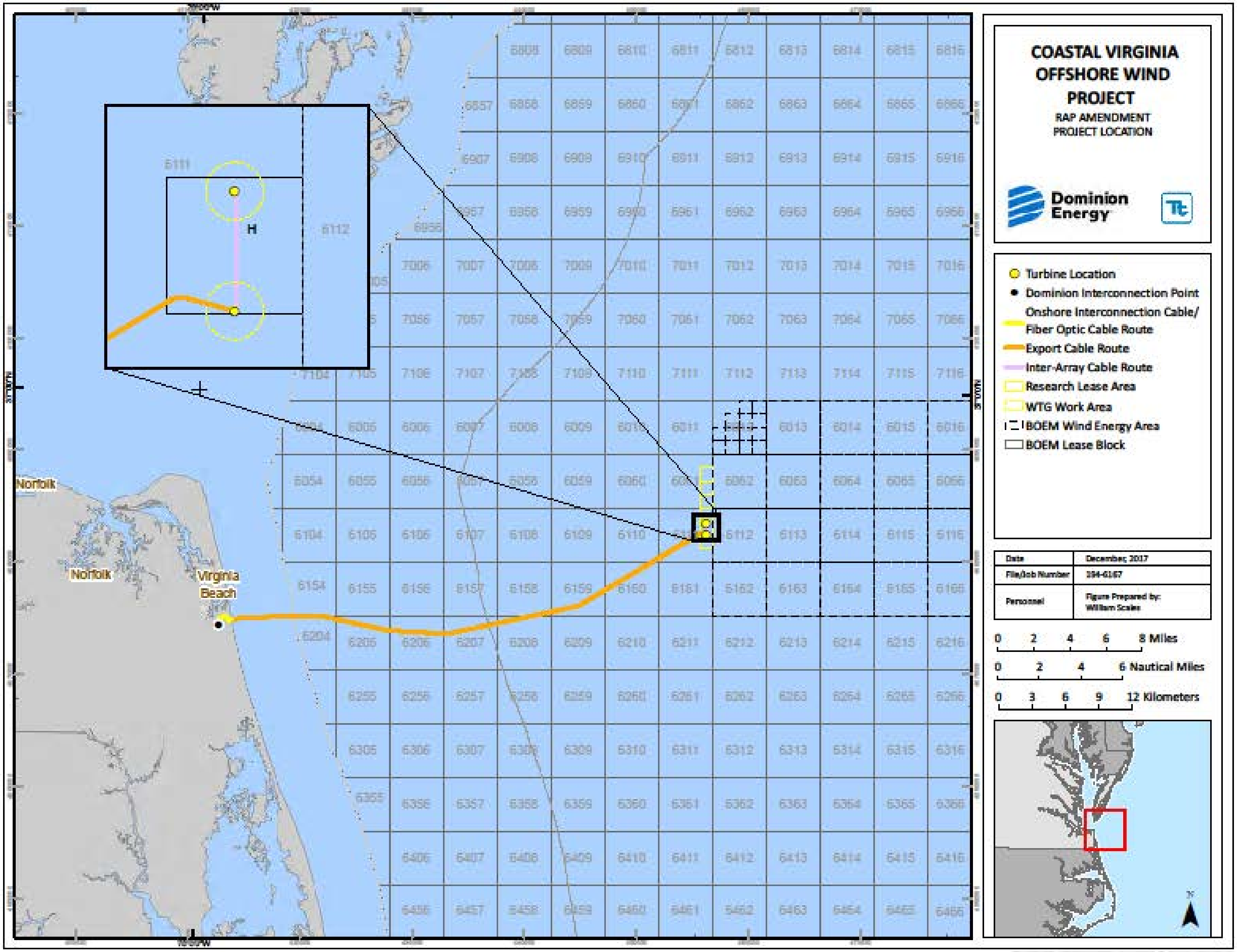

Figure 1. Project Location

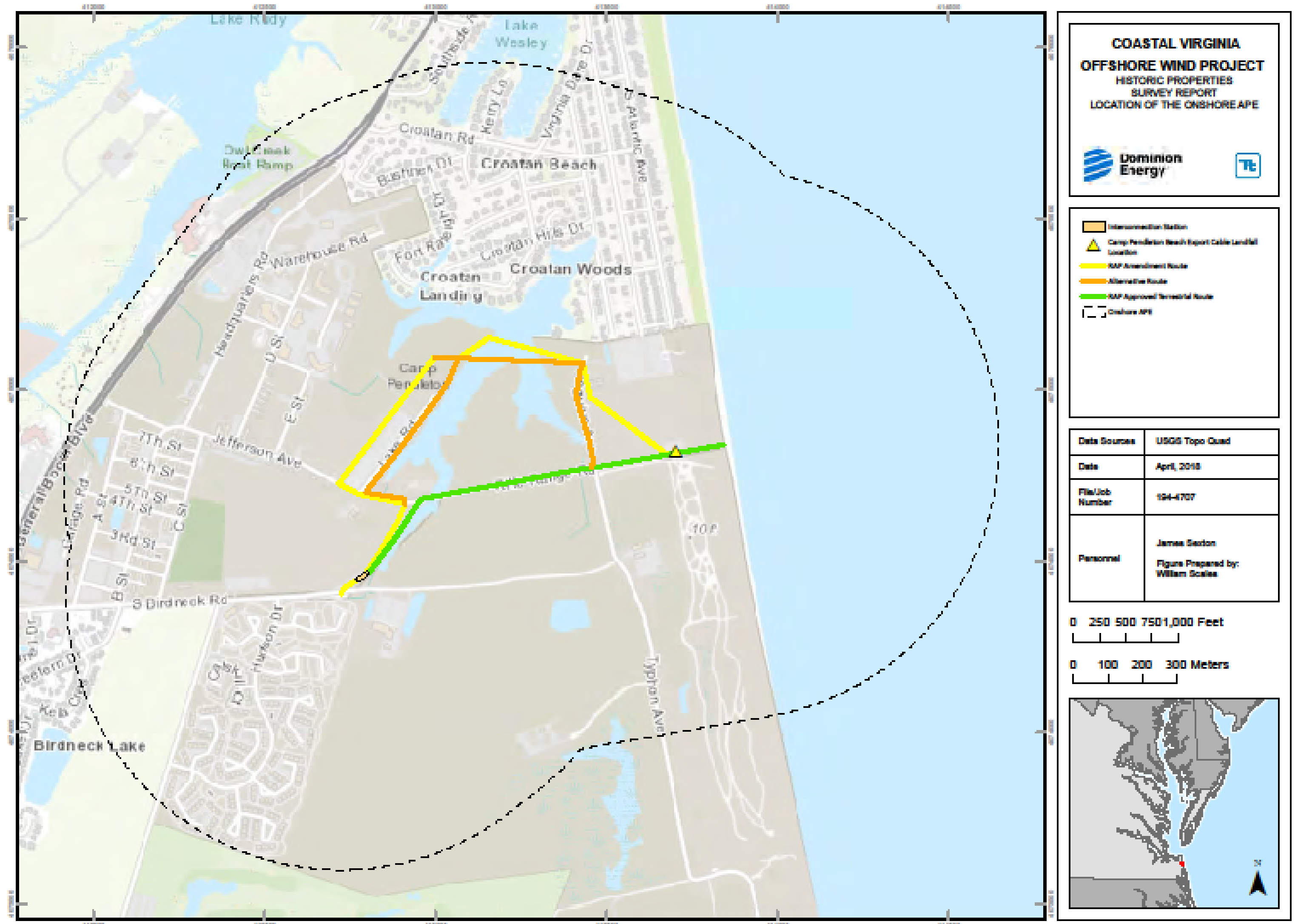

Figure 2. Onshore Area of Potential Effect

area for the horizontal directional drill (HDD) under Lake Christine. The HDD under Lake Christine will be approximately 935 ft (285 m) long and will run in a west/northwest direction to the cleared area on the western side of the lake. After the Lake Christine crossing, the cable route turns to the southwest, for approximately 350 ft (107 m) through a previously disturbed area.

Alternatively, Dominion may elect to locate the Onshore Interconnection Cable Route beginning at the Switch Cabinet extending in a west-south-west direction along Rifle Range Road for approximately 700 ft (213 m) until reaching the intersection of Rifle Range Road and Regulus Avenue. At the intersection of Rifle Range Road and Regulus Avenue, the Onshore Interconnection Cable Route extends in a general northerly direction for approximately 1000 ft (305 m) until reaching the gravel turnaround area, which will serve as an equipment laydown and staging area for the horizontal directional drill (HDD) under Lake Christine. The HDD under Lake Christine for this alternative will be approximately 1200 ft (366 m) long and will run in a generally west direction to a previously disturbed area located approximately 350 ft (107 m) southwest the cleared area on the western side of the lake.

From this point, there are two alternatives for the Onshore Interconnection Cable Route to be installed along the west side of Lake Christine. The first alternative, which would involve crossing an existing fiber optic cable at a perpendicular angle in two locations, extends west for approximately 230 ft (70 m) to the first perpendicular crossing of the existing fiber optic cable. The cable Route then runs southwest for approximately 1,500 ft (457 m) along the western boundary of a paved helicopter landing area until it reaches Jefferson Avenue. The cable route then runs in an east-southeast direction along Jefferson Avenue for approximately 670 ft (204 m) until the second perpendicular crossing of the existing fiber optic cable before reaching the intersection of Jefferson Avenue, Rifle Range Road, and the Gate 10 Access Road. The second alternative, which would not require a fiber optic cable crossing, would extend in a generally south-south-west direction for a distance of approximately 1550 ft (472 m) down the east side of Lake Road, approximately 30 ft (9 m) east of the shoulder, to a location approximately 30 ft (9 m) north of Jefferson Avenue. From this location, the Onshore Interconnection Cable route would extend in a generally westerly direction for a distance of approximately 370 ft (112 m), before turning to the south for a distance of approximately 50 ft (15 m) until reaching the intersection of Jefferson Avenue, Rifle Range Road and the Gate 10 Access Road.

From the intersection of Jefferson Avenue, Rifle Range Road and the Gate 10 Access Road, the cable route extends approximately 750 ft (229 m) down the center of an access road to the proposed Interconnection Station located just north of an entrance for Camp Pendleton at Gate No. 10 (Gate 10 Access Road) off South Birdneck Road. As described in the approved RAP, the cable route then continues from the Interconnection Station on the Gate 10 Access Road approximately 207 ft (63 m) to interconnect with Dominion's existing electrical infrastructure located on the south side of South Birdneck Road. The total length from the Switch Cabinet at Camp Pendleton Beach to Dominion's existing electrical infrastructure ranges from approximately 1.1 mi (1.8 km) to1.2 mi (1.9 km). Determination of the final Onshore Interconnection Cable Route and the Switch Cabinet location will be dependent on the outcome of ongoing easement negotiations between Dominion and Camp Pendleton. A copy of the easement will be provided to BOEM when it is finalized.

Between the Switch Cabinet at Camp Pendleton Beach and the Interconnection Station on the Gate 10 Access Road, the Onshore Interconnection Cable and Fiber Optic Cable will be installed via a series of HDD segments, as approved in the RAP. No direct burial or trenching is proposed for the onshore cables, which is also consistent with what was included in the approved RAP. However, due to the longer route, the Onshore Interconnection Cable and Fiber Optic Cable will be installed in 13 segments, instead of the 12 segments detailed in the approved RAP. Each

HDD segment will range from approximately 230 ft (70 m) to 500 ft (152 m) in length, with the exception of the Lake Christine crossing, which will range from approximately 935 ft (285 m) to 1200 ft (366 m) in length.

The modified cable route will require the use of up to 14 splice pits, which is an increase of 1 pit relative to the approved RAP. The size of each splice pit remains the same and will require the excavation of a 4.0 ft by 6.0 ft by 2.0 ft (1.2 m by 1.8 m by 0.6 m) splice pit. As installation conditions allow, longer HDD segments may be feasible such that fewer splice pits may be required. The splice pits and associated excavated soils will be located within the proposed construction right-of-way and will not require expanded workspaces. Upon completion of cable splicing activities, the excavated material will be returned to the splice pits, compacted, and returned to pre-construction conditions. The splice pit will serve as the location where the cable drilling will either be initiated and/or received. No drilling muds will be required to complete the installation of the Onshore Interconnection Cable or Fiber Optic Cable. All activities will occur along the paved roadways and within the existing cleared areas along the route.

From the proposed Interconnection Station at the Gate 10 Access Road, the Interconnection Cable and Fiber Optic Cable will be installed with one final HDD for an additional 207 ft (63 m) to interconnect with Dominion's existing electrical infrastructure located on the southern side of South Birdneck Road, as described in the approved RAP.

To support the construction and operation of the Onshore Interconnection Cable and Fiber Optic Cable, Dominion proposes a 30 ft (9.1 m) temporary construction right-of-way along the entirety of the route for installation of the cable. Upon completion of construction, 15 ft (4.6 m) will be retained as a permanent easement for access during operation. The Onshore Interconnection Cable and Fiber Optic Cable will be installed in separate boreholes approximately 3 ft (0.9 m) apart and buried to a minimum depth of 3.3 ft (1 m) to be consistent with local utility standards. As an option, the fiber optic cable could be installed in conduit allowing fewer splices. The conduit would be installed by HDD and the fiber optic cable pulled back through the conduit.

The Area of Potential Effect

The Project modifications as described above will result in minor changes to the Onshore APE originally described in Section 4.2.1.1 of Appendix P of the RAP and depicted in Figure 2. The Offshore APE and Shoreline APE are unchanged by the modifications proposed for the Project. The Onshore APE is slightly increased in size, extending further to the north and northwest.

SURVEY FINDINGS

It is not anticipated that Project modifications as described above will result in major changes to visual impacts originally described in Section 5 of Appendix P of the RAP. The only change is that the computer model shows four additional houses in Croatan Beach built prior to 1965 might have a view of Project elements. As these are further from the Project than the previously reviewed houses, the conclusions about the limited visibility of the Project remain the same. Below, are the conclusions from Section 5.2.5 of the Historic Properties Survey Report originally submitted as Appendix P to the RAP:

Newly Identified Historic Properties within the Onshore APE

In addition to documenting previously identified resources within the APE, an architectural survey was undertaken for those areas that fell within the APE and that had not previously been surveyed. The purpose of the survey was to identify resources that were potentially eligible to the NRHP. The computer viewshed model identified areas both north and south of the Project where there was the potential for Project elements to be visible. The viewshed model was overlaid on United States Geological Survey maps from 1965 for the onshore APE to determine the presence of structures of sufficient age to be NRHP eligible. Aboveground structures with potential views of the Project include the Wadsworth Shores military housing development on South Birdneck Road and the facilities on the Fleet Combat Training Center at Dam Neck; however, all such structures were constructed after 1965 (USGS 1965).

The viewshed model and USGS maps suggested that nine buildings that might have a view of elements once the Project is constructed, had been constructed in the Croatan Beach area by 1965 (Figure 3, original Figure 5 of Appendix P of the approved RAP). The viewshed model was further refined during fieldwork by the Tetra Tech visual impact assessment team (Tetra Tech, 2013a). At the time of that report, two potential landfall locations were considered: one at Camp Pendleton and one at Croatan Beach. The Croatan Beach location was located closer to areas with housing. They conclude in their report:

> *Weak contrast would be created by onshore Project components located in the Croatan Beach parking lot north of the Camp Pendleton Rifle Range. The onshore Project Area (Alternative 2 Offshore Cable Landing) is located in the foreground for high sensitivity residential viewers north of the parking lot. Views of the Switch Cabinet would be partially to completely screened by existing vegetation, topography (i.e., sand dunes), and/or an existing restroom structure located just north of the switch cabinet which has already introduced vertical elements into the landscape. Portions of the Switch Cabinet that would be visible would be seen in the context of the existing restroom facility which is similar in form and line.*

This fieldwork-based observation is demonstrated by a view along South Atlantic Avenue in the direction of the Switch Cabinet from the vicinity of South Maryland Avenue (Photo 6).

The selected Switch Cabinet location at Camp Pendleton is approximately 220 m to the south of a restroom building in the Croatan Beach parking lot. This much larger and closer building is not visible in the photograph. The same is true for the view from in front of 801 Vanderbilt Avenue (Photo 7). Fieldwork indicates that the Switch Cabinet would not be visible from any Croatan Beach residences except, perhaps, those closest to the location of the element. None of the potentially-historic structures (i.e., those that appear on the 1965 USGS map) were located this close to the proposed Project element. Therefore, the result of the fieldwork-based refinement of the viewshed indicates that no newly identified historic properties were identified in Croatan Beach or elsewhere in the onshore APE.

RECOMMENDATIONS

It is not anticipated that Project modifications as described above will result in major changes to visual impacts originally described in Section 6 of Appendix P of the RAP. Tetra Tech's recommendations remain the same. Below, are the conclusions from Section 6.2 and 6.3 of the Historic Properties Survey Report originally submitted as Appendix P to the RAP:

Cape Henry Lighthouse (Section 6.2 of the Historic Structures Survey Report)

The Cape Henry Lighthouse is listed in the NRHP, because it was "the first structure authorized and completed by the newly organized Federal Government in 1789" and because it symbolized the "advantages of a strong

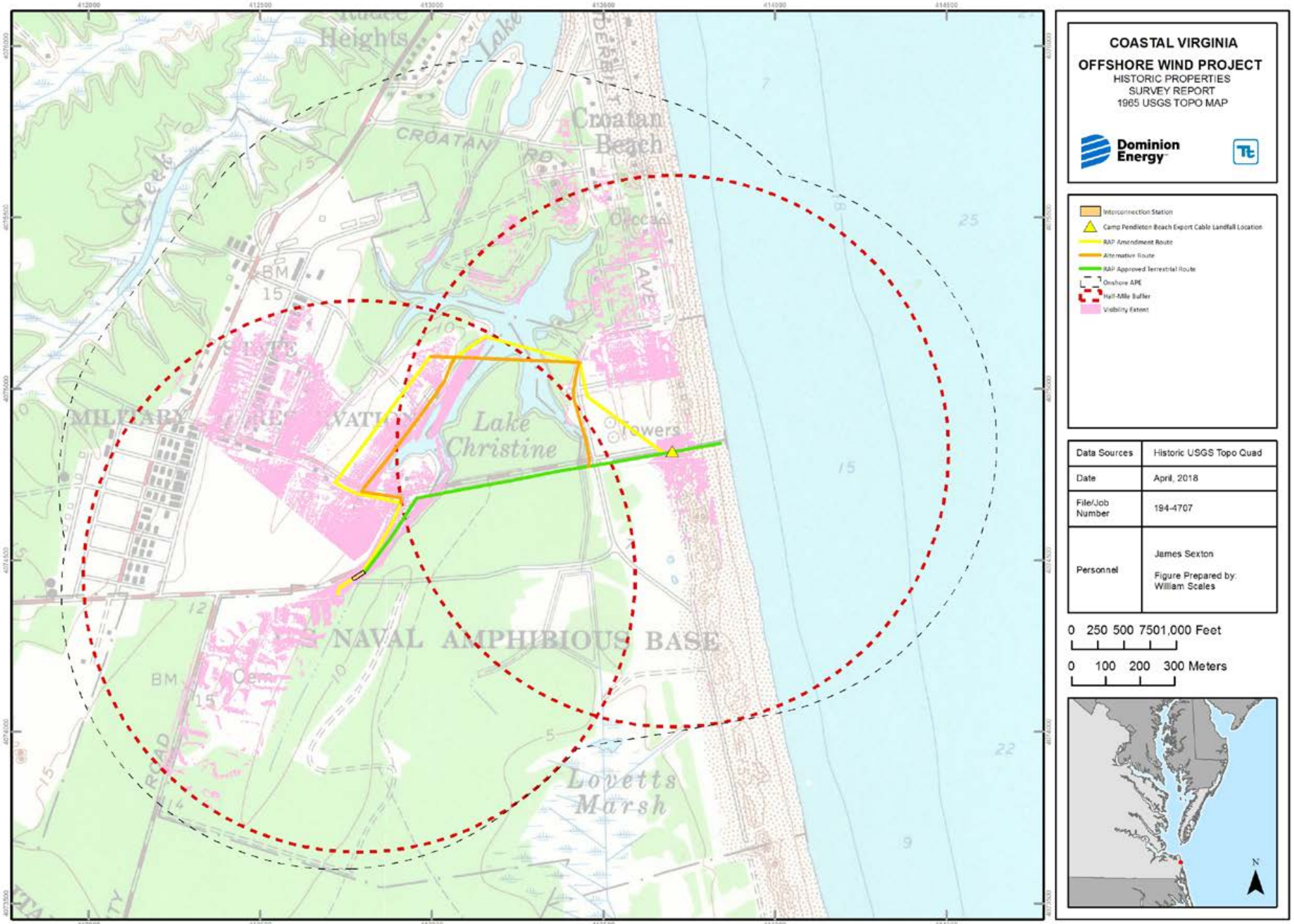

Figure 3 The Viewshed Model Overlaid on the 1965 USGS Map for the Area

national authority" (NRHP 1966). The Visual Impact Assessment developed for the Project (Tetra Tech 2013a) describes the potential impact of the Project on viewers at the Cape Henry Lighthouse:

> *Viewers with a superior viewing position, such as recreational visitors at the Cape Henry Lighthouse, would have unobstructed views toward the offshore Project Area. The WTGs would create weak contrast because at a distance of 29 mi (47 km) from the WTGs, 501 ft (153 m) of the 584 ft (178 m) turbines (or 86 percent of the total height of the WTGs) would be above the visible horizon. In the photographic simulation from the Cape Henry Lighthouse (see Simulation 2, Exhibit C), the simulation was created so that it is true to scale when viewed at a distance of 18 in (457 mm). Under those conditions, the theoretically visible portion of the turbine would amount to 0.06in (1.52 mm) when measured on the simulation graphic. The resulting size of the turbine that is visible in the simulation is due to the superior viewing location at the top of the lighthouse (approximately 134 ft (40.8 m) above MSL. In addition, visible portions of the WTGs would be seen in the context of existing vessels within the bay and along the coast. The WTGs may begin to attract a viewer's attention but would not dominate the characteristic landscape.*

Changes to the proposed turbines have led to the following amendment to the Visual Impact Assessment (VIA):

> *The maximum additional height of the proposed WTG is 33 ft (10 m) taller than the WTG presented in Section 3.2.1 of the approved RAP. This change in turbine height would equate to a change of 0.0038 inch (0.0965 mm) to the turbines shown in Simulations 1 through 5 in Appendix Q, Attachment B of the approved RAP, which were originally created so that it is true to scale when viewed at a distance of 18 in (457 mm).*

The additional turbine height viewed from a distance of more than 29 mi (46.7 km) offshore will not adversely affect the characteristics of the Cape Henry Lighthouse that qualify it for the NRHP.

DeWitt Cottage (Section 6.3 of the Historic Structures Survey Report)

De Witt Cottage is listed in the NRHP as a locally significant resource under Criteria A and C for its role in the history of the development of Virginia Beach and as an example of Victorian/Queen Anne beach architecture. The Project's Visual Impact Assessment (Tetra Tech 2013a) describes the visibility of the Project from Virginia Beach in the following way:

> *Potential viewers located along the Virginia Beach coastline (which is outside of the 25 mi [40 km] Project Study Area) would have limited visibility of the WTGs. …. For viewers associated with Virginia Beach, Croatan Beach, and the Camp Pendleton Beach, at a distance of 27 mi (43km) from the WTGs, 177 ft (54 m) of the 584 (178) (MSL to tip of blades) turbines (or 30 percent of the total height of the WTGs) would be above the visible horizon. In the photographic simulation from the picnic area at Camp Pendleton Beach (see Simulation 1, Exhibit C), the simulation was created so that it is true to scale when viewed at a distance of 18 in (457 mm). Under those conditions, the theoretically visible portion of the turbine would amount to 0.02 in (0.508 mm) when measured on the simulation graphic.*

Changes to the proposed turbines have led to the following amendment to the VIA:

> *The maximum additional height of the proposed WTG is 33 ft (10 m) taller than the WTG presented in Section 3.2.1 of the approved RAP. This change in turbine height would equate to a change of 0.0038 inch (0.0965 mm) to the turbines shown in Simulations 1 through 5 in Appendix Q, Attachment B of the approved RAP, which were originally created so that it is true to scale when viewed at a distance of 18 in (457 mm).*

In addition, the building is currently surrounded by modern high-rise hotels and beach front development; the additional turbine height viewed from a distance of 27 mi (43 km) offshore from the resource will not affect the characteristics that qualified it for listing in the NRHP.

Attachment 12

Air Emissions Supplement and Revised Air Emissions Calculations and Methodology Report

(RAP Appendix I)

AIR EMISSION CALCULATIONS AND METHODOLOGY

Coastal Virginia Offshore Wind Project (CVOW)

Prepared for:

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Prepared by:

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www.tetratech.com

February 2018

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
BOEM	Bureau of Ocean Energy Management
Btu	British thermal units
CH_4	methane
CMV	commercial marine vessels
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
EPA	U.S. Environmental Protection Agency
CVOW	Coastal Virginia Offshore Wind Project
gal	gallons
g	grams
g/kW-hr	grams per kilowatt hour
GHG	greenhouse gas emissions
GWP	Global Warming Potential
hp	horse power
ICF	ICF International
kW	kilowatt
l/cyl	liters per cylinder
lb	pounds
MDO	marine diesel oil
MMBtu	million British thermal units
MOVES	Motor Vehicle Emission Simulator
NO_X	nitrogen oxides
N_2O	nitrous oxide
OGV	ocean-going vessels
ppmw	part per million by weight
SO_2	sulfur dioxide
$PM_{2.5}$	particulate matter 2.5 micrometers in diameter
PM_{10}	particulate matter 10 micrometers in diameter
Project	Coastal Virginia Offshore Wind Project
ULSD	ultra-low sulfur diesel
VOC	volatile organic compound

1 INTRODUCTION

This report describes the methodology applied to calculate the air emissions associated with the Coastal Virginia Offshore Wind Project (CVOW or Project), as well as the results of the emissions calculations, which are detailed in Attachment A. As described in Section 4.16 of the CVOW Research Activities Plan, as amended, there are five primary categories of sources for which emissions were calculated:

- Commercial marine vessels (CMVs);
- Helicopter;
- Backup power system;
- Nonroad engines; and
- Onroad vehicles.

The specific air pollutants estimated from the above listed sources consist of the criteria air pollutants and greenhouse gases (GHGs). Specific pollutants in each group are listed as follows:

- Criteria Pollutants:
  - Nitrogen oxides (NO_X),
  - Volatile organic compounds (VOC),
  - Carbon monoxide (CO),
  - Particulate matter 10 micrometers in aerodynamic diameter or less (PM_{10}),
  - Particulate matter 2.5 micrometers in aerodynamic diameter of less ($PM_{2.5}$), and
  - Sulfur dioxide (SO_2).
- GHGs:
  - Carbon dioxide (CO_2),
  - Methane (CH_4), and
  - Nitrous oxide (N_2O).

Note: While $PM_{2.5}$ is a subset of PM_{10}, for the purposes of this analysis it is conservatively assumed that emissions of $PM_{2.5}$ are the same as PM_{10}.

2 EMISSION CALCULATION METHODS

Methods for calculating criteria pollutant emissions for the respective types of emission sources are summarized in Sections 2.1 through 2.5 below. Section 2.6 discusses the methodology for estimating the total GHG emissions for each of the sources. GHG emissions are presented in CO_2 equivalent or "CO_2e", because the different GHG constituents have different heat trapping capabilities.

2.1 Commercial Marine Vessels

ICF International was contracted by the U.S. Environmental Protection Agency (EPA) to produce a guidance document for estimating CMV emissions, "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" (ICF International 2009), which categorizes tugboats, crew boats, etc. as harbor craft, and which categorizes ships with larger engines as ocean-going vessels (OGVs). The ICF

International factors that were selected for estimating emissions from harbor craft and OGVs are presented in Table 1 below.

It was assumed that all harbor craft will use only ultra-low sulfur diesel (ULSD) fuel, which has a sulfur content of 15 part per million by weight (ppmw). The harbor craft emission factors for SO_2 and PM_{10} presented in Table 3-8 of the ICF report are based on a fuel sulfur content of 1.5 percent. To adjust these emission factors for ULSD fuel, they were multiplied by adjustment factors of 0.001 and 0.86 for SO_2 and PM_{10}, respectively, as recommended in Table 3-9 of the ICF report.

Additionally, the emission factors for PM_{10} and SO_2 from larger-engine OGVs presented in Table 2-9 of the ICF report are based on a fuel sulfur content of 1.0 percent. These factors were adjusted to comply with International Maritime Organization Sulfur Emissions Control Area requirements, which limit fuel sulfur content to 0.1 percent sulfur by weight. For these vessels, factors for PM_{10} and SO_2 were calculated using the formula provided on page 2-14 of the ICF report, assuming marine diesel oil (MDO), and using the appropriate values for brake specific fuel consumption provided in Table 2-9 (main engines) and 2-16 (auxiliary engines).

Table 1. Summary of Harbor Craft and OGV Emission Factors

Minimum Power (kW)		Emission Factor (g/kW-hr)							
		NO_X	VOC	CO	$PM_{10}/PM_{2.5}$	SO_2	CO_2	CH_4	N_2O
Harbor Craft – Worst-Case Rate for Tier 1 and Tier 2 Engines									
Category 1	37-75 kW	9.8	0.27	5	0.77	0.0013	690	0.09	0.02
	75 – 130 kW	9.8	0.27	5	0.34	0.0013	690	0.09	0.02
	130 – 225 kW	9.8	0.27	5	0.34	0.0013	690	0.09	0.02
	225 – 450 kW	9.8	0.27	5	0.26	0.0013	690	0.09	0.02
	450 – 560 kW	9.8	0.27	5	0.26	0.0013	690	0.09	0.02
	560 – 1000 kW	9.8	0.27	5	0.26	0.0013	690	0.09	0.02
	1,000+ kW	9.8	0.27	5	0.26	0.0013	690	0.09	0.02
Category 2	All sizes	9.8	0.5	5	0.62	0.0013	690	0.09	0.02
Ocean-going Vessels									
Category 3	Main Engines	13.2	0.50	1.10	0.19	0.397	646.08	0.004	0.031
	Auxiliary Engines	13.9	0.40	1.10	0.18	0.42	690.71	0.004	0.031

Notes:

1. Category 1 engines have a displacement less than 5 liters per cylinder (L/cyl), Category 2 engines have a displacement greater than or equal to 5 (L/cyl) and less than 30 L/cyl, and Category 3 engines have a displacement greater than or equal to 30 L/cyl.

2. The PM_{10} and SO_2 emission factors presented above for Category 1 and 2 engines for SO_2 and PM_{10} have had an adjustment factor applied, as recommended in Section 3.4.2 of the ICF Report (ICF International 2009) and presented in Table 3-8 of the ICF report which are based on a fuel sulfur content of 1.5 percent. These factors were adjusted for the 15 ppmw sulfur content in ultra-low sulfur diesel fuel, by multiplying the emission factors by 0.001 and 0.86 for SO_2 and PM_{10}, respectively.

2. The emission factors for the Category 3 engines were based on a medium-speed diesel vessel using marine diesel oil fuel.

The basic equation used to estimate annual emissions from each CMV engine and activity is:

$$E = kW \times Act \times LF \times EF$$

Where:

E = emission, grams/year

kW = kilowatts (engine rating)

Act = activity, hours/year

LF = engine load factor (for the activity)

EF = emission factor, g/kW-hr

Because the emission factors in the ICF report are expressed in g/kW-hr, engine horsepower was converted to kilowatts by multiplying the horsepower by 0.746 (one horsepower is equal to 0.746 kilowatts). The calculated emissions were converted to tons per year by dividing the emissions by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to ton (2,000 lb/ton). The emission factors for harbor vessels are based on EPA marine engine emissions standards (i.e., Tier 0 to Tier 3 based on cylinder displacement) and their respective EPA engine categories for CMV main propulsion engines and auxiliary engines. EPA established a tier structure for the emission standards based on age of the engine and cylinder displacement. Tier 0 (baseline), Tier 1, or Tier 2 are applicable to engines built prior to 2009. Stricter Tier 3 emission standards are applicable to engines built starting in 2009; however, for the purpose of estimating the CMV emissions for the construction and operational phase of CVOW commencing in 2020, the worst case Tier 1 or Tier 2 emission factors were used providing a conservative estimate. The EPA categories for CMV engines are defined as follows:

- Category 1: 1-5 liters per cylinder displacement,
- Category 2: 5-30 liters per cylinder displacement, and
- Category 3: over 30 liters per cylinder displacement.

The calculations presented in Attachment A are based on assumed typical vessels representative of the type, configuration, and size to be employed in installation activities associated with offshore elements of the project. Actual vessels to be employed during installation activities will be determined in the coming months, although these are not expected to significantly affect the results of the assessment presented. Any vessel names included are presented for indicative purposes only. Vessel operating durations and configurations are presented based on assumed installation patterns, but have been presented to provide a reasonable worst-case scenario.

It is anticipated that the crew transfer vessel will be equipped with Category 1 main and auxiliary engines, and that all other vessels, including the jack-up vessel to be used for installation of the foundations and wind turbine towers, the cable lay and scour protection installation vessels, as well as other support vessels, will be equipped with Category 2 main engines. It is anticipated that the auxiliary engines on all vessels will be Category 1 engines. Category 1 engines have a range of emission factors depending on size; the highest values (for sizes < 1,000 kW) were conservatively chosen. Currently it is not anticipated that any vessels equipped with Category 3 engines will be used. The CO_2e (GHG) emissions for the CMVs were calculated based on the methodology presented in Section 2.6 below.

2.2 Onshore Emergency Generator

The proposed onshore interconnection station will be equipped with an emergency generator to provide power for certain vital systems during power outages or other events, such as hurricanes, that have the potential to bring down the electrical power grid. The backup power system currently being proposed for the onshore interconnection station is an emergency diesel generator engine rated at approximately 250 kW.

Emission calculations utilize emission factors for criteria air pollutants provided by the generator manufacturer, supplemented with factors presented in EPA's AP-42 Compilation of Air Pollutant Emission Factors (AP-42) Section 3.3, Gasoline and Diesel Industrial Engines (EPA 1996), and the emission factors presented in 40 Code of Federal Regulations 98 Tables C-1 and C-2 for GHG pollutants (CO_2, CH_4, and N_2O). Emissions calculated using the generator manufacturer's emission factors (g/hp-hr) were multiplied by the engine's power rating (hp) (based on a conversion factor of 1.34 hp/kW) and by the total annual operating hours (assumed to be 500 hours per year for the maximum allowable hours of operation for an emergency generator). The calculated emissions were converted to tons per year by dividing the emissions by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to ton (2,000 lb/ton). Emissions calculated using AP-42 emission factors (lb/million British thermal units [MMBtu]) were multiplied by the heat input rate (MMBtu/hr) (calculated from generators fuel consumption (gallons) and the diesel's heat content (Btu/gal)), and by the total annual operating hours and converting from pounds to ton (2,000 lb/ton). The CO_2e (GHG) emissions were calculated based on the methodology presented in Section 2.6.

2.3 Nonroad Engines

Emissions factors for cranes, forklifts, pumps, horizontal directional drilling rigs, generators, and other nonroad engines were calculated using EPA's Motor Vehicle Emission Simulator (MOVES2014a) emission factor modeling system (EPA 2014). To calculate emission factors for this project, a run was conducted for the anticipated construction year of 2020, using the national database and inventory mode.

Emission factors from EPA's MOVES2014a emission model are provided in g/hp-hr, so emissions were estimated by multiplying the emission factor by the nonroad engine's power rating (hp), the total operating hours, and the load factor for each specific type of equipment. The calculated emissions were converted to tons per year by dividing the resultant emissions in grams per year by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to ton (2,000 lb/ton).

Emissions for CH_4 and N_2O are based on EPA emission factors for construction equipment in Table B-8 of the EPA report on "Direct Emissions from Mobile Combustion Sources" (0.57 g CH_4/gal fuel and 0.26 g N_2O/gal fuel, respectively) (EPA 2016). Fuel consumption for each type of equipment was estimated based on CO_2 emission factor (g/hp-hr) generated from the MOVES2014a model and the emission factor for the mass of CO_2 generated per gallon of diesel fuel (10.21 kg CO_2/gal fuel), as presented in Table A-1 of the EPA (2016) report. Therefore, CH_4 and N_2O emissions were calculated based on the following equation:

$$E = FC \times \rho \text{ x } EF \text{ x } 0.4536 \text{ (kg/lb) x Eng. Rating x Act x LF / 453.6 (g/lb) / 2,000 (lb/ton)}$$

Where:

E = emission, tons/year

FC = fuel consumption, gal/hp-hr

ρ = Density, lb/gal

EF = emission factor, g (CH_4 or N_2O)/kg fuel

Eng. Rating = engine rating, hp

Act = activity, hours/year

LF = load factor

The CO_2e (GHG) emissions were, therefore, calculated based on the methodology presented in Section 2.6.

2.4 Onroad Vehicles

Emissions associated with onroad vehicles are negligible compared to those from the CMVs and nonroad engines, due in part to smaller engine sizes and the more stringent emission standards that apply to onroad vehicles. MOVES2014a was used to estimate emissions associated with on-road engines for the anticipated construction year of 2020. This emission modeling system estimates emissions for a broad range of pollutants from mobile sources such as cars, trucks, and motorcycles, and allows multiple scale analysis.

Emission factors (g/mi) for VOC, NO_X, CO, PM, SO_2, and CO_2e were calculated for 2020 using the most current database files provided by the Virginia Department of Environmental Quality for input to MOVES2014a. The model was run for individual counties/cities surrounding Virginia Beach, including Chesapeake, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, and Williamsburg Cities, and James City and York Counties. Calculated emission factors from each county/city were compared and the maximum emission factors were used to calculate onroad vehicle exhaust emissions.

2.5 Helicopter Emissions

Workers for the offshore construction activities will be transported to and from the offshore work locations by a crew transfer vessel, or optionally, by helicopter. For each pollutant, total potential emissions were based on whichever mode of transport produced the highest emissions. The Bureau of Ocean Energy Management (BOEM) has produced a technical document, "BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation" (BOEM 2017), to assist in estimating emissions for construction and operation of offshore wind energy facilities, including emission from helicopters. Table 4 of the BOEM document provides default emission factors for VOC, NO_x, CO, PM, SO_2, CO_2, CH_4, and N_2O, as well as default fuel consumption rates in gallons/hour, based on four categories of helicopter size. Table 9 of the BOEM document provides default airspeeds for each category of helicopter size.

The number of helicopter trips and trip duration were estimated assuming a twin-engine Bell 412EP or similar model helicopter, which is capable of carrying approximately 14 passengers. This model is classified as a "Twin Medium" helicopter in the BOEM document, with a default airspeed of 182.6 miles/hour. Flights were assumed to originate from Naval Air Station Oceana, which is located approximately 26.5 nautical miles from the foundation installation locations.

2.6 GHG Emissions

The GHG emissions from the Project are a result of the combustion of diesel fuel that produces emissions of CO_2, CH_4, and N_2O. GHGs (CO_2, CH_4, and N_2O), are typically presented in CO_2 equivalent or "CO_2e", which is based on their specific Global Warming Potential (GWP). Each GHG constituent has a different heat trapping capability; the corresponding GWP has been calculated to reflect how long the gas remains in the atmosphere, on average, and how strongly it absorbs energy compared to CO_2. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP. Factors used to calculate CO_2e (GWP) and were taken from Table A-1 of 40 CFR 98, Subpart A. The GWP is 25 for CH_4 and 298 for N_2O. Therefore, the equation to calculate CO_2e for each of the sources is:

$$\mathrm{CO2e} = \left[\mathrm{CO2}\,\frac{\mathrm{tons}}{\mathrm{yr}}\ \mathrm{x\ CO2\ GWP(1)}\right] + \left[\mathrm{CH4}\,\frac{\mathrm{tons}}{\mathrm{yr}}\ \mathrm{x\ CH4\ GWP(25)}\right] + \left[\mathrm{N2O}\,\frac{\mathrm{tons}}{\mathrm{yr}}\ \mathrm{x\ N2O\ GWP(298)}\right]$$

3 REFERENCES

Bureau of Ocean Energy Management (BOEM). 2017. BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation, OCS Study BOEM 2017-079, August 1, 2017. Available online at: https://www.boem.gov/Technical-Documentation-stakeholder/

EPA (U.S. Environmental Protection Agency). 1996. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Section 3.3 Gasoline and Diesel Industrial Engines, AP-42, October 1996.

EPA. 2016. Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance, EPA430-K-16-004, January 2016.

EPA. 2014. MOVES (Motor Vehicle Emission Simulator). Available online at: https://www.epa.gov/moves

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Attachment A – Emission Calculations

CVOW - AIR EMISSION CALCULATIONS
Emission Summary

	2020								2021							
	VOC tons	NO_X tons	CO tons	PM/PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	GHG tons CO_2e	VOC tons	NO_X tons	CO tons	PM/PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	GHG tons CO_2e
Onshore Construction Emissions																
Export Cable Landfall Construction	0.23	1.49	1.63	0.09	0.09	0.004	0.06	447	-	-	-	-	-	-	-	-
Onshore Interconnection Cable & Switch Cabinet Installation	0.28	1.65	2.16	0.10	0.09	0.005	0.07	547	-	-	-	-	-	-	-	-
Interconnection Station Installation	0.24	0.95	2.55	0.04	0.04	0.006	0.07	503	-	-	-	-	-	-	-	-
TOTAL	**0.75**	**4.08**	**6.35**	**0.22**	**0.21**	**0.02**	**0.20**	**1497**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Offshore Construction Emissions																
Offshore Turbine Installation	2.75	55.46	28.30	3.38	3.28	0.015	0.57	3,951	-	-	-	-	-	-	-	-
Offshore Cable Installation	1.18	28.59	14.58	1.36	1.32	0.008	0.24	2,041	-	-	-	-	-	-	-	-
TOTAL	**3.93**	**84.05**	**42.88**	**4.74**	**4.59**	**0.02**	**0.81**	**5,992**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Annual Operating Emissions																
O&M	0.17	5.16	2.63	0.18	0.17	0.0007	0.04	367	0.34	10.31	5.26	0.36	0.35	0.001	0.07	735
Emergency Generator	0.01	0.28	0.16	0.01	0.01	0.000	0.0004	15	0.02	0.56	0.31	0.03	0.03	0.000	0.001	30
Circuit Breaker Fugitive GHG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.2
TOTAL	**0.18**	**5.43**	**2.79**	**0.19**	**0.19**	**0.00**	**0.04**	**383**	**0.36**	**10.87**	**5.57**	**0.39**	**0.38**	**0.002**	**0.07**	**765**
ANNUAL TOTAL	**4.86**	**93.57**	**52.01**	**5.15**	**5.00**	**0.04**	**1.04**	**7,872**	**0.36**	**10.87**	**5.57**	**0.39**	**0.38**	**0.002**	**0.07**	**765**

Note:

- 2020 annual operating emissions assumes 6 months of operation based on wind generating turbines becoming fully operational in July of 2020 to provide a conservative estimate.

CVOW - AIR EMISSION CALCULATIONS
Export Cable Landfall Construction

Construction Equipment	Source Category[1]	HP per unit	Fuel Type	Emiss. Factor ID	hrs per day	Load Factor	2020 J	F	M	A	M	J	J	A	S	O	N	D	Total Equip. Months	Fuel Use 2020 gal	Emissions - 2020 VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAP Tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Land-based Nonroad Equip.																															
Mounted Impact Hammer (Hoe Ram)	2270002081	100	diesel	117	4	59%			1										1	413	0.00	0.01	0.01	0.00	0.00	0.000	0.000	4.648	0.000	0.000	4.69
Tracked Excavator	2270002036	200	diesel	106	12	59%			1	1									2	4,464	0.01	0.05	0.02	0.00	0.00	0.000	0.004	50.234	0.001	0.001	50.65
Air Compressor	2270006015	100	diesel	130	12	43%			1	1									2	1,609	0.01	0.05	0.01	0.00	0.00	0.000	0.002	18.106	0.000	0.000	18.26
Water pump	2270006010	100	diesel	127	12	43%			1	1									2	1,788	0.01	0.11	0.06	0.01	0.01	0.000	0.003	20.126	0.001	0.001	20.29
HDD Drilling Machine	2270002033	300	diesel	103	12	43%			1	1									2	4,824	0.03	0.29	0.07	0.01	0.01	0.000	0.007	54.290	0.001	0.001	54.74
Mud Pumps	2270006010	100	diesel	127	12	43%			1	1									2	1,788	0.01	0.11	0.06	0.01	0.01	0.000	0.003	20.126	0.001	0.001	20.29
Generator	2270006005	200	diesel	124	12	43%			1	3									4	6,431	0.04	0.39	0.10	0.02	0.02	0.000	0.009	72.381	0.002	0.002	72.98
Slurry Plant	2270002042	100	diesel	109	12	43%			3	1									4	3,573	0.03	0.23	0.12	0.02	0.02	0.000	0.007	40.215	0.001	0.001	40.55
Desilter	2270003040	100	diesel	120	12	43%			1	1									2	1,609	0.01	0.04	0.01	0.00	0.00	0.000	0.001	18.106	0.000	0.000	18.26
Shale Shaker	2270003040	100	diesel	120	12	43%			1	1									2	1,609	0.01	0.04	0.01	0.00	0.00	0.000	0.001	18.106	0.000	0.000	18.26
Onroad Vehicles																															
Pickup F150		200	gasoline	151	-	-			4	4									8	571	0.01	0.03	0.22	0.00	0.00	0.00	0.00	22.10	0.00	0.00	22.17
Flatbed Truck (Material Supply)		150	diesel	152	-	-			1	1									2	343	0.00	0.02	0.05	0.00	0.00	0.00	0.00	10.23	0.00	0.00	10.26
Dump Truck		200	diesel	152	-	-			1	1									2	343	0.00	0.02	0.05	0.00	0.00	0.00	0.00	10.23	0.00	0.00	10.26
Worker Commute																															
Passenger Truck		-	gasoline	151	-	-			14	14									28	1,600	0.04	0.07	0.63	0.00	0.00	0.00	0.01	61.88	0.00	0.00	62.08
Passenger Vehicle		-	gasoline	150	-	-			7	7									14	697	0.01	0.02	0.20	0.00	0.00	0.00	0.00	23.10	0.00	0.00	23.16
																			Total	31,662	0.23	1.49	1.63	0.09	0.09	0.004	0.059	444	0.018	0.011	446.89

Notes:

- Calculations assume equipment is used 7 days/wk - i.e., 30 days/month to provide conservative estimate.
- Calculations conservatively assume the onroad pickup F150 travels approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume the flatbed truck and dump truck travels approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.

CVOW - AIR EMISSION CALCULATIONS
Onshore Interconnection Cable and Switch Cabinet Installation

Construction Equipment	Source Category[1]	HP per unit	Fuel Type	Emiss. Factor ID	hrs per day	Load Factor	2020 J	F	M	A	M	J	J	A	S	O	N	D	Total Equip. Months	Fuel Use 2020 gal	Emissions - 2020 VOC tons	NO_X tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAP Tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Land-based Nonroad Equip.																															
Mounted Impact Hammer (Hoe Ram)	2270002081	100	diesel	117	4	59%		1	1	1									3	1,239	0.01	0.04	0.04	0.00	0.00	0.000	0.001	13.943	0.000	0.000	14.06
Tracked Excavator	2270002036	200	diesel	106	12	59%		1	1	1									3	6,695	0.02	0.07	0.02	0.00	0.00	0.000	0.005	75.352	0.002	0.002	75.97
Air Compressor	2270006015	100	diesel	130	12	43%		1	1	1									3	2,413	0.01	0.07	0.02	0.00	0.00	0.000	0.002	27.159	0.001	0.001	27.38
Water pump	2270006010	100	diesel	127	12	43%		1	1	1									3	2,682	0.02	0.17	0.09	0.02	0.02	0.000	0.005	30.189	0.001	0.001	30.44
HDD Drilling Machine	2270002033	300	diesel	103	12	43%		1	1										2	4,824	0.03	0.29	0.07	0.01	0.01	0.000	0.007	54.290	0.001	0.001	54.74
Mud Pumps	2270006010	100	diesel	127	12	43%		1	1										2	1,788	0.01	0.11	0.06	0.01	0.01	0.000	0.003	20.126	0.001	0.001	20.29
Generator	2270006005	200	diesel	124	12	43%		3	1	1									5	8,039	0.05	0.49	0.12	0.02	0.02	0.001	0.012	90.476	0.002	0.002	91.22
Slurry Plant	2270002042	100	diesel	109	12	43%		1	1										2	1,787	0.01	0.12	0.06	0.01	0.01	0.000	0.003	20.107	0.001	0.001	20.27
Desilter	2270003040	100	diesel	120	12	43%		1	1										2	1,609	0.01	0.04	0.01	0.00	0.00	0.000	0.001	18.106	0.000	0.000	18.26
Shale Shaker	2270003040	100	diesel	120	12	43%		1	1										2	1,609	0.01	0.04	0.01	0.00	0.00	0.000	0.001	18.106	0.000	0.000	18.26
Onroad Vehicles																															
Pickup F150		200	petrol	151	-	-		4	4	4									12	857	0.02	0.04	0.34	0.00	0.00	0.00	0.01	33.15	0.00	0.00	33.26
Flatbed Truck (Material Supply)		150	diesel	152	-	-		1	1	1									3	514	0.01	0.03	0.08	0.00	0.00	0.00	0.00	15.35	0.01	0.00	15.40
Worker Commute																															
Passenger Truck		-	gasoline	151	-	-		14	14	14									42	2,400	0.06	0.11	0.94	0.00	0.00	0.00	0.02	92.81	0.00	0.00	93.13
Passenger Vehicle		-	gasoline	150	-	-		7	7	7									21	1,046	0.02	0.03	0.29	0.00	0.00	0.00	0.00	34.64	0.00	0.00	34.74
																			Total	37,503	0.28	1.65	2.16	0.10	0.09	0.005	0.072	544	0.019	0.013	547.41

Notes:

- Calculations assume equipment is used 7 days/wk - i.e., 30 days/month to provide conservative estimate.
- Calculations conservatively assume the onroad pickup F150 travels approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume the flatbed truck and dump truck travels approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume workers average daily round trip commute is approximately 40

CVOW - AIR EMISSION CALCULATIONS

Interconnection Station Installation

Construction Equipment	Source Category[1]	HP per unit	Fuel Type	Emiss. Factor ID	hrs per day	Load Factor	2020												Total Equip. Months	Fuel Use 2020 gal	Emissions - 2020										
							J	F	M	A	M	J	J	A	S	O	N	D			VOC tons	NO_X tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAP Tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Land-based Nonroad Equip.																															
Mounted Impact Hammer (Hoe Ram)	2270002081	100	diesel	117	4	59%	1	1											2	826	0.00	0.03	0.03	0.00	0.00	0.000	0.001	9.296	0.000	0.000	9.37
Crane-road	2270002045	200	diesel	111	6	43%	1	1	1	1									4	3,218	0.01	0.07	0.01	0.00	0.00	0.000	0.003	36.214	0.001	0.001	36.51
Earth Compactor	2270002015	200	diesel	101	4	59%	1	1											2	1,488	0.01	0.03	0.01	0.00	0.00	0.000	0.001	16.744	0.000	0.000	16.88
Tracked Excavator	2270002036	200	diesel	106	12	59%	1	1	1	1									4	8,927	0.03	0.10	0.03	0.00	0.00	0.000	0.007	100.469	0.002	0.003	101.29
Generator	2270006005	200	diesel	124	12	43%	1	1	1	1									4	6,431	0.04	0.39	0.10	0.02	0.02	0.000	0.009	72.381	0.002	0.002	72.98
Onroad Vehicles																															
Pickup F150		200	petrol	151	-	-	4	4	4	4									16	1,143	0.03	0.05	0.45	0.00	0.00	0.00	0.01	44.20	0.00	0.00	44.35
Flatbed Truck (Material Supply)		150	diesel	152	-	-	1	1	1	1									4	686	0.01	0.04	0.11	0.00	0.00	0.00	0.00	20.46	0.01	0.00	20.53
Dump Truck		200	diesel	152	-	-	1	1	1	1									4	686	0.01	0.04	0.11	0.00	0.00	0.00	0.00	20.46	0.01	0.00	20.53
Concrete Truck		250	diesel	152	-	-			1	1									2	343	0.00	0.02	0.05	0.00	0.00	0.00	0.00	10.23	0.00	0.00	10.26
Worker Commute																															
Passenger Truck		-	gasoline	151	-	-	14	14	14	14									56	3,200	0.08	0.15	1.26	0.00	0.00	0.00	0.02	123.75	0.00	0.00	124.17
Passenger Vehicle		-	gasoline	150	-	-	7	7	7	7									28	1,394	0.02	0.04	0.39	0.00	0.00	0.00	0.01	46.19	0.00	0.00	46.32
																			Total	28,341	0.24	0.95	2.55	0.04	0.04	0.006	0.066	500	0.029	0.012	503.19

Notes:

- Calculations assume equipment is used 7 days/wk - i.e., 30 days/month to provide conservative estimate.
- Calculations conservatively assume the onroad pickup F150 travels approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume the flatbed truck and dump truck travels approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
- Calculations conservatively assume workers average daily round trip commute is approximately 40

CVOW - AIR EMISSION CALCULATIONS
Offshore Turbine Installation

																Total Emissions										
Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Propulsion	Emission Factor Used (see EFs worksheet)	Activity	Engine Rating (hp)	Fuel Type	Trips	Hrs/trip	Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Average load (%)	Fuel Usage Gallons	VOC tons	NO_x tons	CO tons	PM/PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Foundation Installation Vessel (Vole Au Vent)		3	461 x 135 x 31 (21)	4 main thrusters (2,600 kW each)																						
Main Generators	6			3 bow thrusters (2,500 kW each)	1	Transit/positioning/preload/jacking	5362	Diesel	1	6	2	18	42	83%	56,541.5	0.46	9.04	4.61	0.57	0.55	1.20E-03	0.10	636.34	8.30E-02	1.84E-02	643.91
Main Generators	6				1	Install Foundations	5362	Diesel	1	6	4	24	102	25%	41,360.0	0.34	6.61	3.37	0.42	0.41	8.77E-04	0.07	465.48	6.07E-02	1.35E-02	471.02
Emergency Generator	1				126	Emergency only	781	Diesel	1	6	0	0	6	0%	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind Turbine Installation Vessel (Vole Au Vent)		3	461 x 135 x 31 (21)	4 main thrusters (2,600 kW each)																						
Main Generators	6			3 bow thrusters (2,500 kW each)	1	Transit/positioning/preload/jacking	5362	Diesel	1	6	2	18	42	83%	56,541.5	0.46	9.04	4.61	0.57	0.55	1.20E-03	0.10	636.34	8.30E-02	1.84E-02	643.91
Main Generators	6				1	Install WTGs	5362	Diesel	1	6	4	24	102	25%	41,360.0	0.34	6.61	3.37	0.42	0.41	8.77E-04	0.07	465.48	6.07E-02	1.35E-02	471.02
Emergency Generator	1				126	Emergency only	781	Diesel	1	6	0	0	6	0%	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scour Protection Vessel (Adhemar de Saint-Venant)		1	312 x 72 x 21 (21)	2 main thrusters (1,250 kW each)																						
Main Generators	4			2 bow thrusters (1,250 kW each)	1	Install scour protection	2279	Diesel			2	24	48	43%	9,485.8	0.08	1.52	0.77	0.10	0.09	2.01E-04	0.02	106.76	1.39E-02	3.09E-03	108.03
Emergency Generator	1				126	Emergency only	1086	Diesel			0	0	0	0%	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crew Transfer Vessel			55 x 16.5 x 6.5 (4.5)	FP 32"x36" prop(s) on 3" shafts		Transport crew to/from																				
-main engines	2				2	Vole Au Vent and Adhemar	1220	Diesel	20	6	5	0	120	45%	6,642.7	2.93E-02	1.06	0.54	2.80E-02	2.71E-02	1.41E-04	6.02E-03	74.76	9.75E-03	2.17E-03	75.65
-aux. engines	1				2	de Saint-Venant	33.5	Diesel	20	6	5	0	120	43%	87.1	3.84E-04	1.39E-02	7.11E-03	3.67E-04	3.56E-04	1.85E-06	7.89E-05	0.98	1.28E-04	2.84E-05	0.99
Helicopter - Crew Transfer (Bell 412EP or similar)						Transport crew to/from Vole Au Vent and Adhemar																				
-main engines	2				163	de Saint-Venant	900	Jet fuel	20	1	2	0	20	100%	2,331.8	0.03	0.07	2.00E-03	2.00E-03	2.00E-03	7.80E-03	2.69E-04	24.60	7.00E-04	8.00E-04	24.86
Support Vessel - Bubble Curtain		1	276 x 54 x 24 (14)	2-1500 kW RR azimuth units &		Installation/operation of bubble																				
-main engines	3			2-750kW RR bow thrusters	1	curtain during foundation	1930	Diesel	2	6	4	24	108	45%	14,186.6	0.12	2.27	1.16	0.14	0.14	3.01E-04	0.02	159.66	2.08E-02	4.63E-03	161.56
-aux. engines	2				2	installation	965	Diesel	2	6	4	24	108	43%	4,518.7	0.02	0.72	0.37	0.02	0.02	9.58E-05	4.09E-03	50.86	6.63E-03	1.47E-03	51.46
Guard Vessel			100 x 32 x 12.2																							
-main engines	2				1	Security for site work zone	1500	Diesel	2	6	30	24	732	43%	47,606.1	0.39	7.61	3.88	0.48	0.47	1.01E-03	0.08	535.78	0.07	0.02	542.15
-aux. engines	2				2		133	Diesel	2	6	30	24	732	43%	4,221.1	0.02	0.67	0.34	0.02	0.02	8.95E-05	3.82E-03	47.51	6.20E-03	1.38E-03	48.07
-aux. engines	2				2		119	Diesel	2	6	30	24	732	43%	3,776.8	0.02	0.60	0.31	0.02	0.02	8.01E-05	3.42E-03	42.51	5.54E-03	1.23E-03	43.01
MMO vessel 1			100 x 26 x 6																							
-main engines	2				1	Marine mammal observation	1500	Diesel	2	6	12	24	300	43%	19,510.7	0.16	3.12	1.59	0.20	0.19	4.14E-04	0.03	219.58	0.03	6.36E-03	222.19
-aux. engines	2				2	during piling	54	Diesel	2	6	12	24	300	43%	697.4	3.07E-03	0.11	0.06	2.93E-03	2.85E-03	1.48E-05	6.32E-04	7.85	1.02E-03	2.28E-04	7.94
MMO vessel 2			100 x 26 x 6																							
-main engines	2				1	Marine mammal observation	1500	Diesel	2	6	12	24	300	43%	19,510.7	0.16	3.12	1.59	0.20	0.19	4.14E-04	0.03	219.58	0.03	6.36E-03	222.19
-aux. engines	2				2	during piling	54	Diesel	2	6	12	24	300	43%	697.4	3.07E-03	0.11	0.06	2.93E-03	2.85E-03	1.48E-05	6.32E-04	7.85	1.02E-03	2.28E-04	7.94
Acoustic monitoring vessel			100 x 26 x 6																							
-main engines	2				1	Acoustic monitoring	1500	Diesel	2	6	12	24	300	43%	19,510.7	0.16	3.12	1.59	0.20	0.19	4.14E-04	0.03	219.58	0.03	0.01	222.19
-aux. engines	2				2	during piling	54	Diesel	2	6	12	24	300	43%	697.4	3.07E-03	0.11	0.06	2.93E-03	2.85E-03	1.48E-05	6.32E-04	7.85	1.02E-03	2.28E-04	7.94
															346,952	**2.75**	**55.46**	**28.30**	**3.38**	**3.28**	**0.02**	**0.57**	**3,904.74**	**0.51**	**0.11**	**3,951.21**

Notes:
1. Emissions were estimated based on the number of days of operation and/or the number of trips the vessels made to the CVOW project site from port.
2. Trip constitutes the round trip transit time to and from the project site. The number of hours per trip were estimated based on the vessel's transit speed and additional time required for maneuvering and berthing.
3. The estimated time for installation of the turbines is anticipated to take approximately 4 days, operating on a 24 hours per day basis.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. The installation vessel, bubble curtain support vessel, guard vessel, and marine mammal observation (MMO) vessels are assumed to be in operation for the entire time construction is occurring providing a conservative emission estimate.
6. The crew transfer vessel will be used to transport crew to the project site from the main port, assuming all crew will be deployed once at start of construction, and returned to shore at end of construction (20 total trips, assuming 100 crew, and 10-passenger capacity of crew transfer vessel).
7. The helicopter may be used to transport crew as an alternative, assuming all crew will be deployed once at start of construction, and returned to shore at end of construction (10 total trips, assuming 50 crew, and 10-passenger capacity of helicopter).
8. The installation vessel for the foundations and wind turbines will transport components from an onshore staging area outside the 25 nm boundary from the project site. Emission calculations were estimated beginning when the vessel reaches the 25 nm boundary from the project site and consist of transit, maneuvering and berthing time.
9. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
10. HAP emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2011) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM_{10}, $PM_{2.5}$, or VOC emissions from the CMVs.
    The HAP emisson for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
11. Average load factors were estimated based on load factors presented in the ICF International report "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories", April 2009, and best engineering estimates.
12. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.
13. Highlighted cells indicates emission sources that would be considered OCS sources, since vessel would be attached to the OCS seabed or moored to a vessel/barge that will be attached to the OCS seabed.

CVOW - AIR EMISSION CALCULATIONS
Offshore Transmission Cable Installation

																Total Emissions										
Vessels/Equipment	**No. of Engines per vessel**	**1. DP 2.Anchored 3.Spuds**	**Dimensions (ft) length x width x depth (draft)**	**Propulsion**	**Emission Factor Used (see EFs worksheet)**	**Activity**	**Engine Rating (hp)**	**Fuel Type**	**Trips**	**Hrs/trip**	**Operating Days**	**Operating Hours (hrs/day)**	**Total Operating Hours (hrs)**	**Average load (%)**	**Fuel Usage Gallons**	**VOC tons**	**NO_X tons**	**CO tons**	**PM/PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Cable Lay Vessel (Stemat Spirit)		1	295ft x 93ft x 16ft	2 stern azimuth thrusters (ZF AT 6111 electric)																						
-Main Engines (CAT 3512HD)	2			2 bow azimuth thrusters (ZF AT 6111 electric)	1	Install submarine cable	1773	Diesel			20	24	480	43%	36,898.7	0.30	5.90	3.01	0.37	0.36	7.82E-04	0.06	415.27	0.05	1.20E-02	420.21
-Bow Thruster Engines (CAT 3512B)	2			1 tunnel thruster (ZF TT 5001 electric)	1	Install submarine cable	2010	Diesel			20	24	480	43%	41,831.0	0.34	6.69	3.41	0.42	0.41	8.87E-04	0.07	470.78	0.06	1.36E-02	476.38
-Main Generators	3				2	Power generation	1163	Diesel			20	24	480	43%	36,305.5	0.16	5.80	2.96	0.15	0.15	7.70E-04	0.03	408.60	0.05	1.18E-02	413.46
-Aux Generators	3				2	Power generation	1139	Diesel			20	24	480	43%	35,556.3	0.16	5.68	2.90	0.15	0.15	7.54E-04	0.03	400.17	0.05	1.16E-02	404.93
-Emergency/harbor generator	1				125	Emergency only	311	Diesel			0	0	0	0%	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cable Protection Vessel (Adhemar de Saint-Venant)		1	312 x 72 x 21 (21)	2 main thrusters (1,250 kW each)																						
Main Generators	4			2 bow thrusters (1,250 kW each)	1	Install cable protection	2279	Diesel			5	24	120	43%	23,714.6	0.19	3.79	1.93	0.24	0.23	5.03E-04	0.04	266.89	0.03	7.74E-03	270.07
Emergency Generator	1				126	Emergency only	1086	Diesel			0	0	0	0%	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crew Transfer Vessel			55 x 16.5 x 6.5 (4.5)	FP 32"x36" prop(s) on 3" shafts		Transport crew to/from																				
-main engines	2				2	Stemat Spirit and Adhemar	1220	Diesel	10	6	5	0	60	45%	3,321.4	0.01	0.53	0.27	0.01	0.01	7.04E-05	3.01E-03	37.38	4.88E-03	1.08E-03	37.82
-aux. engines	1				2	de Saint-Venant	33.5	Diesel	10	6	5	0	60	43%	43.6	0.00	0.01	0.00	0.00	0.00	9.24E-07	3.95E-05	0.49	6.40E-05	1.42E-05	0.50
Helicopter - Crew Transfer (Bell 412EP or similar)						Transport crew to/from																				
						Stemat Spirit and Adhemar																				
-main engines	2				163	de Saint-Venant	900	Jet fuel	10	1	2	0	10	100%	1,165.9	0.02	0.04	1.00E-03	1.00E-03	1.00E-03	3.90E-03	1.34E-04	12.30	3.50E-04	4.00E-04	12.43
Tug - Support Barge			100 x 26 x 6			Locate support barge																				
-main engines	2				2	Support	1100	Diesel	4	6	4	0	24	31%	825.2	3.63E-03	0.13	0.07	3.47E-03	3.37E-03	1.75E-05	7.47E-04	9.29	1.21E-03	2.69E-04	9.40
-aux. engines	2				2		160	Diesel	4	6	4	0	24	43%	166.5	7.33E-04	0.03	1.36E-02	7.01E-04	6.80E-04	3.53E-06	1.51E-04	1.87	2.44E-04	5.43E-05	1.90
-aux. engines	1				2		67	Diesel	4	6	4	0	24	43%	34.9	1.54E-04	5.57E-03	2.84E-03	1.47E-04	1.42E-04	7.39E-07	3.16E-05	0.39	5.12E-05	1.14E-05	0.40
Support Barge		2	400 x 120 x 25 (12)	None		Barge for seabed levelling; PLGR;																				
						anchor handling for cable lay																				
generator	1				125	vessel	200	Diesel			20	24	480	10%	498.7	2.55E-03	0.03	0.01	1.24E-03	1.21E-03	3.29E-05	1.34E-04	5.61	1.28E-04	1.43E-04	5.66
															179,196	**1.18**	**28.59**	**14.58**	**1.36**	**1.32**	**0.01**	**0.24**	**2,016.75**	**0.26**	**0.06**	**2,040.72**

Notes:

1. Emissions were estimated based on the number of days of operation and/or the number of trips the vessels made to the CVOW project site from port.
2. Trip constitutes the round trip transit time to and from the project site. The number of hours per trip were estimated based on the vessel's transit speed and additional time required for maneuvering and berthing.
3. The estimated time for installation of the transmission cable is anticipated to take approximately 20 days, operating on a 24 hours per day basis.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. The cable lay vessel is assumed to be in operation for the entire time transmission cable installation activities are occurring.
6. The crew transfer vessel will be used to transport crew to the project site from the main port, assuming all crew will be deployed once at start of construction, and returned to shore at end of construction (10 total trips, assuming 50 crew, and 10-passenger capacity of crew transfer vessel).
7. The helicopter may be used to transport crew as an alternative, assuming all crew will be deployed once at start of construction, and returned to shore at end of construction (10 total trips, assuming 50 crew, and 10-passenger capacity of helicopter).
8. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
9. HAP emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2011) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM_{10}, $PM_{2.5}$, or VOC emissions from the CMVs.
   The HAP emisson for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. Average load factors were estimated based on load factors presented in the ICF International report "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories", April 2009, and best engineering estimates.
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.
12. Highlighted cells indicates emission sources that would be considered OCS sources, since vessel would be attached to the OCS seabed or moored to a vessel/barge that will be attached to the OCS seabed.

CVOW - AIR EMISSION CALCULATIONS
Annual Operational and Maintenance Activities

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Propulsion	Emission Factor Used (see EFs worksheet)	Activity	Engine Rating (hp)	Fuel Type	Trips	Hrs/trip	Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Average load (%)	Fuel Usage Gallons	Total Annual Emissions VOC tons	NO_X tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Crew Transfer Vessel			55 x 16.5 x 6.5 (4.5)	FP 32"x36" prop(s) on 3" shafts																						
-main engines	2				2	Maintenance	1220	Diesel	112	6	112	0	672	45%	37,199.2	0.16	5.95	3.03	0.16	0.15	0.00	0.03	418.66	0.05	0.01	423.64
-aux. engines	1				2		33.5	Diesel	112	6	112	0	672	43%	488.2	0.00	0.08	0.04	0.00	0.00	0.00	0.00	5.49	0.00	0.00	5.56
Work Vessel			276 x 54 x 24 (14)	2-1500 kW RR azimuth units &																						
-main engines	3	1		2-750kW RR bow thrusters	1	Cable & foundation inspection	1930	Diesel	2		2	12	24	43%	3,012.9	0.02	0.48	0.25	0.03	0.03	0.00	0.01	33.91	0.00	0.00	34.31
-aux. engines	2				2		965	Diesel	2		2	12	24	43%	1,004.3	0.00	0.16	0.08	0.00	0.00	0.00	0.00	11.30	0.00	0.00	11.44
Crew Transfer Vessel			55 x 16.5 x 6.5 (4.5)	FP 32"x36" prop(s) on 3" shafts																						
-main engines	2				2	Data Collection	1220	Diesel	12	6			72	45%	3,985.6	0.02	0.64	0.33	0.02	0.02	0.00	0.00	44.86	0.01	0.00	45.39
-aux. engines	1				2		33.5	Diesel	12	6			72	43%	52.3	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.60
Crew Transfer Vessel			55 x 16.5 x 6.5 (4.5)	FP 32"x36" prop(s) on 3" shafts																						
-main engines	2				2	Emergency Preparedness &	1220	Diesel	8	6			48	45%	2,657.1	0.01	0.42	0.22	0.01	0.01	0.00	0.00	29.90	0.00	0.00	30.26
-aux. engines	1				2	Misc. O&M activities	33.5	Diesel	8	6			48	43%	34.9	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.40
Work Vessel			276 x 54 x 24 (14)	2-1500 kW RR azimuth units &																						
-main engines	3	1		2-750kW RR bow thrusters	1	Emergency Preparedness &	1930	Diesel			8	12	96	43%	12,051.7	0.10	1.93	0.98	0.12	0.12	0.00	0.02	135.63	0.02	0.00	137.25
-aux. engines	2				2	Misc. O&M activities	965	Diesel			8	12	96	43%	4,017.2	0.02	0.64	0.33	0.02	0.02	0.00	0.00	45.21	0.01	0.00	45.75
															64,503.4	**0.34**	**10.31**	**5.26**	**0.36**	**0.35**	**0.00**	**0.07**	**725.9**	**0.1**	**0.0**	**734.6**

Notes:

1. Two crew boats are anticipated to take 1 trip per week per turbine for the first year and one trip per month there after for small maintenance trips (small equipment). Additionally, it is anticipated that they will make 1 trip per 3 months for small maintenance to the foundation.
2. A work vessel will be used to inspect the cable and foundations. It is anticiapate two trips will occur within the first year and one trip per year afterwards. Since the vessel may be operating the entire trip, emissions were based on days performing inspecion for 12 hours per day.
3. A crew boat is anticipated to be used to collect research data from the WTGs on a monthly basis.
4. A crew boat and a work vessel are anticipated to be used to perform emergency preparedness activities (in the event of major weather related storms) and other miscellaneous O&M activities up to 8 times per year.
5. Emission calcs based on vessels traveling from Rudee Inlet which is the base case port for O&M operations.
6. Trip constitutes the round trip transit time to and from the project site. The number of hours per trip were estimated based on the vessel's transit speed and additional time required for maneuvering and berthing.
7. Jack-up barge, guard vessel, tug boats, and helicopter would only be utilized for emergency scenarios and would not be considered part of the typical annual operational and maintenance activities of the turbines. Therefore, emissions for these sources were not estimated.
8. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
9. HAP emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2011) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM_{10}, $PM_{2.5}$, or VOC emissions from the CMVs.
10. Average load factors were estimated based on load factors presented in the ICF International report "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories", April 2009, and based on best engineering estimate.
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

CVOW - AIR EMISSION CALCULATIONS
Emergency Generator

Generator Engine Data

Generator Manufacturer	Cummins	
Model	QSL9-G3	
Engine Type	4 cycle, in-line, 6 cy diesel	
Rated engine output	kW	297
Rated engine output	bhp	399
Standyby genset output	kW	250
Total displacement	L	8.9
Number of cylinders	cy	6
Displacement per cylinder	L/cy	1.5
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	19.0
Exhaust temperature	°F	1035
Exhaust flow at actual temp	cfm	2040
Number of generators	engines	1
Annual operating hours per generator	hr/yr	500
Annual Fuel Usage per generator	gal/yr	9,500

Fuel Data

Fuel type	Ultra low sulfur diesel	
Fuel heat content	Btu/lb (LHV)	19,300
Fuel heat content	Btu/lb (HHV)	20,316
Fuel density	lb/gal	7.1
Fuel sulfur content	% weight	0.0015
Conversion factor	LHV/HHV	0.95

Tetra Tech assumptions/calculations

Engine load	%	100
Heat input rate	MMBtu/hr (HHV)	0.72

Engine Emission Factors

NOx	g/hp-hr	2.54
CO	g/hp-hr	1.42
HC (VOC)	g/hp-hr	0.07
PM/PM10	g/hp-hr	0.13
PM2.5	g/hp-hr	0.13
SO2	lb/MMBtu (HHV)	0.0015
HAP	lb/MMBtu (HHV)	0.004
CO2	lb/MMBtu (HHV)	163.1
CH4	lb/MMBtu (HHV)	0.007
N2O	lb/MMBtu (HHV)	0.001

Engine Emission Estimates

NOx	lb/hr (per engine)	2.2
CO	lb/hr (per engine)	1.2
VOC	lb/hr (per engine)	0.06
PM10	lb/hr (per engine)	0.11
PM2.5	lb/hr (per engine)	0.11
SO2	lb/hr (per engine)	1.07E-03
HAP	lb/hr (per engine)	2.82E-03
CO2	lb/hr (per engine)	118.1
CH4	lb/hr (per engine)	4.79E-03
N2O	lb/hr (per engine)	9.58E-04
CO2e	lb/hr (per engine)	118.5

	Short Term Emissions (lb/hr)	Annual Emissions (tons/yr)
NOx	2.2	0.56
CO	1.2	0.31
VOC	0.06	0.02
PM10	0.11	0.03
PM2.5	0.11	0.03
SO2	1.07E-03	2.67E-04
HAP	2.82E-03	7.04E-04
CO2	118.1	29.5
CH4	4.79E-03	1.20E-03
N2O	9.58E-04	2.39E-04
CO2e	118.5	29.6

Notes:

1. Engine power rating, displacement, fuel consumption, and exhaust temperature and flow are based on manufacturer's specification sheet for the Cummins QSL9-G3 engine.
2. Assumed this engine will only be used for emergency purposes and limited to no more than 500 hours per year to include maintenance and testing.
3. Emission factors for NOx, CO, and PM are based on manufacturer's emission data sheet.
4. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
5. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
6. Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.
7. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

CVOW - AIR EMISSION CALCULATIONS
Circuit Breaker Fugitive GHG Emissions

Circuit Breaker SF_6 [1] Fugitive Emissions

SF_6 Storage Capacity per WTG	lbs	7.1
WTG Quantity	units	3
SF_6 Leak Rate (by weight) [2]	% per year	0.5%
SF_6 Emissions	lbs/year	0.11
SF_6 Emissions	tons/year	0.0001
Annual GHG emissions (CO_2e) [3]	tons/year	1.21

1. SF_6 = Sulfur Hexafluoride
2. Leak rate for the SF6 is based on the International Electrotechnical Commission Standard 62271-1, 2004, as presented in the U.S. EPA technical paper, "SF6 Leak Rates from High Voltage Circuit Breakers - U.S. EPA Investigates Potential Greenhouse Gas Emissions Source."
3. CO_2e emission rates use the following carbon equivalence factors based on Table A-1 to Subpart A of 40 CFR Part 98—Global Warming Potentials: 22,800 for SF6.

CVOW
Emission Factors

Commercial Marine Vessels (CMVs)

	Engine Type	Commercial Marine Vessel Emission Factors (g/hp-hr) /a VOC	NO_x	CO	PM/ PM_{10} /b, /c	$PM_{2.5}$ /b	SO_2 /c	CO_2	CH_4	N_2O	Fuel Cons. (gal/hp-hr) /d
1	Category 2 engines	0.37	7.3	3.73	0.46	0.45	0.0010	515	0.067	0.015	0.050
2	Category 1 engines < 1000 kW	0.20	7.3	3.73	0.19	0.19	0.0010	515	0.067	0.015	0.050
3	Category 3 engines (MSD using MDO) (>30L/cyl.)	0.37	9.8	0.82	0.14	0.13	0.296	482	0.003	0.023	0.046
4	All Categories aux. engines (MSD using MDO)	0.30	10.4	0.82	0.14	0.13	0.316	515	0.003	0.023	0.049

/a Emission factors for Category 1 and 2 engines are from Table 3-8 and Category 3 engines are from Tables 2-9, 2-13, and 2-16 from ICF International report to the U.S. EPA, "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009 (converted from g/kW-hr to g/hp-hr by multiplying by 0.746 kW/hp). Assumed all Category 1 and 2 engines to be used for for CVOW are certified to meet EPA Tier 1 and 2 marine engine standards respectively (providing conservative estimate for Category 1 engines); therefore the Tier 1 and 2 emission factors in Table 3-8 from the ICF International report was used.

/b All PM is assumed to less than 10 µm in diameter; therefore, PM emission factor is equivalent to PM_{10} emission factor. $PM_{2.5}$ is estimated to be 97 % of PM_{10} per EPA guidance in "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition," EPA420-R-10-018/NR-009d, July 2010.

/c Emission factors for Category 1 and 2 engines for SO_2 and PM_{10} presented in Table 3-8 of the ICF report (ICF International 2009) are based on a fuel sulfur content of 1.5 percent. These factors were adjusted for the 15 ppmw sulfur content in ultra-low sulfur diesel fuel, by multiplying the emission factors by 0.001 and 0.86 for SO_2 and PM_{10}, respectively, following the approach used in Section 3.4.2 of the ICF Report.

/d Fuel consuption rate for category 1 and 2 marine engines was estimated based on CO_2 emission factor (g/hp-hr) and the emission factor for the mass of CO_2 generated per gallon of fuel (10.21 kg CO_2/gal fuel) as presented in Table A-1 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016. Fuel consumption for Category 3 marine engines was based on the BSFC (g/kW-hr) in the ICF International report.

Land-based Nonroad Engines and Other Equipment

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hour) /a								Climate Leaders		NONROAD
	SCC	Description	Engine Size (hp)	Exhaust+ Crankcase VOC	Exhaust NO_x	Exhaust CO	Exhaust PM_{10}	Exhaust $PM_{2.5}$	Exhaust SO_2	Exhaust CO_2	Exhaust CH_4	Exhaust N_2O	Fuel Consumption gal/hp-hr /c	Default Load Factor
	Construction & Mining Subcategory (*002*)													
101	2270002015	Diesel Rollers	175 < HP <= 300	0.17	0.95	0.30	0.05	0.05	0.003	536	0.014	0.014	0.053	59%
103	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.27	2.86	0.68	0.14	0.14	0.003	530	0.013	0.014	0.052	43%
106	2270002036	Diesel Excavators	175 < HP <= 300	0.16	0.53	0.17	0.02	0.02	0.003	536	0.013	0.014	0.053	59%
109	2270002042	Diesel Cement & Mortar Mixers	75 < HP <= 100	0.41	3.41	1.82	0.30	0.29	0.004	589	0.015	0.015	0.058	43%
111	2270002045	Diesel Cranes	175 < HP <= 300	0.17	1.02	0.22	0.04	0.04	0.003	531	0.014	0.014	0.052	43%
117	2270002081	Diesel Other Construction Equipme	75 < HP <= 100	0.22	1.69	1.65	0.21	0.20	0.003	596	0.016	0.015	0.058	59%
	Industrial Equipment Subcategory (*003*)													
120	2270003040	Diesel Other General Industrial Eqp	175 < HP <= 300	0.18	1.22	0.27	0.05	0.05	0.003	531	0.014	0.014	0.052	43%
	Commercial Equipment Subcategory (*006*)													
124	2270006005	Diesel Generator Sets	175 < HP <= 300	0.28	2.89	0.73	0.15	0.14	0.003	530	0.013	0.014	0.052	43%
125	2270006005	Diesel Generator Sets	300 < HP <= 600	0.24	2.88	0.83	0.12	0.11	0.003	530	0.012	0.014	0.052	43%
126	2270006005	Diesel Generator Sets **/d**	750 < HP <= 1200	0.17	4.10	0.76	0.13	0.13	0.005	531	0.029	0.013	0.052	43%
127	2270006010	Diesel Pumps	75 < HP <= 100	0.41	3.24	1.82	0.32	0.31	0.004	590	0.016	0.015	0.058	43%
130	2270006015	Diesel Air Compressors	175 < HP <= 300	0.18	1.34	0.30	0.06	0.06	0.003	531	0.014	0.014	0.052	43%

/a Emission factors for the land-based nonroad engines were estimated using EPA's MOVES2014a emission model for the anticipated construction year of 2020.

/b Emission factors for N_2O are based on Table B-8 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016. (0.57 g CH4/gal fuel and 0.26 g N2O/gal fuel, respectively)

/c Fuel consumption for each type of equipment was estimated based on CO2 emission factor (g/hp-hr) generated from the MOVES2014a model and the emission factor for the mass of CO2 generated per gallon of fuel (10.21 kg CO_2/gal fuel) as presented in Table A-1 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016.

On-road Vehicles

		MOVES2014a Emission factors in lb/VMT /a VOC	NO_x	CO	PM_{10}	PM2.5	SO_2	HAP	CO_2	CH_4	N_2O	CO2e	mi/gal
150	Light-Duty Gasoline Vehicles (LDGV)	0.00138	0.00215	0.02325	0.00006	0.00005	0.00005	0.00039	2.750	0.00005	0.000056	2.757	24.1
151	Light-Duty Gasoline Trucks (< 3 ton)	0.00232	0.00433	0.03745	0.00007	0.00006	0.00007	0.00066	3.683	0.00011	0.000093	3.696	21
152	Single-Unit Short-haul Truck	0.00402	0.01557	0.04561	0.00030	0.00027	0.00007	0.00132	8.526	0.00285	0.000107	8.553	7

/a Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014a model and inputs for calendar year 2020 using the latest input files for calendar year 2014 from Virgnia Department of Environmental Quality.

Helicopters

	Helicopter Type	Default Speed (mph	Emission Factors (lb/hr) /a VOC	NO_x	CO	PM/PM10	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	Fuel Use (gal/hr)
161	Single	157.5	1.89	2.32	0.07	0.07	0.07	0.3	956.92	0.03	0.03	45.36
162	Twin Light	177	4.3	3.1	0.10	0.09	0.09	0.5	1589.69	0.04	0.05	75.35
163	Twin Medium	182.6	3.5	7.2	0.20	0.20	0.20	0.78	2459.92	0.1	0.1	116.59
164	Twin Heavy	188.2	2.67	34.66	0.82	0.80	0.80	2.11	6640.46	0.19	0.22	314.74

/a Emission factors for VOC, NOx, CO, PM, SO2, CO2, CH4, and N2O are from "BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation,"OCS Study BOEM 2017-079, August 1, 2017 (https://www.boem.gov/Technical-Documentation-stakeholder/). Table 4 in this document provides default emission factors and gal/hr fuel consumption rates based on helicopter type. Table 9 provides default speeds based on helicopter type.

CVOW
EPA NEI HAP emission factors for Commercial Marine Vessels

HAP emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2011) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM10, PM2.5, or VOC emissions from the CMVs.

CMV fuel type			Diesel (distillate)		Residual			
Operating description			In Port	Underway	In Port		Underway	
SCC code			2280002100	2280002200	2280003100		2280003200	
Type			Maneuvering	Cruising	Manuevering	Hotelling	Cruising	Reduced Speed Zone
Type Code			M	C	M	H	C	Z
Pollutant	HAP?*	Fraction of						
Ammonia	No	PM10	0.01	0.02	0.00238	0.0108	0.00477	0.00477
Arsenic	Yes	PM10	0.0000175	0.00003	8.74126E-05	0.0004	0.000174825	0.000174825
Benzo[a]Pyrene	Yes	PM10	0.0000025	0.000005	4.37063E-07	0.000002	8.74126E-07	8.74126E-07
Benzo[b]Fluoranthene	Yes	PM10	0.000005	0.00001	8.74126E-07	0.000004	1.74825E-06	1.74825E-06
Benzo[k]Fluoranthene	Yes	PM10	0.0000025	0.000005	4.37063E-07	0.000002	8.74126E-07	8.74126E-07
Beryllium	Yes	PM10			0.000000546	0.000000546	0.000000546	0.000000546
Cadmium	Yes	PM10	0.00000283	0.00000515	0.0000226	0.0000059	0.0000226	0.0000226
Chromium (VI)	Yes	PM10	0.0000085	0.000017	0.00006528	0.000204	0.00006528	0.00006528
Chromium III	Yes	PM10	0.0000165	0.000033	0.00012672	0.000396	0.00012672	0.00012672
Cobalt	Yes	PM10			5.94406E-05	0.000292	0.000153846	0.000153846
Hexachlorobenzene	Yes	PM10	0.00000002	0.00000004	3.4965E-09	0.000000016	6.99301E-09	6.99301E-09
Indeno[1,2,3-c,d]Pyrene	Yes	PM10	0.000005	0.00001	8.74126E-07	0.000004	1.74825E-06	1.74825E-06
Lead	Yes	PM10	0.000075	0.00015	1.39642E-05	0.00006	0.0000262	0.0000262
Manganese	Yes	PM10	0.00000153	0.000001275	0.0000573	0.0000573	0.0000573	0.0000573
Mercury	Yes	PM10	0.000000025	0.00000005	2.7076E-07	0.0000014	5.24476E-07	5.24476E-07
Nickel	Yes	PM10	0.0005	0.001	0.003250219	0.0154	0.00589	0.00589
Phosphorus	Yes**	PM10			0.001787587	0.00438	0.005734266	0.005734266
Polychlorinated Biphenyls	Yes	PM10	0.00000025	0.0000005	4.37063E-08	0.0000002	8.74126E-08	8.74126E-08
Selenium	Yes	PM10	2.83E-08	5.15E-08	1.9125E-06	0.00000908	0.00000348	0.00000348
Total HAP (ratioed to PM10)			**0.0006**	**0.0013**	**0.0055**	**0.0212**	**0.0123**	**0.0123**
Acenaphthene	Yes	PM2.5	0.000018	0.000015	0.00000034	0.00000034	0.00000034	0.00000034
Acenaphthylene	Yes	PM2.5	0.00002775	0.000023125	0.000000525	0.000000525	0.000000525	0.000000525
Anthracene	Yes	PM2.5	0.00002775	0.000023125	0.000000525	0.000000525	0.000000525	0.000000525
Benz[a]Anthracene	Yes	PM2.5	0.00003	0.000025	0.000000567	0.000000567	0.000000567	0.000000567
Benzo[g,h,i,]Perylene	Yes	PM2.5	0.00000675	0.000005625	0.000000128	0.000000128	0.000000128	0.000000128
Chrysene	Yes	PM2.5	0.00000525	0.000004375	9.93E-08	9.93E-08	9.93E-08	9.93E-08
Fluoranthene	Yes	PM2.5	0.0000165	0.00001375	0.000000312	0.000000312	0.000000312	0.000000312
Fluorene	Yes	PM2.5	0.00003675	0.000030625	0.000000695	0.000000695	0.000000695	0.000000695
Naphthalene	Yes	PM2.5	0.00105075	0.000875625	0.0000199	0.0000199	0.0000199	0.0000199
Phenanthrene	Yes	PM2.5	0.000042	0.000035	0.000000794	0.000000794	0.000000794	0.000000794
Pyrene	Yes	PM2.5	0.00002925	0.000024375	0.000000553	0.000000553	0.000000553	0.000000553
Total HAP (ratioed to PM2.5)			**0.0013**	**0.0011**	**0.000024**	**0.000024**	**0.000024**	**0.000024**
2,2,4-Trimethylpentane	Yes	VOC	0.0003	0.00025	NA	NA	NA	NA
Acetaldehyde	Yes	VOC	0.0557235	0.04643625	0.000229	0.000229	0.000229	0.000229
Acrolein	Yes	VOC	0.002625	0.0021875	NA	NA	NA	NA
Benzene	Yes	VOC	0.015258	0.012715	0.0000098	0.0000098	0.0000098	0.0000098
Ethyl Benzene	Yes	VOC	0.0015	0.00125	NA	NA	NA	NA
Formaldehyde	Yes	VOC	0.1122	0.0935	0.00157	0.00157	0.00157	0.00157
Hexane	Yes	VOC	0.004125	0.0034375	NA	NA	NA	NA
Propionaldehyde	Yes	VOC	0.004575	0.0038125	NA	NA	NA	NA
Styrene	Yes	VOC	0.001575	0.0013125	NA	NA	NA	NA
Toluene	Yes	VOC	0.0024	0.002	NA	NA	NA	NA
Xylenes (Mixed Isomers)	Yes	VOC	0.0036	0.003	NA	NA	NA	NA
Total HAP (ratioed to VOC)			**0.2039**	**0.1699**	**0.0018**	**0.0018**	**0.0018**	**0.0018**

*For completeness, all of the pollutants in EPA's database are shown, but not all are HAP as defined in Section 112 of the Clean Air Act and as updated in 40 CFR 63 Subpart C.
**Only elemental phosphorus (CAS #7723140) is a HAP; phosphorus-containing compounds in general are not.

Reference: US EPA, "2011 National Emissions Inventory, version 1, Technical Support Document", draft, November 2013, available from http://www.epa.gov/ttn/chief/net/2011nei/2011_neiv1_tsd_draft.pdf; Table 104 on pp. 178-179 refers to the dataset "2011EPA_HAP-Augmentation" for HAP emissions, which is available from ftp://ftp.epa.gov/EmisInventory/2011/doc; the factors above are from that dataset.

CVOW
HAP Emission Factor Calculation Sheet
Small Diesel Engines

Pollutant	Emission Factor (lb/MMBtu)[a]	Emission Factor Rating	Source (AP-42 Table)	
Organic Compounds				
Benzene[b]	9.33E-04	E	3.3-2	
Toluene[b]	4.09E-04	E	3.3-2	
Xylene[b]	2.85E-04	E	3.3-2	
1,3 Butadiene	< 3.91E-05	E	3.3-2	
Propylene	2.58E-03	E	3.3-2	
Formaldehyde[b]	1.18E-03	E	3.3-2	
Acetaldehyde[b]	7.67E-04	E	3.3-2	
Acrolein[b]	< 9.25E-05	E	3.3-2	
PAH				
Naphthalene[b]	8.48E-05	E	3.3-2	
Acenaphthylene[b]	< 5.06E-05	E	3.3-2	
Acenaphthene[b]	< 1.42E-06	E	3.3-2	
Fluorene[b]	2.92E-05	E	3.3-2	
Phenanthrene[b]	2.94E-05	E	3.3-2	
Anthracene[b]	1.87E-06	E	3.3-2	
Fluoranthene[b]	7.61E-06	E	3.3-2	
Pyrene[b]	4.78E-06	E	3.3-2	
Benzo(a)anthracene[b]	1.68E-06	E	3.3-2	
Chrysene[b]	3.53E-07	E	3.3-2	
Benzo(b)fluoranthene[b]	< 9.91E-08	E	3.3-2	
Benzo(k)fluoranthene[b]	< 1.55E-07	E	3.3-2	
Benzo(a)pyrene[b]	< 1.88E-07	E	3.3-2	
Indeno(1,2,3-cd)pyrene[b]	< 3.75E-07	E	3.3-2	
Dibenz(a,h)anthracene[b]	< 5.83E-07	E	3.3-2	
Benzo(g,h,i)perylene[b]	< 4.89E-07	E	3.3-2	
TOTAL PAH	1.68E-04	E	3.3-2	
Metals and inorganics[c]				
Arsenic[b]	4.62E-08			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Cadmium[b]	5.13E-09			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Chromium[b]	1.24E-05			Based on average ppb by weight in fuel in Rising et al. 2004
Chromium VI[b]	2.24E-06			18% of value for chromium
Lead[b]	7.69E-07			Based on average ppb by weight in fuel in Rising et al. 2004
Mercury[b]	1.03E-08			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Nickel[b]	1.48E-06			Based on average ppb by weight in fuel in Rising et al. 2004
Selenium[b]	2.56E-07			Based on ppb by weight in fuel detection limit in Rising et al. 2004

Total for substances identified as HAP[e]	< 3.9E-03

CVOW
HAP Emission Factor Calculation Sheet
Large Stationary Diesel Engines

Pollutant		Emission Factor (lb/MMBtu)[a]	Emission Factor Rating	Source (AP-42 Table)	
Organic Compounds					
Benzene[b]		7.76E-04	E	3.4-3	
Toluene[b]		2.81E-04	E	3.4-3	
Xylene[b]		1.93E-04	E	3.4-3	
Methane		8.10E-03	E	3.4-1	
Propylene		2.79E-03	E	3.4-3	
Formaldehyde[b]		7.89E-05	E	3.4-3	
Acetaldehyde[b]		2.52E-05	E	3.4-3	
Acrolein[b]		7.88E-06	E	3.4-3	
PAH					
Naphthalene[b]		1.30E-04	E	3.4-4	
Acenaphthylene[b]		9.23E-06	E	3.4-4	
Acenaphthene[b]		4.68E-06	E	3.4-4	
Fluorene[b]		1.28E-05	E	3.4-4	
Phenanthrene[b]		4.08E-05	E	3.4-4	
Anthracene[b]		1.23E-06	E	3.4-4	
Fluoranthene[b]		4.03E-06	E	3.4-4	
Pyrene[b]		3.71E-06	E	3.4-4	
Benz(a)anthracene[b]		6.22E-07	E	3.4-4	
Chrysene[b]		1.53E-06	E	3.4-4	
Benzo(b)fluoranthene[b]		1.11E-06	E	3.4-4	
Benzo(k)fluoranthene[b]	<	2.18E-07	E	3.4-4	
Benzo(a)pyrene[b]	<	2.57E-07	E	3.4-4	
Indeno(1,2,3-cd)pyrene[b]	<	4.14E-07	E	3.4-4	
Dibenz(a,h)anthracene[b]	<	3.46E-07	E	3.4-4	
Benzo(g,h,i)perylene[b]	<	5.56E-07	E	3.4-4	
TOTAL PAH	<	2.12E-04	E	3.4-4	
Metals and inorganics[c]					
Arsenic[b]		**4.62E-08**			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Cadmium[b]		**5.13E-09**			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Chromium[b]		**1.24E-05**			Based on average ppb by weight in fuel in Rising et al. 2004
Chromium VI[b]		**2.24E-06**			18% of value for chromium
Lead[b]		**7.69E-07**			Based on average ppb by weight in fuel in Rising et al. 2004
Mercury[b]		**1.03E-08**			Based on ppb by weight in fuel detection limit in Rising et al. 2004
Nickel[b]		**1.48E-06**			Based on average ppb by weight in fuel in Rising et al. 2004
Selenium[b]		**2.56E-07**			Based on ppb by weight in fuel detection limit in Rising et al. 2004

Total for substances identified as HAP[e]	**<**	**1.6E-03**

Discussion: The emission factors for individual organic compounds shown at the right are from the U.S. Environmental Protection Agency (EPA), "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources" (AP-42), Section 3.4 for "Large Stationary Diesel and All Stationary Dual-fuel Engines", rev. 10/96. Emission factors prefaced with a "<" are based on method detection limits.

Section 3.4 of AP-42 does not provide emission factors for metals and inorganics from diesel engines. Metal emission factors shown here are from Section 1.3 of AP-42, for No. 6 fuel oil.

[a] Factors should be converted from lb/10^6 scf to lb/MMBtu (HHV) by dividing by 1,020 Btu/scf, as per EPA. Numbers preceded by "<" are based on method detection limits.

[b] Specifically listed as a "Hazardous Air Pollutant" (HAP) in the Clean Air Act, or a component of Polycyclic Organic Matter, which is also listed as a HAP.

[c] Emission factors were converted from AP-42 units (lb/1000 gal) to lb/MMBtu by dividing by a heat content of 150 MMBtu/1000 gal.

[d] Chloride and fluoride are included in the HAP total, based on the assumption that the predominant forms emitted are hydrogen chloride and hydrogen fluoride (both of which are listed HAP).

[e] Total calculated using the TOTAL PAH emission factor instead of factors for individual PAH.

[f.] Metal emissions are based on the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels,* 11th Annual International Petroleum Conference, Oct 12-15, 2004. Where trace metals were detected in any of 13 samples, the average result is used. Where no metals were detected in any of 13 samples, the detection limit is used.

[g.] Hexavalent chrome was not detected in any fuel oil samples (in the note f reference study). However, to allow for potential hex chrome emissions formed during combustion, 18% of the total chrome emissions were assumed to be hex chrome (per EPA 453/R-98-004a)

CVOW
EPA NEI HAP emission factors for Nonroad Diesels

HAP emission factors for nonroad diesels (below) were obtained from Eastern Research Group, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003 (available from ftp://ftp.epa.gov/pub/EmisInventory/finalnei99ver3/criteria/documentation/nonroad/99nonroad_vol1_oct2003.pdf), Appendix D, Tables D-1 through D-3.

Pollutant	Fraction of	Emissions Factor %
1,3-butadiene	VOC - Exhaust	0.0018616
formaldehyde	VOC	0.11815
benzene	VOC	0.020344
acetaldehyde	VOC	0.05308
ethylbenzene	VOC - Exhaust	0.0031001
styrene	VOC - Exhaust	0.00059448
acrolein	VOC	0.00303
toluene	VOC	0.014967
hexane	VOC	0.0015913
propionaldehyde	VOC	0.011815
2,2,4-trimethylpentane	VOC	0.000719235
2,3,7,8-TCDD TEQ **	tons TEQ/gal	1.90705E-14
xylenes	VOC	0.010582
Total HAP (ratioed to VOC)		**0.239834715**
PAH		
benz[a]anthracene	PM10	0.0000071
benzo[a]pyrene	PM10	0.00000035
benzo[b]fluoranthene	PM10	0.00000049
benzo[k]fluoranthene	PM10	0.00000035
chrysene	PM10	0.0000019
dibenzo[a,h]anthracene	PM10	2.9E-09
indeno[1,2,3-c,d]pyrene	PM10	0.000000079
acenaphthene	PM10	0.0001
acenaphthylene	PM10	0.000084
anthracene	PM10	0.00000043
benzo[g,h,i]perylene	PM10	0.00000019
fluoranthene	PM10	0.000017
fluorene	PM10	0.0001
naphthalene	PM10	0.00046
phenanthrene	PM10	0.00026
pyrene	PM10	0.0000029
Total HAP (ratioed to PM10)		**0.001034792**
chromium	ug/bhp-hr	0.03
manganese	ug/bhp-hr	1.37
nickel	ug/bhp-hr	2.035
Total HAP (Metals ug/bhp-hr)		**3.435**

** Note: the emission rate for 2,3,7,8-TCDD TEQ is significantly lower than any other HAP and therefore, was not factored into the total HAP emission factor.

Attachment 13

Vessel in Distress Requirement Waiver Request
(RAP Section 4.17.2.2 and 4.18.7)

Ørsted

Memo

Subject	VCW01 - Emergency Boat Tie-Off	15 December 2017
To	Dominion Energy / US Coast Guard	
Copy	-	
From	VCW01 Orsted Project Team	
Regarding	Emergency Boat Tie-Off	

Our ref. JMOIO
Document 2989534
Case 200-17-3483

Recommendation to omit pleasure craft boat emergency tie-off

This memo has the objective of documenting the safety reasons associated to Orsted's recommendation for not to account for pleasure craft boats emergency tie-offs on Virginia Coastal Offshore Wind project (VCW01)'s foundations. This is in line with recommended operational practices in existing offshore wind farms in Europe.

- *Safety of unauthorized personnel and leisure vessel*

All access to offshore structures requires special training and use of appropriate fall arrest equipment. Climbing by unqualified or inappropriately equipped persons is not permitted. Aside from potential injuries and loss of human lives, any incidents could trigger liability discussions.

The foundation structure supports an offshore wind turbine (WTG) which has the purpose of producing power. Both the WTG and the inside of the TP are defined as electrical areas and can be accessed only by electrical qualified persons (i.e. electricians with an electrical competent person training), electrical instructed persons (e.g. mechanic or layman with electrical training) or layman without specific training but accompanied by a qualified person.

The existence of an emergency tie-off point could unintentionally convey the idea to the public that the structure could be approached in a safe manner and counteract its purpose. Furthermore, an attempt to access the structure could eventually compromise the safety of the leisure vessel itself.

- *Boat landing purpose and structural integrity*

The boat landing structure is designed for access by a Crew Transfer Vessel (CTV) with specific bow dimensions and height. The CTV makes use of its thrusters to push against the boat landing allowing for crew transfer. Accounting for additional attachment

Our ref. 2989534

points at the front of the boat landing could compromise its main purpose for normal CTV operations.

The boat landing is attached to a Transition Piece (TP) skirt, which is not designed as a primary but as a secondary structure. In other words, the loading from a typical approach is not directly transferred into the soil but up to the bolted connection between TP and Monopile. Any unforeseen additional loading conditions or damage to the TP skirt could compromise the integrity of the bolted connection.

A non-standard approach to the boat landing could lead to coating damages and dents on both the boat landing and the TP structure. This area of the foundation is designed for no repair work over the entire lifetime of 25 years, as offshore repair works in this zone would be dangerous and entail additional risk to the personnel involved.

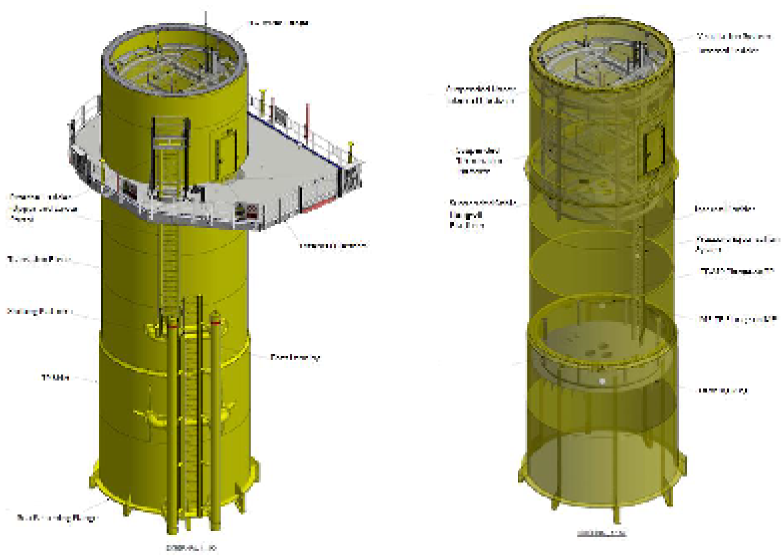

Figure 1 TP illustration (not VCW01-specific)