MAYFLOWER WIND

Prepared for:
Mayflower Wind Energy LLC

Outer Continental Shelf Permit – Revised Air Quality Modeling Protocol

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Acronyms and Abbreviations

Abbreviation or Acronym	Definition
AERCOARE	Meteorological data processor for the Coupled Ocean Atmosphere Response Experiment
AERMET	AERMOD Meteorological Preprocessor
AERMOD	AMS/EPA Regulatory Model
AERSURFACE	Surface characteristics tool
AQRV	Air Quality Related Values
AQS	USEPA's Air Data Air Quality System
ARM2	Ambient Ratio Method 2
BI	Block Island Buoy
BB	Buzzards Bay Buoy
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
CO	Carbon Monoxide
COA	Corresponding Onshore Area
COP	Construction and Operations Plan
CTV	Crew Transfer Vessel
EEZ	Exclusive Economic Zone
ESRL	Earth System Research Laboratories
ft	feet
GBS	Gravity-Based Structure
hr	hour
ISO-NE	ISO New England Inc.
K	degrees Kelvin
km	kilometer
km^2	square kilometers
KMVY	Martha's Vineyard Airport
kW	kilowatts
MA	Massachusetts
MassDEP	Massachusetts Departments of Environmental Protection
$\mu g/m^3$	Microgram per cubic meter
m	meter
m/s	meters per second
mb	milibars
MERPs	Modeled Emission Rates for Precursors

Abbreviation or Acronym	Definition
MET	meteorological data
mi	mile
MIXHGT	meteorological preprocessor program
mph	miles per hour
MMIF	Mesoscale Model Interface Program
MPCA	Minnesota Pollution Control Agency
MVA	megavolt ampere
NAAQS	National Ambient Air Quality Standards
NCEI	National Centers for Environmental Information
NHDES	New Hampshire Department of Environmental Services
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NO_2	Nitrogen Dioxide
NOI	Notice of Intent
NO_X	Nitrogen Oxides
NNSR	Non-Attainment New Source Review
NSR	New Source Review
NWS	National Weather Service
NY	New York
O&M	Operations and Maintenance
O_3	Ozone
OCD	Offshore and Coastal Dispersion Model
OCS	Outer Continental Shelf
OEM	Original Equipment Manufacturer
OLM	Ozone Limiting Method
O&M	Operations and Maintenance
OSP	Offshore Substation Platform
Pb	Lead
PCRAMMET	meteorological preprocessor program
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
POI	point of interconnection
PSD	Prevention of Significant Deterioration
PVMRM	Plume Volume Molar Ratio Method
R^2	Coefficient of determination
RI	Rhode Island
RIDEM	Rhode Island Department of Environmental Management

Abbreviation or Acronym	Definition
RMSE	Root Mean Square Error
SFW	South Fork Wind
SIA	Significant Impact Area
SIL	Significant Impact Level
SO_2	Sulfur Dioxide
TP	Transfer Piece
tpy	tons per year
ULSD	Ultra-Low Sulfur Diesel Fuel
USC	United States Code
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VW	Vineyard Wind
VOC	Volatile Organic Compound
W/m^2	watts per square meter
WRF	Weather Research and Forecast Model
WTG	Wind Turbine Generator

1.0 Introduction

Mayflower Wind Energy LLC (Mayflower Wind) proposes an offshore wind renewable energy generation project (the Project) located in federal waters off the southern coast of Massachusetts in the Outer Continental Shelf (OCS) Lease Area OCS-A 0521 (Lease Area). The Project will deliver electricity to the regionally administered transmission system via export cables with a sea-to-shore transitions in Falmouth and Somerset, Massachusetts and onshore transmission system extending to the anticipated points of interconnection (POIs) in Massachusetts. The Mayflower Wind Project Lease Area is 127,388 acres (515 square kilometers [km^2]) and is located approximately 26 nautical miles (nm) (48 kilometers [km]) south of the island of Martha's Vineyard and 20 nm (37 km) south of Nantucket (Figure 1-1).

Mayflower Wind is required to submit an OCS Air Permit application that includes a demonstration through dispersion modeling that air emissions from the Project will not cause or contribute to an exceedance of the National Ambient Air Quality Standards (NAAQS). The NAAQS are established for six pollutants designated by the United States Environmental Protection Agency (USEPA) as "criteria pollutants". The criteria pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2). PM is characterized according to size; PM having an effective aerodynamic diameter of 10 microns or less is referred to as PM_{10}, or "respirable particulate." PM having an effective aerodynamic diameter of 2.5 microns or less is referred to as $PM_{2.5}$, or "fine particulate"; $PM_{2.5}$ is a subset of PM_{10}.

It is expected that the Project will be subject to Prevention of Significant Deterioration (PSD) review with emissions exceeding the major source threshold of 250 tons per year (tpy). As such, modeled concentrations due to the Project will also need to demonstrate compliance with PSD Increments that have been established for NO_2, $PM_{2.5}$, PM_{10}, and SO_2.

1.1 Goals and Objectives

This modeling protocol has been prepared in support of Mayflower Wind's OCS Air Permit application to describe the methodologies that will be used to conduct dispersion modeling of the Project's associated air emissions. Emissions from both the construction phase as well as the operations and maintenance (O&M) phase will be addressed. The emission sources and operational scenarios that will be modeled will be described and preliminary emissions estimates will be quantified. Note that final emissions estimates will be provided in the OCS Air Permit application. With approval from USEPA Region 1, this modeling protocol would serve as a guide for conducting the dispersion modeling analysis that will be submitted with the OCS Air Permit application.

1.2 Report Organization

This protocol document consists of six sections. Section 1 provides an introduction. Section 2 contains a Project description, including information regarding the emission sources associated with both the construction and O&M phases. Section 3 describes the applicable regulatory requirements. Section 4 provides a detailed description of the modeling approach that will be used in evaluating air quality impacts of the Project. Section 5 describes how the modeling results will be presented, and Section 6 documents the references that were used in preparing this document.

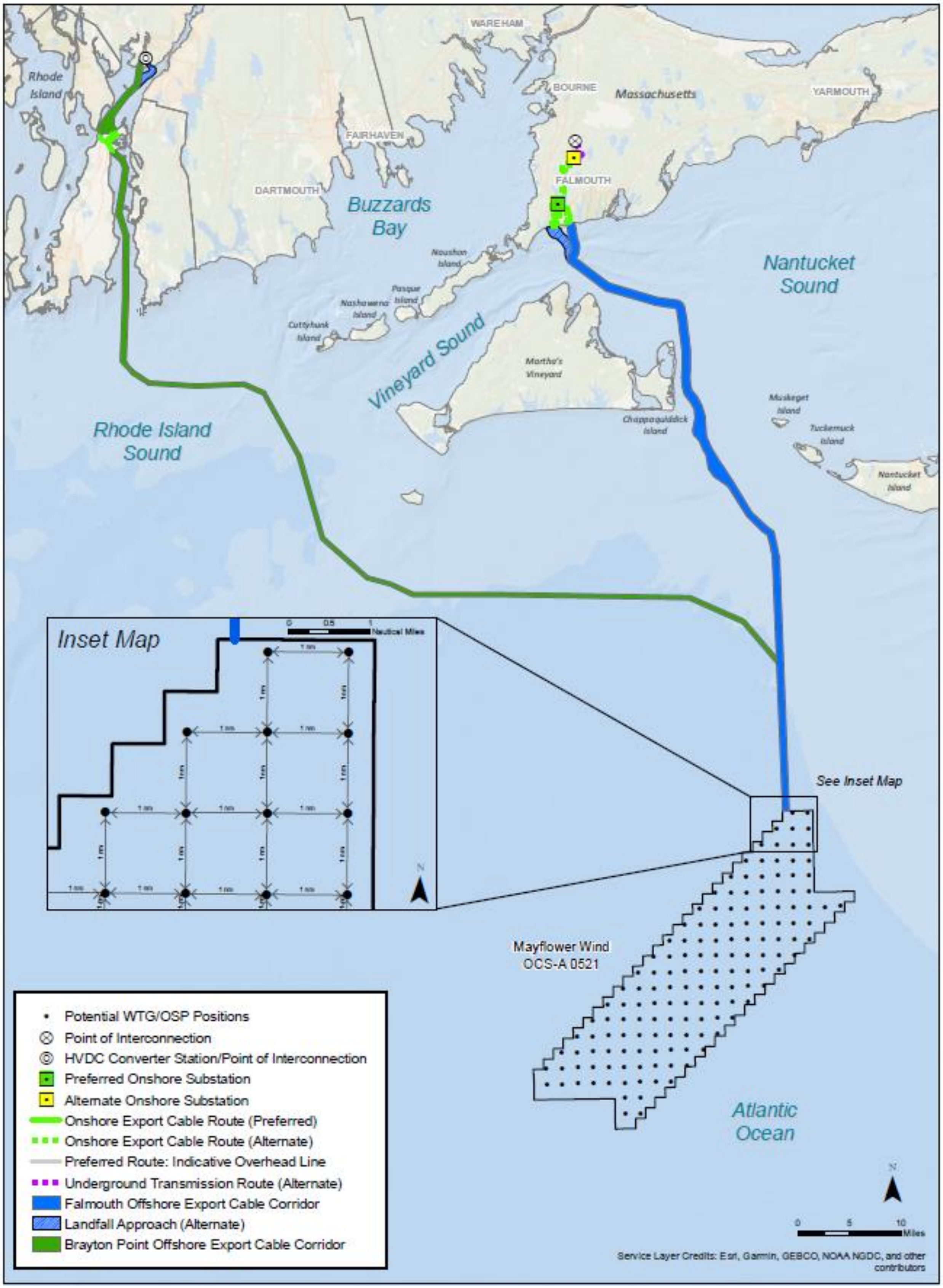


Figure 1-1. Location of Mayflower Wind Renewable Energy Generation Project

2.0 Project Description

2.1 Project Overview

The Project will include up to 149 positions in the Lease Area to be occupied by up to 147 wind turbine generators (WTGs) and up to 5 offshore substation platforms (OSPs). The 149 positions will conform to a 1.0 nm x 1.0 nm (1.9 km x 1.9 km) grid layout with an east-west and north-south orientation. WTGs and OSPs will be connected via inter-array cables within the Lease Area. The Project will also include two export cable corridors, one making landfall and interconnecting to the ISO New England Inc. (ISO-NE) grid in Falmouth, Massachusetts, and one making landfall and interconnecting to the ISO-NE grid at Brayton Point, in Somerset, Massachusetts.

Construction will occur in two stages, referred to as Project 1 and Project 2. An indicative construction schedule that depicts the current conservative estimates for when Project 1 and Project 2 components will be installed is provided in Figure 2-1. Project 1 is anticipated to be located in the northern portion of the Lease Area and will be ~1200 MW in size. The power generated from this Project will be delivered to Brayton Point in Somerset, Massachusetts and will fulfill the first two Power Purchase Agreements that Mayflower Wind has with the state of Massachusetts. Project 2 is anticipated to be located in the southern portion of the Lease Area and will also be ~1,200 MW in size. The power generated from Project 2 is intended to be delivered to Falmouth, Massachusetts.

Mayflower Wind's lease term for the operational phase is 33 years. Offshore construction activities will start with seabed preparations. This may involve scour protection installation, although scour protection may be placed either prior to or after OSP and Substructure installation, depending on the requirements of each substructure type. Installation of substructures will be the next installation activity. The export cables and/or inter-array cables will be pulled into the OSPs and / or WTGs and will be tested prior to energization. The OSP topsides could be installed immediately after the OSP foundation(s) are installed or could be installed after the export cable and/or inter-array cables are pulled into the OSPs. Inter-array cable installation typically begins after the offshore export cable installation commences, but the order of installation will be finalized before construction commences. WTG installation and commissioning are expected to be the final offshore construction activities.

Mayflower Wind will execute planned and unplanned maintenance activities during the life of the proposed Project. Tasks will have a frequency recommended such as quarterly, annually, every 3 years, etc. based on industry best practices and OEM recommendations. The Mayflower Wind O&M strategy addresses maintenance of primary components including WTGs, OSPs, substructures, inter-array and export cables, and onshore substation/converter station. Planned maintenance including predictive, preventive, and corrective maintenance are key features of the O&M plan, as well as preparation for major repairs, retrofitting, inventory, and spare parts management. Unplanned maintenance includes any unscheduled repair or replacement which may become necessary. The Mayflower Wind O&M team will utilize remote monitoring systems to detect failures needing repair and will schedule maintenance activities as necessary. In some instances, heavy-lift vessels are required to replace damaged or degraded major components.

2.2 Project Emission Sources

Emissions from equipment used during construction and O&M activities will come mainly from combustion engines used to power main and auxiliary vessel engines as well as additional auxiliary equipment.

Table 2-1 provides a summary of the Project emission sources that will support both the construction and O&M phases of the Project.

Figure 2-1. Indicative Construction Schedule

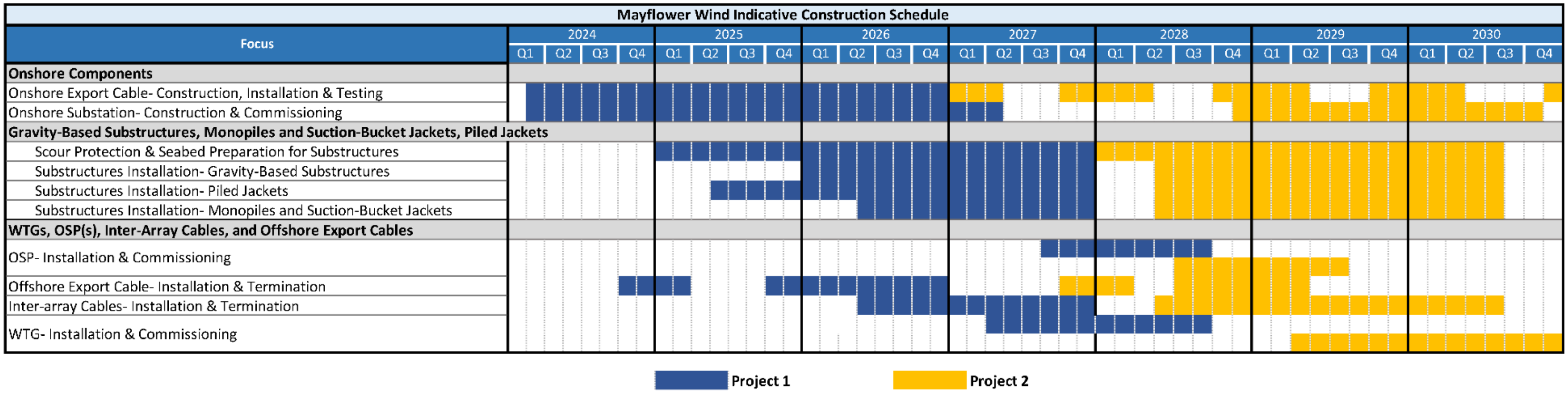


Table 2-1. Description of Project Emission Sources

Emission Source	Phase	Description
Anchor handling tug supply vessels	Construction/ O&M	General support during offshore export cable installation and maintenance.
Cable installation vessels	Construction/ O&M	Lay and bury export and inter-array cables in the seafloor.
Crew transfer/service vessels	Construction/ O&M	Transport crew and equipment to/from the Project site
Dredging vessels	Construction/ O&M	Used in certain areas prior to cable laying to remove the upper portions of sand waves.
Heavy lift crane vessels	Construction/ O&M	Lift, support, and orient substructures during installation. Lift, support, and orient the components of WTGs and OSPs during installation. Can also be used for major repairs during O&M.
Heavy transport vessels	Construction/ O&M	Transport WTG and OSP components from overseas to the construction or operations staging area.
Jack-up vessels	Construction/ O&M	Extends legs to the sea floor to lift vessel out of the water for stability during transfer/installation/major replacement of foundation and/or WTG components, vessel type could also be used for accommodation vessel.
Multi-purpose support vessels	Construction/ O&M	Clear the seabed floor of debris prior to laying export and inter-array cables general support. Install bubble curtains for noise mitigation. General support during various construction and O&M activities.
Scour protection installation vessels	Construction/ O&M	Deposit a layer of stone around the WTG substructures to prevent the removal of sediment by hydrodynamic forces. Also used in scour protection repair during O&M.
Survey vessels	Construction/ O&M	Used to perform site characterization surveys and pre/post-installation and operational inspections and surveys.
Tugboats	Construction/ O&M	Transport equipment and barges to the Lease Area, if required. General support during various construction and O&M activities.
Pile driving hammer	Construction	Drives the monopile foundations and pin piles for the WTGs and OSPs into the seafloor.
Air compressors	Construction	Supply compressed air to noise mitigation devices.
Temporary diesel generators	Construction/ O&M	Temporarily supply power to a WTG prior to the WTG commissioning into the integrated power system to the OSPs and grid. Supply power to the temporary vessel equipment, if needed. Periodic testing of back-up power during O&M.
Helicopters and Airplanes	Construction/ O&M	Transport crew and equipment to the Lease Area. Emergency support. Will be used sparingly.

3.0 Regulatory Requirements

In accordance with Section 328(a) of the Clean Air Act, Title 40 Part 55 of USEPA's Code of Federal Regulations (CFR) (40 CFR 55) establishes air pollution control requirements for OCS sources including an OCS Air Permit process that regulates some air emissions from the Project. OCS sources located within 25 nm (46 km) of States' seaward boundaries are subject to all requirements of this part. Per 40 CFR 55.2, an OCS source is defined as "any equipment, activity, or facility which:

1. Emits or has the potential to emit any air pollutant;
2. Is regulated or authorized under the Outer Continental Shelf Lands Act (OCSLA) (43 United States Code [USC] 1331 et seq.); and
3. Is located on the OCS or in or on waters above the OCS."

The Mayflower Wind Project meets the OCS source criteria. Applicable regulations at 40 CFR 55.13 and 55.14 outline federal, state, and local requirements of the Corresponding Onshore Area (COA), to which OCS sources located within 25 nm (46 km) of a states' seaward boundary are subject. After a Notice of Intent (NOI) is submitted for the Project, 40 CFR 55.5 requires the EPA to designate the COA. Mayflower Wind submitted a NOI for the Project to the USEPA Regional Office, the Massachusetts Department of Environmental Protection (MassDEP), the Rhode Island Department of Environmental Management (RIDEM) Office of Air Resources, and the New Hampshire Department of Environmental Services (NHDES) Air Resources Division on May 31, 2022. While not yet designated, it is anticipated that USEPA will select Massachusetts as the COA. That being the case, the Project's OCS sources will be required to comply with the applicable Massachusetts air quality regulations which include PSD Review for those pollutants that exceed certain thresholds as described below.

3.1 Prevention of Significant Deterioration Review

OCS Air Regulations 40 CFR 55.13(d) specify that the federal PSD program (codified under 40 CFR 52.21) applies to OCS sources located within 25 miles of a State's seaward boundary if those regulations are in effect in the COA. Massachusetts regulation 310 CMR 7.02(5)(d) incorporates the PSD program by reference. 40 CFR 52.21 specifies that new "major" stationary sources of air contaminants located in areas in attainment with air quality standards are subject to the PSD program. Major sources located in "non-attainment" areas are subject to Non-Attainment New Source Review (NNSR). The nearest onshore area (NOA) is Dukes County, MA which is designated as attainment/unclassified for all criteria pollutants with the exception of O_3. Thus, all pollutants with the exception of O_3 precursor VOC, are evaluated under the PSD program. NO_X is evaluated under both the PSD program (the area is classified as attainment for nitrogen dioxide, "NO_2") and the NNSR program (since it is also an O_3 precursor compound). NNSR requirements include offsets (NO_X in this case) instead of an ambient impact analysis to comply with the NAAQS for O_3.

The Mayflower Wind Project meets the definition of a "major" source because it has the potential-to-emit (PTE) at least 250 tpy of any criteria pollutant. Potential air emissions must include emissions from OCS sources, vessels while within the Lease Area, and vessels traveling to and from the Lease Area when within 25 nm (46 km) of the Lease Area's centroid (hereafter referred to as the "OCS permit area"). Table 3-1 summarizes the Project's preliminary potential emissions and presents a comparison to PSD significant emission thresholds. Note that these emissions are based on the most up-to-date Project design assumptions available as of the submission of this document. Actual emissions may differ as the Project design progresses. The potential emissions correspond to the Project 1 construction phase, assuming all emissions occur in one year. This is highly conservative since Project 1 will realistically span multiple years as shown in Figure 2-1. The O&M phase will result in far lower annual emissions, and thus was not used for the comparison.

The evaluation in Table 3-1 indicates that PSD review is triggered for CO, NO_X, CO, PM_{10}, PM_{25}, and SO_2. In accordance with 40 CFR 52.21(k), an ambient air quality analysis (source impact analysis) using dispersion modeling is required for these pollutants to demonstrate the Project does not cause or contribute to the exceedance of any applicable air quality standards or PSD increments.

Table 3-1. PSD Regulatory Threshold Evaluation

Pollutant	Project Potential Emissions from Worst-Case Construction Year(1) (tpy)	PSD Significant Emissions Threshold (tpy)	PSD Applies? (Yes/No)
CO	1,795	100	Yes
NO_X	8,858	40	Yes
Pb	0.04	0.6	No
PM_{10}	258	15	Yes
$PM_{2.5}$	244	10	Yes
SO_2	248	40	Yes
VOC	383	40	Yes(2)

Notes:

(1) Preliminary emissions estimate from the single construction year expected to produce the highest emissions, which includes a buildout of up to 85 WTGs (Project 1).

(2) While VOC emissions also exceed the PSD significant emission threshold, the Project triggers NNSR for O_3 based on the non-attainment status of Dukes County.

3.2 Ambient Air Quality Standards

To protect public health and welfare, the USEPA has developed National Ambient Air Quality Standards (NAAQS) for the criteria pollutants. The NAAQS have been developed for various durations of exposure. The NAAQS for short-term periods (24 hours or less) typically refer to pollutant levels that cannot be exceeded except for a limited number of times per year. The NAAQS for long-term periods refer to pollutant levels that cannot be exceeded for exposures averaged typically over one year. The NAAQS include both "primary" and "secondary" standards. The primary standards are intended to protect human health and the secondary standards are intended to protect the public welfare from any known or anticipated adverse effects associated with the presence of air pollutants. Table 3-2 presents the NAAQS for the criteria pollutants.

The NAAQS is a maximum allowable concentration "ceiling". In areas attaining the NAAQS, air quality is not permitted to degrade beyond specified levels, called PSD increments. A PSD increment is the maximum allowable increase in concentration that is allowed to occur above a baseline concentration for a pollutant.

Certain sensitive areas, defined as Class I areas under the Clean Air Act (CAA), have a smaller allowable incremental increase in new emissions than Class II and III areas. Areas such as international parks, national parks greater than 6,000 acres, national memorial parks larger than 5,000 acres, and national wilderness areas larger than 5,000 acres are granted Class I status and the highest level of air quality protections under section 162(a) of the CAA. Class II areas are allowed more moderate pollution increases. Class III areas are areas that do not have any air quality standards, and the air quality may be degraded to levels in line with the NAAQS. To date, no Class III areas have been designated; therefore, all areas not established as Class I areas are designated as Class II areas. The closest Class I area relative to the Project is Lye Brook Wilderness area approximately 204 mi (329 km) northwest of the Lease Area in southern Vermont (see Figure 4-8). Table 3-3 presents the PSD Increments for the criteria pollutants.

To identify new emission sources with the potential to significantly impact ambient air quality, the USEPA and MADEP have adopted significant impact levels (SILs) for the criteria pollutants. Applicants for new major sources are required to perform source impact analyses to predict air quality impacts of the new sources in comparison to the SILs. If the maximum modeled concentrations due to the new sources are less than the

SIL for a particular pollutant and averaging period, then the impacts are considered "insignificant" for that pollutant and averaging period. If modeled concentrations are less than the SILs, compliance with the NAAQS and PSD Increments is demonstrated and additional analysis is not necessary. However, if the maximum modeled concentrations due to the new sources are greater than the SIL for a particular pollutant and averaging period, then further impact evaluation is required, as described below. Table 3-4 presents the SILs for the criteria pollutants.

Table 3-2. National Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS (µg/m^3) Primary	NAAQS (µg/m^3) Secondary	Form of Design Concentration
CO	1-hour	40,000	Same	Not to be exceeded more than once per year.
	8-hour	10,000	Same	
Pb	3-month	0.15	Same	Not to be exceeded on a rolling 3-month basis.
NO_2	1-hour	188	None	98th percentile of 1-hour daily maximum concentrations, not to be exceeded as averaged over 3 years.
	Annual	100	Same	Annual mean never to be exceeded.
O_3	8-hour	137.4	Same	4th highest daily maximum as averaged over 3 years.
PM_{10}	24-hour	150	Same	Not to be exceeded more than once per year on average over 3 years.
$PM_{2.5}$	24-hour	35	Same	98th percentile, not to be exceeded as averaged over 3 years.
	Annual	12	15	3-year average never to be exceeded.
SO_2	1-hour	196	None	99th percentile of 1-hour daily maximum concentrations, not to be exceeded as averaged over 3 years
	3-hour	None	1,300	Not to be exceeded more than once per year.

Table 3-3. PSD Increments

Pollutant	Averaging Period	PSD Increment (µg/m^3) Class I	PSD Increment (µg/m^3) Class II	Form of Design Concentration
CO	1-hour	none	none	none
	8-hour	none	none	none
Pb	3-month	none	none	none
NO_2	1-hour	none	none	none
	Annual	2.5	25	Annual mean never to be exceeded.
O_3	8-hour	none	none	none
PM_{10}	24-hour	8	30	Not to be exceeded more than once per year.
$PM_{2.5}$	24-hour	4	17	Annual mean never to be exceeded.
	Annual	2	9	Not to be exceeded more than once per year.
SO_2	1-hour	1	4	Annual mean never to be exceeded.
	3-hour	25	512	Not to be exceeded more than once per year.

Table 3-4. Significant Impact Levels

Pollutant	Averaging Period	NAAQS SILs ($\mu g/m^3$)	PSD Increment SILs ($\mu g/m^3$)		Rank of Modeled Concentration
			Class I	Class II	
CO	1-hour	2,000	none	none	none
	8-hour	500	none	none	
Pb	3-month	None	none	none	none
NO_2	1-hour	7.5	none	none	none
	Annual	1	0.1	1	Annual mean never to be exceeded.
O_3	8-hour	1.96	none	none	none
PM_{10}	24-hour	5	0.3	5	Not to be exceeded more than once per year.
$PM_{2.5}$	24-hour	1.2	0.07	1.2	Annual mean never to be exceeded.
	Annual	0.2	0.06	0.2	Not to be exceeded more than once per year.
SO_2	1-hour	7.9	none	none	Annual mean never to be exceeded.
	3-hour	25	25	25	Not to be exceeded more than once per year.
	24-hour	5	0.2	5	Not to be exceeded more than once per year.
	Annual	1	0.1	1	Annual mean never to be exceeded.

3.3 Ambient Air Quality Analysis

As noted above, based on annual emissions during the construction phase of the Project, PSD requirements are triggered for CO, NO_X, PM_{10}, $PM_{2.5}$, and SO_2. As such, an ambient air quality analysis will be conducted for these pollutants as described below. Modeling will be conducted for various scenarios that cover both the construction and O&M phases of the Project. The modeled scenarios are described further in Section 4.5 and Section 4.6.

3.3.1 Significant Impact Levels (SILs)

Modeled scenarios will first be evaluated against the SILs to determine if the Project will have a significant impact on ambient air quality. The use of the SILs is applicable for this Project for all pollutants and averaging periods because the difference between the NAAQS and the representative ambient background is greater than the SILs. This is discussed in more detail in Section 4.1. For scenarios with modeled concentrations less than the SILs, no further modeling is required to demonstrate compliance with the NAAQS and PSD increments. For scenarios with modeled concentrations greater than the SILs, additional analysis to evaluate compliance with the standards and increments will be conducted as described below.

Since the Project is subject to PSD for $PM_{2.5}$, secondary $PM_{2.5}$ concentrations associated with Project NO_X and SO_2 precursor emissions will also be addressed. USEPA guidance based on Modeled Emission Rates for Precursors (MERPs) will be used to develop the secondary $PM_{2.5}$ concentrations that will be added to primary concentrations (from direct emissions) and compared to the SIL. Section 4.8 provides additional details on the approach that will be used.

3.3.2 NAAQS

If modeled concentrations due to emissions from any of the operational scenarios (both construction and O&M) are above the SILs, a NAAQS compliance analysis will be conducted that will include dispersion modeling of the Projects sources and additional background sources that may interact with Project sources (if applicable). The cumulative modeled concentration will then be added to an ambient background component for comparison to the NAAQS. The consideration of background sources that may be included in the cumulative modeling analysis is described in Section 4.12. The development of the ambient background component is detailed in Section 4.1.

3.3.3 PSD Increment

If modeled concentrations due to emissions from any of the operational scenarios (both construction and O&M) are above the SILs, cumulative modeling will be conducted which will include dispersion modeling of the Projects sources and as well as additional PSD increment consuming sources that may interact with Project sources (if applicable). The cumulative modeled concentration will be compared to PSD increments to assess compliance. Potential PSD increment consuming sources that may be included in the cumulative modeling are discussed in Section 4.12

3.3.4 Additional Impacts Analysis

For projects subject to PSD review, various additional analyses are required that assess potential impacts on soils, vegetation, and visibility in the project area caused by project emissions in combination with emissions from growth in the area due to the Project. The additional impact analysis (40 CFR 52.21(o,p)) generally consists of the following components:

- Growth Analysis - an analysis of the air quality impact predicted for the area as a result of general commercial, residential, industrial, and other growth associated with the source or modification (40 CFR 52.21(o)(2));
- Soil and Vegetation Impacts - a discussion of predicted ambient air quality impacts relative to soils and vegetation in the project impact area having significant commercial or recreational value (40 CFR 52.21(o)(1));
- Visibility Impairment Analysis (40 CFR 52.21(o)(1), 40 CFR 51.301) – an estimate of the impacts due to Project emissions on the visual quality in the area. This analysis is typically an assessment of plume blight and not regional haze.
- Class I Area Impact Analysis (40 CFR 52.21(p)) – This analysis would aid the USEPA and Federal Land Managers (FLMs) that are charged with determining whether a proposed project will consume a significant portion of PSD increment or have an adverse impact on Air Quality Related Values (AQRVs) in Federal Class I areas. A distance of 186 mi (300 km) is often used as a threshold for the need to conduct these analyses. The nearest Class I area to the Project is Lye Brook Wilderness in Vermont which is approximately 204 mi (329 km) northwest of the Lease Area.

Additional details for these analyses as they relate to the current modeling analysis are presented in Section 4.12.

3.4 State Requirements

As noted above, OCS sources located within 25 nm (46 km) of a state's seaward boundary are subject to federal, state, and local requirements of the COA per 40 CFR 55.13 and 40 CFR 55.14. While not yet designated, it is expected that USEPA will select Massachusetts as the COA. Massachusetts requirements related to air dispersion modeling include the adoption of ambient air quality standards set forth in 310 CMR 6.00. These regulations were last amended in June 2019, where previous standards were updated to be equal to the current NAAQS. Therefore, meeting the federal requirements of demonstrating modeled compliance with the NAAQS will also satisfy Massachusetts state requirements.

3.5 Summary of Modeling Requirements

Table 3-5 below presents a summary of the various dispersion modeling requirements that are applicable to emissions due to the Project during both the construction and O&M phases.

Table 3-5. Summary of Modeling Requirements

Modeling Requirement	Applies to Construction Emissions	Applies to O&M Emissions
SIL Analysis for NAAQS and PSD Class II Areas	Yes	Yes
Secondary Formation of $PM_{2.5}$	Yes	Yes
Modeling of Ozone	No	No
NAAQS Cumulative Source Modeling	If necessary(1)	If necessary(1)
PSD Increment Analysis	If necessary(1)	If necessary(1)
SIL Analysis for PSD Class I Areas	If necessary(2)	If necessary(2)
Visibility Analysis	Yes	Yes
Soils and Vegetation Analysis	Yes	Yes
Growth Analysis	Yes	Yes

Notes:

(1) Analysis only necessary if not already satisfied by results of the Class II SIL analysis.

(2) USEPA determines necessity for PSD increment analyses and FLMs regulate the need for analysis of AQRVs in Class I areas.

4.0 Air Quality Impact Assessment Methodology

Dispersion modeling will be conducted for both the construction and O&M phases of the Mayflower Wind Project. To assess compliance with applicable air quality standards, dispersion modeling will be conducted for short-term (≤24 hours) and annual averaging periods.

For the construction phase, annual average modeling is based upon emissions estimated to occur during the worst-case construction year. For the purposes of modeling, it will be assumed that the worst-case year (resulting in the highest air emissions) will include up to 85 potential WTGs constructed and one (1) OSP constructed within that year. If modeled compliance with applicable annual air quality standards is demonstrated for the construction year with the highest air emissions, it will be assumed that any other construction year would also demonstrate compliance. Short-term modeling will include all the activities that could occur simultaneously during a single day. Modeling for the O&M phase will also conservatively assume worst-case (resulting in the highest air emissions) short-term and annual operational scenarios.

Dispersion modeling will be conducted for the Project sources in accordance with USEPA's Guideline on Air Quality Models ("Guideline"), which is contained in 40 Code of Federal Regulations (CFR) Part 51, Appendix W) (USEPA 2017), Guidance for Ozone and Fine Particulate Matter Permit Modeling (USEPA 2022a), and MassDEP's Modeling Guidance for Significant Stationary Sources of Air Pollution (MassDEP 2011) to demonstrate modeled compliance with the NAAQS and PSD increments.

In accordance with USEPA's New Source Review (NSR) Workshop Manual (USEPA 1990), the dispersion modeling will be conducted in two stages:

1. Preliminary Analysis – Several operational scenarios for both construction and O&M activities, associated with the Project, will be modeled for comparison to USEPA SILs (see Table 3-4). For those pollutants and averaging periods where modeled concentrations are less than the SILs, the preliminary analysis serves as a demonstration of compliance with the NAAQS and PSD increments and further analysis is not required. A full impact analysis, described below, is required for pollutants and averaging periods with modeled concentrations above the SILs.
2. Full Impact Analysis – If the Project sources are determined to result in a "significant impact" on air quality by exceeding their respective SIL, then a full impact analysis is required. This analysis is cumulative in nature by including the Project sources, as well as existing or reasonably foreseeable future sources located nearby that may interact with Project. Results of the full impact analysis are compared to NAAQS and PSD increments, as applicable.

The sections below provide specific details pertaining to the dispersion modeling that will be conducted, including a discussion on the dispersion model, source characteristics and operating scenarios, and various other model inputs and methodologies.

4.1 Background Air Quality Data

In accordance with 40 CFR 52.21(m), an application for a PSD permit must contain an analysis of ambient air quality in the vicinity of the proposed Project for each pollutant subject to PSD review (CO, NO_X, CO, PM_{10}, $PM_{2.5}$, and SO_2). Background air quality data are also used to justify the use of the SILs in the preliminary analysis, as described below. Lastly, background air quality data are used in the full impact analysis (if required) to represent natural background concentrations and emission sources not explicitly modeled, where background air quality data are added to the total cumulative modeled concentration for comparison to the NAAQS.

4.1.1 Available Representative Data

Table 4-1 provides information about the closest onshore monitors and Table 4-2 provides a summary of the criteria pollutant concentrations recorded by the monitors for the most recent 3-year period (2019-2021).

Given the suburban and urban locations of the monitors, data recorded in these locations are conservative for the rural, offshore Lease Area location. Figure 4-1 displays the monitor locations relative to the Lease Area.

Table 4-1. Monitors Most Representative of Lease Area

Pollutant	Site Name	AQS Site ID
CO, NO_2	Francis School in East Providence, RI	44-007-1010
PM_{10}	Community College of Rhode Island Liston Campus rooftop in Providence, RI	44-007-0022
$PM_{2.5}$, SO_2	Fall River, MA	25-005-1004

Table 4-2. Summary of Background Monitored Concentrations

Pollutant	Averaging Period	Ambient Background Concentrations (μg/m³) 2019	2020	2021	Background Value	NAAQS/ MAAQS (μg/m³)	Form of Design Concentration
CO	1-hour	1,803	1,492	1,218	1,803	40,000	Not to be exceeded more than once per year.
	8-hour	1,031	1,146	1,031	1,146	10,000	
NO_2	1-hour	77.91	74.72	67.00	73.21	188	98th percentile of 1-hour daily maximum concentrations, not to be exceeded as averaged over 3 years.
	Annual	12.38	11.63	11.37	12.38	100	Annual mean never to be exceeded.
PM_{10}	24-hour	23.0	20.0	26.0	26.0	150	Not to be exceeded more than once per year on average over 3 years.
$PM_{2.5}$	24-hour	15.3	16.8	16.5	16.2	35	98th percentile, not to be exceeded as averaged over 3 years.
	Annual	6.70	6.31	6.83	6.61	12	3-year average never to be exceeded.
SO_2	1-hour	7.86	8.65	7.07	7.86	196	99th percentile of 1-hour daily maximum concentrations, not to be exceeded as averaged over 3 years
	3-hour	7.07	7.34	8.65	8.65	1,300	Not to be exceeded more than once per year.

4.1.2 Justification to Use SILs

Use of the SILs as described above for the preliminary analysis is appropriate if the value of the NAAQS minus the monitored background concentration is greater than the SILs. In such a case, it is logical to conclude that a proposed source with an impact less the SILs would not cause or contribute to a violation of the NAAQS and additional analysis is not required to demonstrate NAAQS compliance. Table 4-3 confirms use of the SILs is appropriate.

Table 4-3. Difference between the NAAQS and Monitored Concentrations as Compared to the SILs

Pollutant	Averaging Period	NAAQS (µg/m³)	Background Value (µg/m³)	Difference (NAAQS – Background Value) (µg/m³)	SILs (µg/m³)
CO	1-hour	40,000	1,803	38,197	2,000
	8-hour	10,000	1,146	8,854	500
NO_2	1-hour	188	73.21	115	7.5
	Annual	100	12.38	88	1
PM_{10}	24-hour	150	26.00	124	5
$PM_{2.5}$	24-hour	35	16.20	19	1.2
	Annual	12	6.61	5	0.2
SO_2	1-hour	196	7.86	188	7.9
	3-hour	1,300	8.65	1,291	25

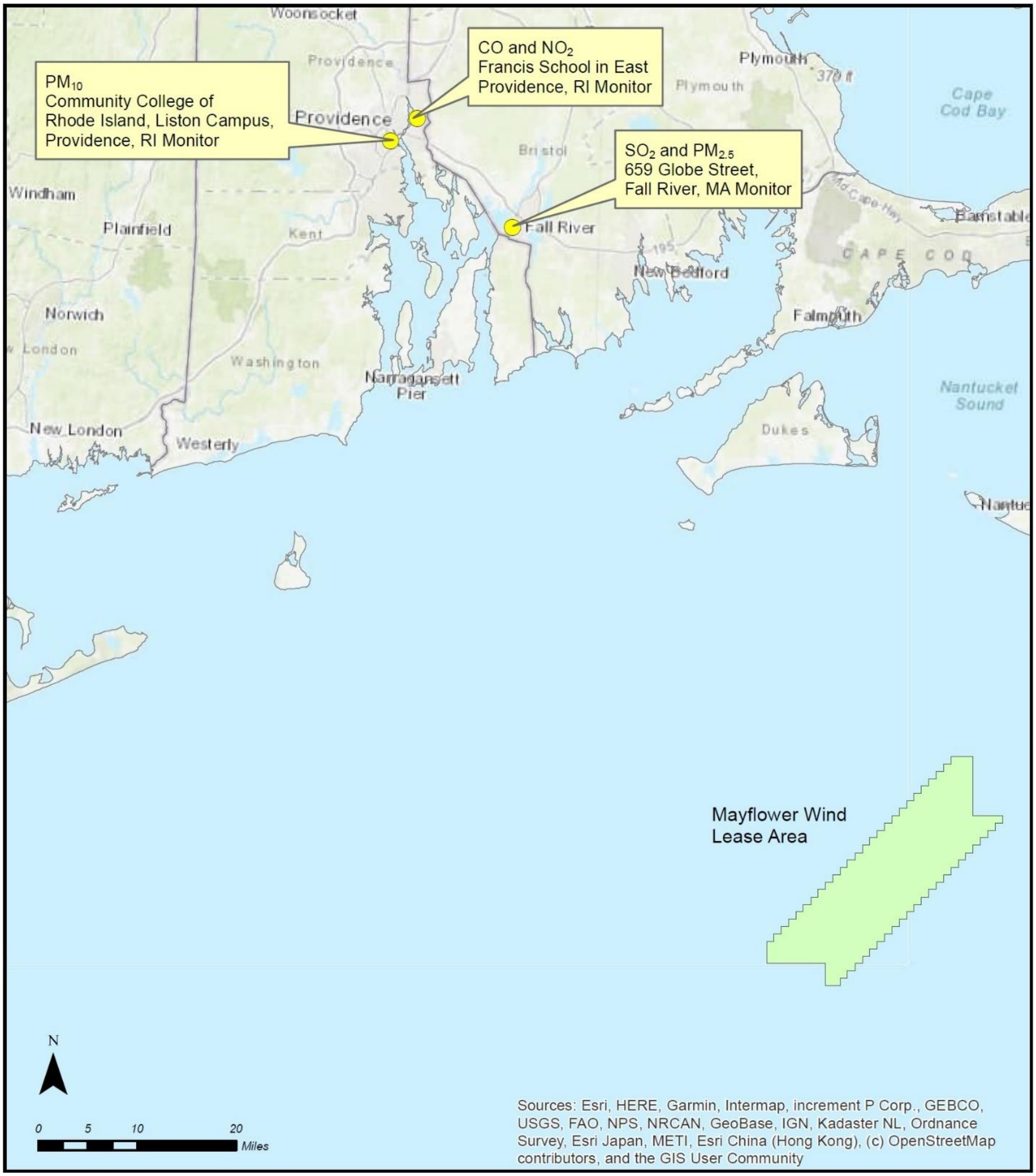


Figure 4-1. Background Monitor Locations

4.2 Air Quality Model Selection and Options

USEPA's Guideline prescribes a set of approved models for regulatory applications for a wide range of source types and dispersion environments. The Project sources are unique in that they are located over water. While the Offshore and Coastal Dispersion model is the only USEPA-approved model for predicting overwater impacts at locations within 50 km of a source (USEPA 2017), the model contains limitations in model formulation, technical disadvantages, and implementation-related issues for the proposed Project that justify the use of an alternative model. These items are discussed in greater detail in the letter from Mayflower Wind to USEPA Region on October 17, 2022 (Mayflower Wind 2022) seeking approval to use AERMOD-AERCOARE for the air dispersion modeling described in this document.

On April 1st, 2011, EPA Region 10 granted approval for the use of output from the COARE algorithm coupled with AERMOD to estimate ambient air pollutant concentrations in an ice-free marine environment (USEPA 2011a, USEPA 2011b). Since the EPA Region 10 approval in May 2011, there have been five (5) additional USEPA Model Clearing house approvals to use AERMOD-AERCOARE. In each of its memoranda, the USEPA Model Clearinghouse stated that its concurrence with the USEPA regional office approvals did not constitute a generic approval of AERCOARE-AERMOD for other applications. Mayflower Wind understands that the AERMOD-AERCOARE alternative model cannot be used without specific approval from USEPA Region 1. While Mayflower Wind has not yet received approval to use the model, in the interest of expediency, this protocol assumes that formal approval is forthcoming. Therefore, the inputs described below are related to the use of AERMOD-AERCOARE.

The latest version of the AERMOD model (version 22112) will be executed with default regulatory model options in accordance with USEPA's Guideline. Because the Lease Area is located overwater and clearly rural, the URBAN model option will not be used.

4.3 Meteorological Data

Use of the AERCOARE-AERMOD model requires meteorological data representative of the over water location be processed with the AERCOARE processor. AERCOARE is the counterpart to the AERMET overland meteorological data processor in the AERMOD modeling system. AERCOARE can process overwater data obtained from either buoy measurements or prognostic data.

USEPA's Guideline indicates prognostic meteorological data may be used in near-field dispersion modeling applications where there is no representative observational data (USEPA 2017). In consultation with USEPA Region 1 (USEPA 2002c), three years (2018-2020) of Weather Research and Forecasting (WRF) prognostic model data obtained from USEPA were selected for use in developing the overwater data required by AERCOARE. The Mesoscale Model Interface Program (MMIF – Version 4.0, USEPA 2022d) was used to extract the meteorological data from a specific grid point located nearest to the Lease Area centroid (as shown in Attachment 1). The "AERCOARE" option was used in MMIF to extract the necessary overwater variables, including use of the "AER_MIXHT = WRF" option to specify use WRF mixing heights and not MMIF-calculated mixing heights.

Attachment 1 provides additional details regarding the data as well an evaluation that indicates good agreement between the WRF data and similarly located observational data for several parameters. The results of the evaluation presented in Attachment 1 indicate the overwater data developed from the WRF model are suitable for use in OCD.

AERCOARE will be run with the default options listed in the User's Guide (USEPA 2012) (with the exception of the calms threshold) to develop the SURFACE and PROFILE meteorological data files required to run AERMOD. Specifically, the following options will be used:

- Calms threshold = 0.283 m/sec, based on the minimum wind speed used by AERMOD.
- Mixing heights provided by WRF-MMIF will be used, with a minimum mixing height of 25 meters, assigned under the MMIF processing step, maintained.
- Minimum absolute value of Monin-Obukhov Length of 5 meters.
- Warm layer and cool-skin effects will not be considered.

- Friction velocity determined from wind speed only; wave height will not be considered.

Additionally, surface characteristics provided by WRF (as opposed to AERSURFACE) will be used.

4.4 Modeling Scenarios

The following scenarios describe the operational activities and emission sources associated with Project 1 construction as well as O&M that are expected to occur within the OCS permit area. Modeling of these scenarios will be based on consideration of the locations in which they are expected to occur as well as the likelihood that activities could take place simultaneously.

- Scenario 1 – Seabed Prep / Scour Protection: Includes inspection and preparation of the seabed in advance of substructure and foundation installation for the WTGs/OSPs. For all substructure and foundation types, the seabed may be leveled to prepare for installation. For gravity-based structures (GBS), additional preparation in the form of seabed clearing may be needed. This scenario also includes installation of scour protection which involves the deposition a layer of stone around the WTG substructure location to prevent the removal of sediment by hydrodynamic forces. Scour protection may take place prior to or after substructure installation. In the case of GBS, a layer of rock is deposited on the seabed prior to installation. This scenario includes the use of multipurpose support vessels for seabed preparation, pre-installation inspection surveys, and general support, as well as a fall-pipe vessel for rock deposition.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations and one OSP location. While it is possible that vessels would perform work at up to two WTG/OSP locations per day, short-term modeling will conservatively assume that the vessels remain at a single location per day which consolidates emissions.

- Scenario 2 – Foundation Installation, Monopile or Pin Pile (piled jacket): Includes embedding of a single steel cylindrical monopile or several smaller steel pin piles into the seabed using a heavy crane, dynamic positioning installation vessel, as well as a pile driving hammer. Additional support vessels are expected to include tugs for materials transport and multipurpose support vessels for environmental monitoring and marine observation. An additional multipurpose support vessel will carry air compressors used to create a “bubble curtain” for noise mitigation during pile driving. This scenario includes a crew transport vessel (CTV) and may also use an airplane for mammal observation and/or helicopter for materials/crew transport. The Project is considering four substructure types: monopile, piled jacket, suction-bucket jacket, and GBS. However, the dispersion modeling will assume either a monopile or pin pile substructure will be installed because they have a larger emissions footprint than either suction-bucket jacket or GBS due to the need for pile driving and noise mitigation. Monopile installation emissions would take place during the same year as the transition piece installation while emissions related to pin pile installation would take place the year prior to jacket installation. Dispersion modeling will use an envelope approach that will include the worst-case emissions for vessels that could be used for either scenario. The emissions modeled will include at least all the emissions associated with each scenario and likely more than is realistic to ensure the characterization represents either scenario.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations and one OSP location. While it is possible that up to two WTG/OSP locations could be installed per day, short-term modeling will conservatively assume that all vessels and equipment used in this scenario work only at a single location per day which consolidates emissions.

- Scenario 3 –Transition Piece Installation or Jacket Installation: Includes either the installation of the transition piece (TP) onto the monopile substructure or the installation of the jacket onto the pin piles using a heavy crane, dynamic positioning installation vessel. While the substructure may be an extended monopile design where a TP would not be needed, emissions associated with installation of a TP will be included as a potential worst-case for construction. Additional vessels that will support this activity include tugs for materials transport and a multipurpose support vessel to grout the connection between the transition piece and monopile substructure. Jacket installation could also require a CTV and helicopter for crew transport. Dispersion modeling will use an envelope approach that will include the worst-case emissions for vessels that could be used for either scenario. The emissions modeled will include at least all the emissions associated with each scenario and likely more than is realistic to ensure the characterization represents either scenario.

Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations and one OSP location. While it is possible that TPs could be installed at up to two WTG/OSP locations per day, short-term dispersion modeling will conservatively assume that all vessels used in this scenario will work only at a single location per day which consolidates emissions.

- Scenario 4 – Offshore Export Cable Prep: Includes one or more surveys of the cable route that would be conducted to determine the optimal cable installation method using a multipurpose support vessel. Preparation of the seafloor by removing boulders or other obstacles is also included, including the potential for a pre-lay grapnel run to remove buried hazards. Seafloor prep is assumed to include the use of multipurpose support vessels. An anchor handling tug is also anticipated to provide general support to activities in this scenario.

  Dispersion modeling conducted for the annual averaging period will assume activities in this scenario will be located along the portion of the export cable corridor located within the OCS permit area. The vessels will be traveling along the route distance at a pace of 1640 ft (500 m) per hour. As such, this activity will not be included in modeling of short-term periods (≤24 hours) because the vessels will not be in any one location long enough to contribute to any short-term concentrations. In addition to the cable lay vessel, various multipurpose support vessels will be used to transport various installation and burial equipment and may be used for cable protection installation and general support.

- Scenario 6 – Inter-Array Cable Prep: Includes one or more surveys of the cable route that would be conducted to determine the optimal cable installation method using an offshore service vessel. Preparation of the seafloor by removing boulders or other obstacles is also included, as well as the potential for a pre-lay grapnel run to remove buried hazards. Seafloor prep is assumed to include the use of multipurpose support vessels.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations and one OSP location, with the vessels traveling the route between three locations in one day. However, to be conservative, the modeling will assume that vessels associated with this activity travel only between two locations per day. As such, the potential daily emissions included in the short-term modeling of these activities will be divided among two locations.

- Scenario 7 – Inter-Array Cable Lay, Burial, and Termination: Includes the laying and burial of inter-array cables in continuous lengths between structure pull-ins using a dedicated cable lay vessel. Installation of any required cable protection at the cable ends would typically be installed on the cable prior to cable installation from the vessel. Additional multipurpose vessels will be used to transport various installation and burial equipment and may be used for cable protection installation and general support.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations and one OSP location, with the vessels traveling the route between three locations in one day. However, to be conservative, the modeling will assume that vessels associated with this activity travel only between two locations per day. As such, the potential daily emissions included in the short-term modeling of these activities will be divided among the two locations.

- Scenario 8 – OSP Installation: Includes installation of the jacket and topsides of the OSP using a heavy crane, dynamic positioning installation vessel. Several different designs are under consideration, however for the purposes of dispersion modeling, this scenario will include vessel types and a duration of installation that would result in the highest emissions. Additional vessels that will provide support include heavy lift transport vessels to transport the OSP pieces, multipurpose support vessels for environmental monitoring and marine observation, and tugs for general support.

An additional multipurpose vessel will carry air compressors used to create a “bubble curtain” for noise mitigation. This scenario includes a CTV and may also use a helicopter for crew transport.

While the full build-out of the Mayflower Wind project may include multiple OSPs, dispersion modeling conducted for the annual averaging period will assume that one OSP will be installed per year. Therefore, activities included in this scenario will be modeled only at a single OSP location.

- Scenario 9 – OSP Commissioning: Includes connecting the inter-array cables and offshore export cables to their designated switchgear on the OSP. This activity will include a variety of electrical and mechanical work and quality testing. After the grid interconnection is energized, commissioning steps will include checking and testing of major substation/converter station components, electrical circuits, sensors, auxiliary and safety systems. A dynamically positioning accommodation vessel will be assumed to be used for crew accommodations. A multipurpose support vessel will be used for environmental monitoring and marine observations. A CTV and helicopter will be used to transport workers. Additionally, modeling for this scenario will also include a 2,000 kW generator that could be used continuously for up to 6 months to aid in “hot” commissioning.

  Activity included in this scenario will take place at a single OSP location.

- Scenario 10 – WTG Installation: Includes installation of WTGs onto the prepared substructures using a heavy lift jack-up installation vessel. How the WTG will be installed will depend on the amount of pre-assembly that will be completed at the port, the substructure type, WTG type, and installation vessel. However, for the purposes of dispersion modeling, this scenario will include vessel types and a duration of installation that would result in the highest emissions. Additional vessels that will provide support include tugs and multipurpose support vessels, a service operations vessel for crew accommodations, a CTV, and a helicopter for crew transfer.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations. Short-term modeling of emissions associated with this scenario will assume that vessels will only work at one WTG location.

- Scenario 11 – WTG Commissioning: Similar to OSP Commissioning, activities in this scenario will include a variety of electrical and mechanical work and quality testing. Commissioning steps will include checking and testing to validate mechanical and electrical integrity of the complete WTG prior to energizing. Final electrical testing will be performed during hot commissioning while the WTG is energized but not generating power. Lastly, each WTG will undergo operational testing and quality controls to validate reliability and systems interaction. A CTV will be used to transport workers and a service operations vessel will be used for crew accommodations. A multipurpose support vessel will be used for general support. Additionally, modeling for this scenario will also include up to sixty (60) 150 kW generators located at 60 WTGs that could be used continuously for up to 40 days to aid in “hot” commissioning.

  Dispersion modeling conducted for the annual averaging period will conservatively assume all Project 1 activities occur within a single year, with vessels located at up to 84 WTG locations. Short-term modeling of emissions associated with this scenario will assume that vessels will only work at one WTG location, but that generators are emitting from 60 WTG locations.

- Scenario 12 – O&M Daily Inspection/ Routine Maintenance: Includes inspection of equipment for wear and tear, inspections of WTGs safety and electrical equipment, and routine inspection/maintenance of OSPs. Periodic surveys of the cable system and repairing of scour protection around foundations is also included. This scenario includes the use of a service operations vessel for crew accommodations and a CTV.

  Annual dispersion modeling will assume that these O&M activities will be located at all WTG/OSP locations. Short-term dispersion modeling will assume that daily O&M activities will be located at up to 3 WTG/OSP locations.

- Scenario 13 – WTG & OSP Major Repair: Includes replacement of major WTG components, that cannot be handled as part routine maintenance. This scenario also accounts for a potential major repair where a jack-up vessel would be needed to replace damaged or degraded major components.

Additional vessels include the use of a service operations vessel for crew accommodations, a CTV, and tugboat for general support and transport of repair equipment.

Annual dispersion modeling will assume that these O&M activities will be located at all WTG/OSP locations. Short-term dispersion modeling will assume that daily O&M activities will be located at up to 3 WTG/OSP locations.

4.4.1 Short-Term Modeling

Table 4-4 presents the scenarios that will be evaluated in the modeling for short-term (≤24 hours) averaging periods, as well as the estimated number of vessels associated with each scenario and those scenarios that can potentially occur simultaneously at different locations throughout the Lease Area. Attachment 2 provides additional details such as the number of each vessel type and daily hours of operation assumed for each scenario.

Model Group A reflects all construction activities that can occur simultaneously in the Lease Block but at separate/adjacent WTG locations. The overlap of impacts from an adjacent WTG location will be accounted for by adding a representative design concentration from another activity within Model Group A.

Model Group B reflects only OSP installation – no other construction activities will occur simultaneously in the vicinity of this activity.

Model Group C reflects all O & M activities that can occur simultaneously in the Lease Block, but at separate/ adjacent WTG locations. The overlap of impacts from an adjacent WTG location will be accounted for by adding a representative design concentration from another activity within Model Group C.

Short-term impacts for CO, SO_2, $PM_{2.5}$ (24-hour PSD increment), and PM_{10} will be assessed using the procedure outlined below.

1. Model an individual scenario to determine the design concentration in the form of the applicable standard based on the pollutant/averaging period being assessed.

   If the individual scenario design concentration in Step #1 is in Model Group A or C (see Table 4-4 and 4-5), determine the total design concentration from scenarios that can occur simultaneously and are assumed to be located at separate but adjacent WTG location/OSP locations. The concentration from simultaneous activities in separate but adjacent WTG location/OSP locations will be based on maximum design concentration at 1.1 miles (1.8 km) away, which corresponds to the distance between adjacent WTG locations. This is conservative because each scenario will realistically be located at least several kilometers away. If the contributions at this distance prove to be too conservative to demonstrate compliance with air quality standards, the distance will be refined to a more realistic separation.

2. Add the contribution of the simultaneous sources to the design concentration found in Step #1 for comparison to the NAAQS/PSD increments. Note that total impacts for Scenario 8 (Model Group B) will not include a contribution from simultaneously occurring scenarios as there will be no activity in the vicinity of the OSP location with emissions that that could overlap those in Scenario 8.

Because of the uncertainty in how simultaneously operating scenarios will be oriented in relation to one another, rather than approximating their relationship using the actual WTG coordinates, each individual scenario will be modeled on a local coordinate system. Maximum contributions from simultaneously operating scenarios will conservatively be determined without pairing in time and space. Table 4-5 provides an example illustrating the proposed procedure using values that do not represent actual modeled concentrations.

Short-term NO_x and $PM_{2.5,}$ impacts will be assessed differently due to the probabilistic nature of the NAAQS which is also based on a 3-year average. Impacts for these pollutants will be determined using the procedure outlined below.

1. For a given location, develop a profile of 3 consecutive years that indicates which construction scenarios (scenarios described in the protocol) could occur during the same year and which would occur during different years.
2. Model each scenario separately for each individual meteorological year to determine the highest, 8th highest (H8H) concentration for each year, for each scenario (to ensure emissions are modeled during the worst-case meteorological conditions).
3. For each scenario, assign the maximum modeled H8H across the individual meteorological year to a construction year if that scenario would operate. Assign a zero for construction years that scenario does not operate.
4. For each of the construction years, determine the maximum H8H concentrations across the scenarios that could operate that year.
5. Average the H8H concentrations over the 3 construction years to develop a 3-year design concentration that would then be compared to the NAAQS.
6. Where appropriate, contributions from simultaneous activities possibly occurring at nearby WTGs will be added to the 3-year average prior to comparison against the NAAQS. These contributions would be determined by finding the maximum concentration due to the simultaneous activities at 1.8 km, similar to the approach described above.

Table 4-6 and Table 4-7 provide examples of the proposed procedure. Table 4-6 presents an example for developing modeled concentrations at the OSP location and assumes there is no other activity occurring at any other WTG location in the vicinity of the OSP. Table 4-7 presents an example for developing modeled concentrations at one of the WTG locations and assumes that there are simultaneous activities possibly occurring at other nearby WTGs that may contribute to concentrations at the primary modeled activity location. Note that these tables are presented simply to demonstrate the proposed procedure. The values in the tables do not represent actual modeled concentrations

This methodology is consistent with discussions with USEPA on this topic during a conference call on 10/05/2022 between Mayflower Wind, AECOM, and USEPA.

Attachment 5 provides the emissions source layout for the individual scenarios.

Table 4-4. Short-Term Modeling Scenarios

Scenario	Phase	Description	Estimated Number of Vessels Operating per Day	Modeling Group (Simultaneous Activities)[1]
1	Construction	Seabed Prep / Scour Protection	3	A
2	Construction	Foundation Installation, Monopile	9	A
3	Construction	Foundation Installation, Transition Piece	4	A
6	Construction	Inter-Array Cable, Installation Survey and Seafloor Prep	5	A
7	Construction	Inter-Array Cable Lay, Burial, & Termination	3	A
8	Construction	OSP Installation	13	B
9	Construction	OSP Commissioning	4	A
10	Construction	WTG Installation	10	A
11	Construction	WTG Commissioning	4	A
12	O&M	Daily Inspection	3	C
13	O&M	WTG and OSP Major Repair	6	C

Notes:
(1) Scenarios will be modeled grouped by their designated letter. For example, all "A" scenarios will be modeled as occurring simultaneously.

Table 4-5. Example Calculation of Short-Term CO, SO_2, and PM_{10} Impacts

Scenarios that Operate Simultaneously (Model Group A)	Individual Modeled Design Concentrations ($\mu g/m^3$) **EXAMPLE VALUES**	Modeled Design Concentration at 1.8 km[1] ($\mu g/m^3$) **EXAMPLE VALUES**	Total Modeled Impact (individual scenario plus maximum contribution from simultaneous scenarios)[2]
Scenario 1	12	5	Total Scenario 1 Impact = 12 + 7 = 19
Scenario 2	10	6[3]	Total Scenario 2 Impact = 10 +7 =17
Scenario 3	14	4	Total Scenario 3 Impact = 14 + 7 = 21
Scenario 6	20	7[3]	Total Scenario 6 Impact = 20 + 6 =26
Scenario 7	13	2	Total Scenario 7 Impact = 13 + 7 = 20
Scenario 10	11	1	Total Scenario 10 Impact = 11 + 7 = 18
Scenario 11	9	3	Total Scenario 11 Impact = 9 + 7 =16

Notes:

(1) 1.8 km represents the closest distance another activity could be located (the adjacent WTG location). This distance may be refined to a more realistic separation if the total modeled concentration including the contribution from simultaneous scenarios is greater than air quality standards.

(2) The contribution from simultaneous scenarios is the maximum concentration at 1.8 km over all scenarios (excluding the primary individual scenario). It is assumed that only two scenarios could have overlapping impacts: the primary individual scenario & one of the simultaneously operating scenarios. Because all scenarios are separated by at least 1.8 km, it is unlikely that emissions from multiple WTG locations could line up and impact a single location.

(3) The design concentration at 1.8 km for Scenario 6 is the largest of all the scenarios at that distance and is used to represent the contribution from simultaneously occurring scenarios in most cases. However, when finding the total Scenario 6 impact, the concentration at 1.8 km for Scenario 2 is selected as the contribution from simultaneous sources.

Table 4-6. Example for Developing Modeled Concentration for Short-Term NO_2 and $PM_{2.5}$ – at an OSP Location

Construction Scenarios that Operate at OSP	Modeled Individual Year High Eighth High Concentrations (μg/m^3) **EXAMPLE VALUES**			Maximum High Eighth High Concentrations Assigned to Construction Years[1] (μg/m^3)		
	Meteorological Year 1 (2018)	Meteorological Year 2 (2019)	Meteorological Year 3 (2020)	Construction Year 1	Construction Year 2	Construction Year 3
Scenario 1	8	7	6	0	8	0
Scenario 7	4	5	3	0	5	0
Scenario 8	3	1	4	0	4	0
Scenario 9	9	5	2	0	9	0
Maximum concentration for scenarios that could operate in same year				**0**	**9**	**0**
3-Year design concentration for comparison to NAAQS				**(0 + 9 + 0) /3 = 3**		

Notes:

[1] If the scenario is operating during a given construction year, the concentration shown is the maximum of modeled individual years. A zero indicates the scenario is not operating. In the configuration above, the scenarios listed could all operate during the same year at the OSP location. There would be no activity prior to their operating and none in the following year at this location.

Table 4-7. Example for Developing Modeled Concentration for Short-Term NO_2 and $PM_{2.5}$ – at a WTG Location

Construction Scenarios that Operate at WTGs	Modeled Individual Year High Eighth High Concentrations (μg/m^3) **EXAMPLE VALUES**			Maximum High Eighth High Concentrations Assigned to Construction Years[1] (μg/m^3)		
	Meteorological Year 1 (2018)	Meteorological Year 2 (2019)	Meteorological Year 3 (2020)	Construction Year 1	Construction Year 2	Construction Year 3
Scenario 1	5	8	4	8	0	0
Scenario 2	3	1	2	3	0	0
Scenario 3	4	5	3	0	5	0
Scenario 6	1	7	5	0	7	0
Scenario 7	5	6	1	0	6	0
Scenario 10	3	5	6	0	6	0
Scenario 11	6	2	9	0	0	9
Maximum concentration for scenarios that could operate in same year				**8**	**7**	**9**
3-Year design concentration				**(8+ 7 + 9) /3 = 8**		
Contribution from nearby simultaneous activity[2]				**0.5**		
Total concentration for comparison to the NAAQS				**8 + 0.5 = 8.5**		

Notes:

[1] If the scenario is operating during a given construction year, the concentration shown is the maximum of modeled individual years. A zero indicates the scenario is not operating. In the configuration above, the scenarios listed could all operate during the same year at the WTG location. There would be no activity prior to their operating and none in the following year at this location.

4.4.2 Annual Modeling

For the construction phase, annual average modeling will be based upon Project 1 emissions, assuming all emissions occur within one year, even though, activities will realistically span more than 1 year. If preliminary modeling indicates this assumption results in excessively high concentrations, refinements may be applied to reduce the conservatism which would be based on the schedule that will be submitted with the Air Permit application.

For Scenarios 4 and 5, annual emissions from vessels installing the offshore export cables will be modeled as a series of point sources spaced 1 nm (1.8 km) apart with total emissions split among the sources. For Scenarios 8 and 9, all annual emissions will be modeled at the assumed OSP location. For the remainder of the scenarios, activities are assumed to occur at up to 84 WTG locations and one OSP location. Therefore, the total annual emissions will be spilt among all locations. As with the short-term modeling, annual modeling will use a local coordinate system to determine impacts around a single WTG/OSP. The maximum contributions from activities at neighboring WTG locations will be added to account for potential overlap of impacts from the different locations. Attachment 5 provides the annual source layout.

For the O&M phase, annual average modeling will assume both daily routine activities (Scenario 12) as well as major WTG/OSP repair (Scenario 13) can occur during the same year at any of the 149 WTG/OSP locations. Therefore, the total annual emissions will be spilt among all 149 locations.

Annual modeling of both construction and O&M emissions will also include all potential emissions from each of the vessels transiting between the port (assumed to be New Bedford) and the Lease Area. Only those emissions occurring in the OCS permit area will be modeled. Transit emissions will be modeled as a series of point sources spaced approximately 1.8 mi (3 km) apart with the total emissions split among the sources. The proposed layout of annual emissions sources is provided in Attachment 5.

Attachment 3 provides the estimated annual parameters associated with Project 1 as well as for O&M for each of the vessels that will be modeled, which will assume all activities occur within the same year.

4.5 Source Characterization

The Bureau of Ocean Energy Management (BOEM) has developed the Offshore Wind Energy Facilities Emissions Tool (Version 2.0) to easily quantify emissions associated with proposed offshore wind energy facilities (BOEM 2021). The model is based on emission factors from USEPA's 2020 *Ports Emissions Inventory Guidance/Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions Report* (USEPA 2020) and uses a single set of emission factors for marine vessels, assuming they are all USEPA Category 2/Tier 1 marine diesel engines. The Mayflower Wind Project will use a variety of vessels, some of which use Category 3 engines and so the BOEM Tool, Version 2.0, is not appropriate for use in developing emissions for dispersion modeling for the Project.

An earlier version of the BOEM Tool (Eastern Research Group 2017), provides emission factors for a larger variety of EPA Category/Tier combinations based on the 2014 National Emissions Inventory (USEPA 2014). While these data could be used to develop the emissions needed for dispersion modeling, USEPA has recently published an updated version of its *Ports Emissions Inventory Guidance/Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions Report* (USEPA 2022f). This version supersedes the 2020 and 2009 versions of the Report and is selected as an appropriate source for marine engine emission factors based on its historical use in the development of the BOEM Tool. Emissions for the different vessel types that are planned to be used for the Project will be based on the emission factors in USEPA's 2022 Report and vessel-specific data such main engine power rating, auxiliary engine power rating, and assumed USEPA Category/ Tier of the vessel engine. Attachment 4 presents the emission factors and other vessel parameters that will be used to develop the emissions for dispersion modeling.

In addition to pollutant emissions, stack exhaust parameters are required for each of the vessels as input the AERMOD model. Mayflower Wind expects to use vessels similar to those that will be used for recently permitted neighboring offshore wind projects. As such, stack exhaust temperature, stack exit velocity, and stack diameter data for vessels used for the Project will be based on data used for similar vessel types from those projects. Stack parameters for each of the vessel types are summarized in Attachment 4.

4.6 Structure Downwash

USEPA modeling guidelines require the evaluation of the potential for physical structures to affect the dispersion of emissions from stack emission points. The exhaust from stacks that are located within specified distances of structures, and whose physical heights are below specified levels, may be subject to "aerodynamic building downwash" under certain meteorological conditions.

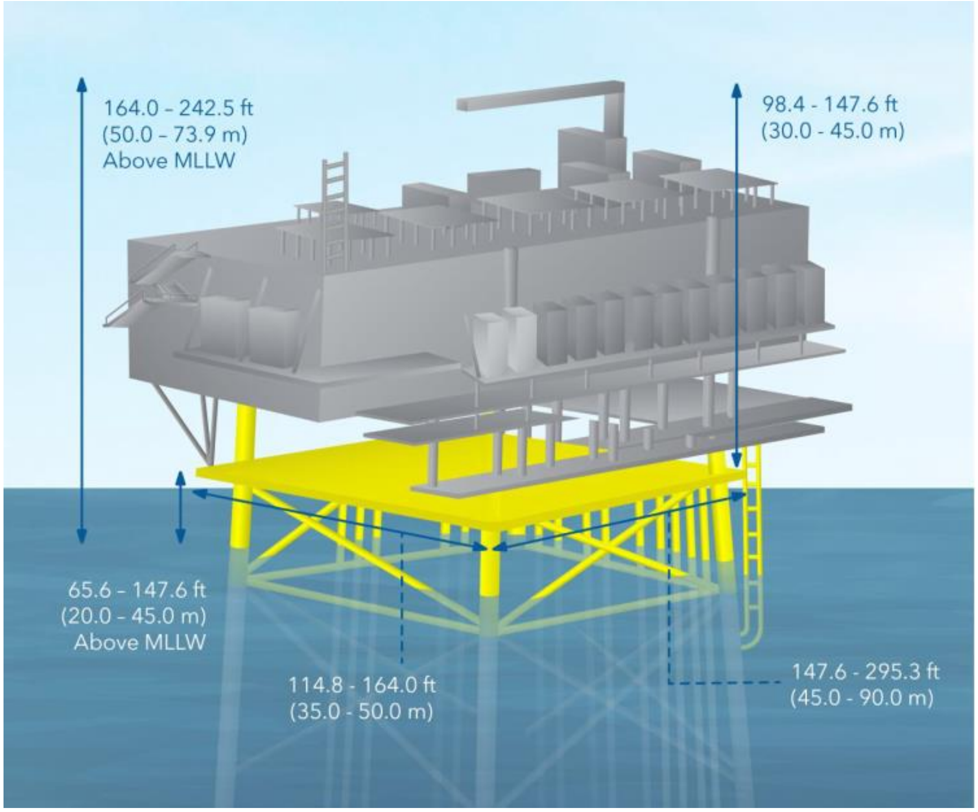
The significant stature of the OSPs will be included in AERMOD downwash calculations for vessels in its immediate vicinity. As of this submittal, the OSP is expected to be approximately 295 ft (90 m) long, 125-197 ft (38-60 m) wide, and 207 ft (63 m) tall (above the mean lower low water (MLLW)). These dimensions include the OSP structure itself as well as the supporting platform. Figure 4-2 provides an example representation of one potential OSP design and platform, indicating how the supporting platform would be relatively insignificant compared to the OSP structure.

To maximize downwash potential (which tends to maximize low level concentrations in the near field of an emissions source), the OSP was assumed to be wider with the width set equal the length. Assuming a square structure also reduces the sensitivity of source placement in the vicinity of the OSP since vessels could be located on any side of the OSP. Actual dimensions of the OSP may vary as Project design is optimized.

Wind direction-specific dimensions required for input to the model will be developed using the PRIME version of USEPA's Building Profile Input Program (BPIP-PRIME version 04274). BPIP-PRIME input and output files will be provided with the modeling archive that will accompany the OCS permit application.

Dimensions of support vessels not adjacent or attached to the OSP will not be included in the AERMOD downwash calculations because not only are the solid structures on those vessels much smaller compared to the OSP, but the dynamic movement of the vessels would result in an unstable and transient wake cavity that would likely not affect stack emissions. This methodology was selected in consultation with USEPA Region 1 (USEPA 2022e).

Note that there are no significant structures associated with the WTGs that are expected to influence dispersion of emissions from nearby vessels. Figure 4-3 and Figure 4-4 below provide examples of the potential foundation and platform types that could be used to support the WTGs. While other foundation designs are also being considered, construction of the types shown in the figures would result in higher emissions (because of the need for pile driving) and therefore these are the two that were considered for dispersion modeling. The photos demonstrate that, relative to the WTG itself (which is designed to be aerodynamic thus limiting downwash), the platform on the WTGs would be insignificant and not expected to influence the dispersion of emissions from nearby vessel stacks.



Source: Mayflower Wind Construction and Operations Plan, issued October 2021.

Figure 4-2. Diagram of Indicative OSP and Platform

Source: Mayflower Wind Construction and Operations Plan, issued October 2021.

Figure 4-3. Example Wind Turbine with Monopile Foundation

Source: Vuyk, Dick (Mayflower). Photograph of wind turbine with piled jacket foundation. Author's personal collection.

Figure 4-4. Example Wind Turbine with Piled Jacket Foundation

4.7 Receptor Grids

Mayflower Wind anticipates that the U.S. Coast Guard will enforce the establishment of a safety exclusion zone of 1640 ft (500 m) around all construction activity. Mayflower Wind understands that the U.S. Coast Guard (USCG) is prepared to establish and enforce safety zones for special activities, which include offshore wind installation activities, in the Exclusive Economic Zone (EEZ) under the 2021 National Defense Authorization Act. Mayflower Wind will work to obtain the required documentation for an agreement with the USCG to enforce a 1640-ft (500-m) zone around construction activity as soon as practicable and will provide it to the EPA once it is available.

Both short-term and annual modeling will utilize a local coordinate system consisting of a polar grid of receptors with 10-degree spacing at the following distances will be centered around the WTG/OSP location that would be located at the center (0, 0):

- every 82 ft (25 m) out to 0.43 mi (0.70 km)
- every 328 ft (100 m) out to 0.62 ft (1 km)
- every 0.31 mi (500 m) out to 3.1 mi (5 km)
- every 0.93 mi (1,500 m) out to 6.2 mi (10 km)
- every 3.1 mi (5,000 m) out to 31.1 mi (50 km)

Figure 4-5 displays the near field view of receptors centered around a single WTG/OSP location. A similar receptor grid will also be used to model short-term O&M scenarios, however there will be no exclusion zone for these activities and receptors will start at 82 ft (25 m) from the center of the WTG/OSP location. Figure 4-6 displays the far-field view of receptors centered around the example WTG/OSP location.

Note that receptors greater than 25 nm beyond the state seaward boundary (a total of 28 nm from the coast) are not required to be modeled. Figure 4-7 shows that the maximum distance from the northern-most WTG locations to the southern edge of the 28 nm boundary is 11.8 miles (19 km). Therefore, receptors located south of the WTG/OSP location will only extend out 11.8 miles (19 km), as shown in Figure 4-6.

Most receptor locations are over water and thus the terrain elevation would be zero. There are some receptors located 24 – 31 miles (38 – 50 km) from the northern-most WTG locations that are over Nantucket. AERMAP will be run for a grid of receptors spaced 30.5 ft (100 m) apart to determine the maximum terrain elevation on the island. That elevation will conservatively be assigned to all receptors from 23.6 – 31 mi (38 – 50 km) from the WTG.

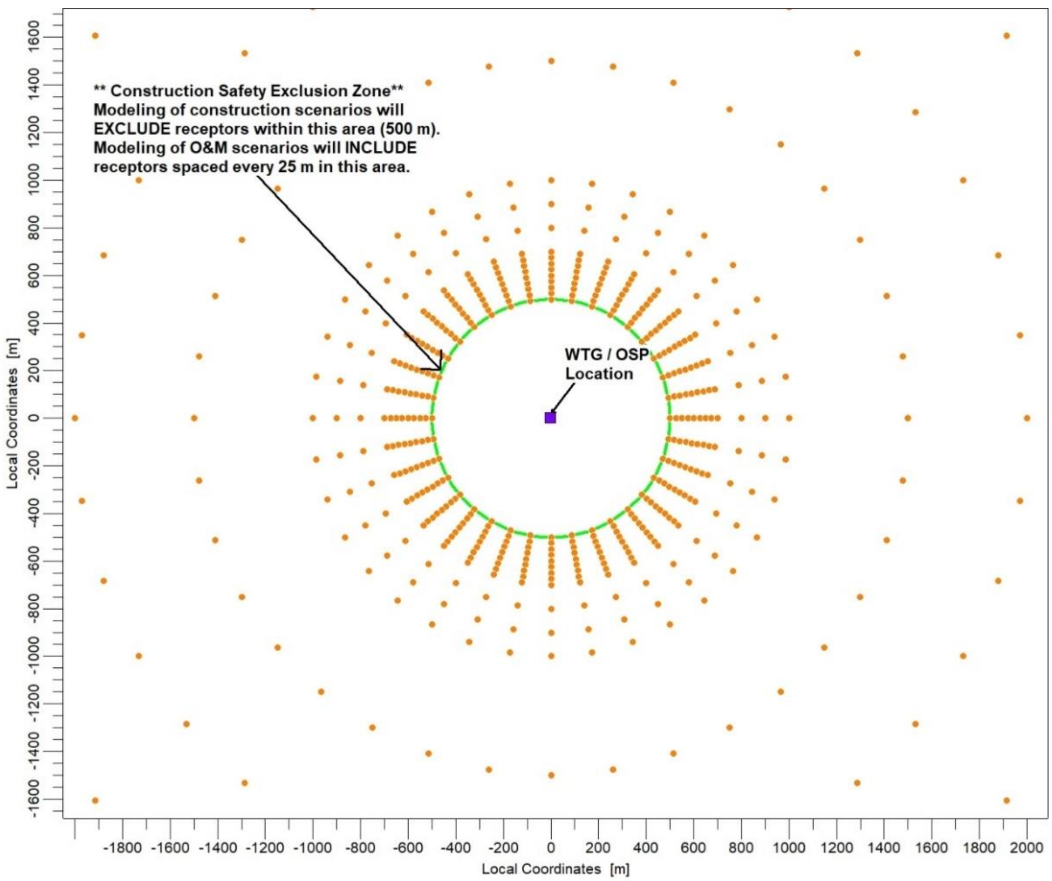


Figure 4-5. Receptors (Near Field View)

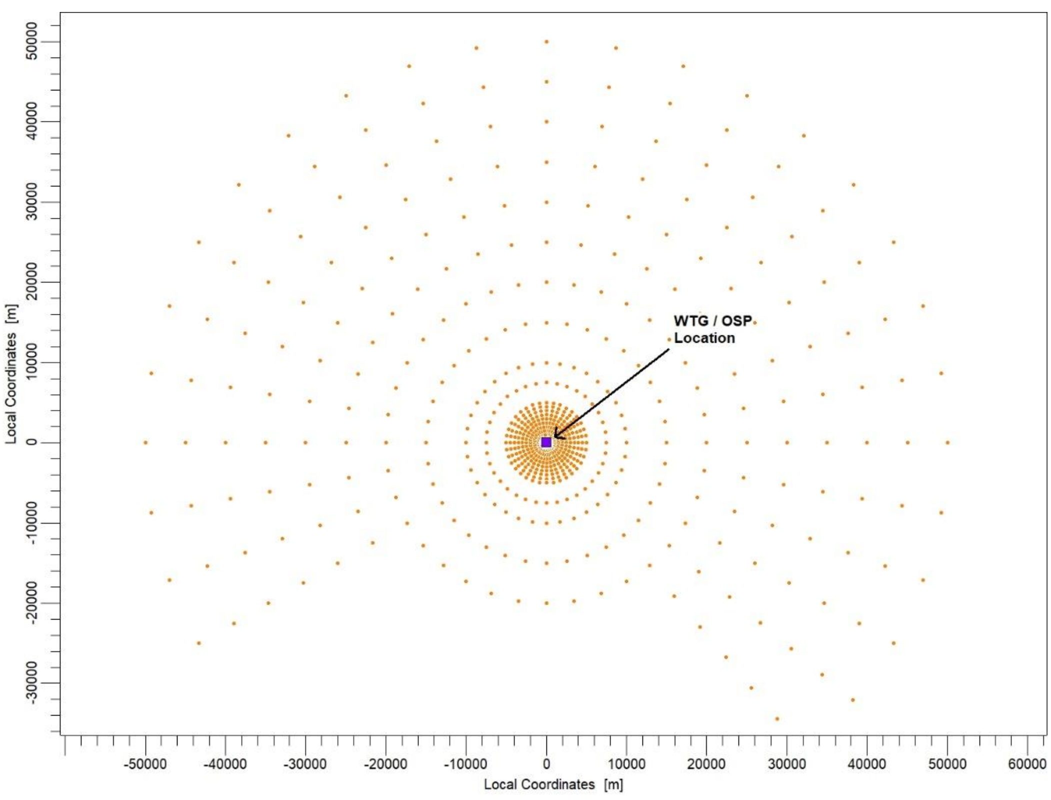


Figure 4-6. Receptors (Far Field View)

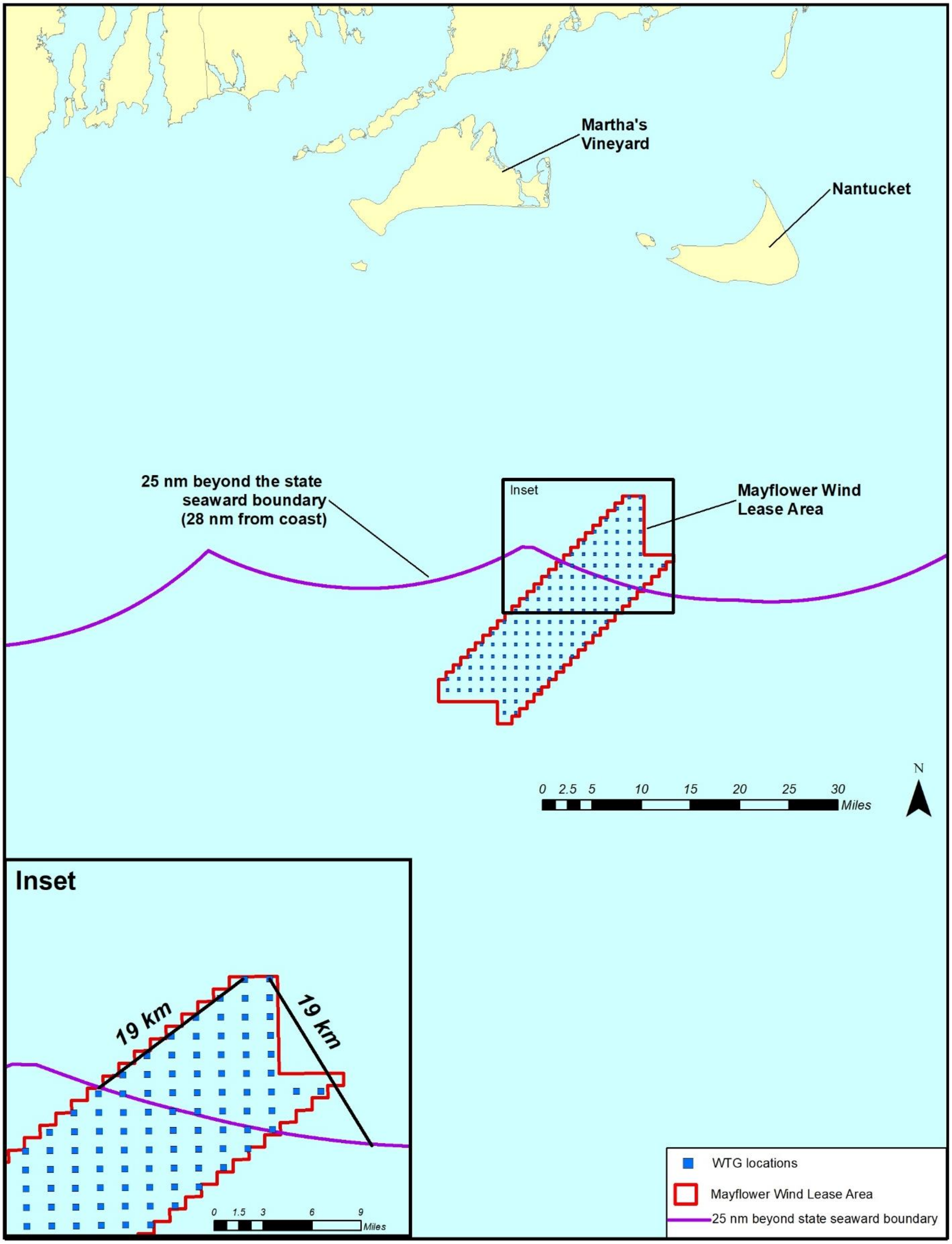


Figure 4-7. Boundary Limiting the Receptors to be Modeled

4.8 Nitrogen Oxide Conversion

The USEPA Guideline (USEPA 2017), describes the following three-tiered approach to calculating NO_2 concentrations based on modeled NO_X concentrations:

- Tier 1 assumes 100 percent NO to NO_2 conversion;
- Tier 2 utilizes the Ambient Ratio Method 2 (ARM2) option, which is based on a formula derived empirically from ambient measurements of NO_2/NO_x ratios; and
- Tier 3 allows the use of refined techniques such as the Ozone Limiting Method (OLM) or the Plume Volume Molar Ratio Method (PVMRM). PVMRM and OLM options in AERMOD account for ambient conversion of NO_x to NO_2 in the presence of ozone based on the same basic chemical mechanism of ozone titration, the interaction of NO_x with ambient ozone (O_3) to form NO_2 and O_2. Two key model inputs for PVMRM and OLM are hourly ambient background ozone concentrations concurrent with the meteorological data and source-specific in-stack ratios of NO_2/NO_x emissions.

Tier 1 and Tier 2 are expected to be too conservative for use in the dispersion modeling for the Project. Therefore, the modeling will use a Tier 3 option. PVMRM is recommended for relatively isolated, elevated sources. PVMRM is not recommended for area or line sources, near-surface releases, or groups of sources with moderate distances between them due to the potential to overestimate plume volumes in these cases (USEPA 2015). Therefore, OLM is a more appropriate selection for modeling of the Project emission sources and will be used in AERMOD.

Hourly ambient background ozone concentrations required to implement OLM will be obtained from USEPA's Air Data Air Quality System (AQS) website (USEPA 2022g) for the years 2018-2020 for the Aquinnah monitor site in Vineyard Haven, MA. Missing data will be filled using the guidance provided by the Minnesota Pollution Control Agency (MPCA). Source-specific in-stack ratios of NO_2/NO_x emissions, also required as input to implement OLM, will be obtained from USEPA's in-stack ratio database (USEPA 2022h).

4.9 Treatment of Intermittent Emissions

USEPA provides guidance in the form of a clarification memo ("Memo") on the dispersion modeling of intermittent emissions of NO_X based on the concern that assuming continuous operations for intermittent emissions would "effectively impose an additional level of stringency beyond that intended by" the 1-hour NO_2 NAAQS (USEPA 2011c). Furthermore, USEPA considers it acceptable to limit compliance demonstrations for the 1-hour NO_2 NAAQS to those emissions that are relatively continuous emissions or that occur with enough frequency to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. As an alternative to wholly excluding those intermittent emissions from modeling demonstrations, the Memo suggests an approach where intermittent emissions would be modeled based on an average, rather than maximum, hourly emission rate. The average emission rate would be an "annualized" rate determined as the maximum hourly rate multiplied by the actual annual operating hours divided by 8760.

Similar to reasoning presented in the OCS permit applications for South Fork Wind (SFW) (Jacobs 2020) and Vineyard Wind (VW) (Epsilon Associates 2018) and accepted by EPA Region 1, activities related to O&M for the Mayflower Wind Project will truly only be emitting at any one particular WTG/OSP location intermittently. The schedule of these activities is unpredictable and could take place at any of the 149 WTG/OSP locations with vessels spending no more than 24 hours at any one location at a time. Hourly emissions associated with activities that would occur during O&M of the wind turbines within the Mayflower Wind Lease Area are expected to be very similar to those that would occur within the SFW and VW Lease Areas. Therefore, methodologies used to conduct dispersion modeling of O&M emissions for those projects should also be applicable to O&M emissions related to the Mayflower Wind Project. As such, Mayflower proposes to annualize modeled short-term NO_2 emissions related to O&M activities for comparison to the 1-hour NO_2 NAAQS.

4.10 Secondary Particulate Formation

Since the Project is subject to PSD for $PM_{2.5}$, secondary $PM_{2.5}$ concentrations associated with Project NO_X and SO_2 precursor emissions will be addressed. In April 2019, USEPA released the final *Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program* (USEPA 2019). A first-tier analysis uses the relationships between precursor emissions and concentrations of ozone and $PM_{2.5}$ that were developed using USEPA modeling of hypothetical sources known as MERPs. A MERP is the level of precursor emissions that would hypothetically result in the formation of ozone and $PM_{2.5}$ at a concentration equal to the Class II SIL.

A Tier 1 analysis will be conducted that will use USEPA's MERPs View Qlik web tool (USEPA 2022b) to develop secondary $PM_{2.5}$ concentrations that will be added to primary $PM_{2.5}$ concentrations modeled with OCD. The web tool provides hypothetical single source modeled $PM_{2.5}$ concentrations for both 33-foot (10-meter) and 295-foot (90-meter) stacks for various locations in the United States. The closest hypothetical source locations to the Lease Area are located in Norfolk County, MA (97 miles northwest) and Franklin County, MA (160 miles northwest). Table 4-8 presents the hypothetical sources impact assuming a 33-foot (10-meter) stack. The table shows daily and annual impacts for both NO_X and SO_2 precursors. The maximum of the impacts from both counties (Table 4-8, bold text) will be used as the hypothetical source concentration in the following equation to develop the secondary $PM_{2.5}$ concentrations from the Project for both the construction phase and the O&M phase, separately:

$$Secondary\ PM_{2.5}\ component\ from\ SO_2\ precursors = \left(\left(\frac{SO2_{Em-MFW}}{SO2_{Em-Hyp}}\right)\right) * Hypothetical\ Source\ Conc.$$

Where:

- $SO2_{Em\text{-}MFW}$ is the Project related SO_2 emissions for construction or O&M (tpy);
- $SO2_{Em\text{ - }Hyp}$ is the hypothetical source SO_2 emissions from the web tool (500 tpy); and
- *Hypothetical Source Conc*. is the hypothetical source concentration from USEPA's web tool (µg/m^3).

The secondary $PM_{2.5}$ component from SO_2 precursors will be determined with the above equation. The secondary $PM_{2.5}$ component from NO_2 precursors will be determined with the same equation but based on NO_2 emissions/concentrations instead of SO_2.The two components will be summed to determine the total secondary $PM_{2.5}$ concentration that will be added to primary $PM_{2.5}$ concentrations modeled with OCD.

This procedure will be conducted separately for modeling of the construction-related emissions and modeling of the O&M-related emissions because these operational phases will not occur simultaneously.

Table 4-8. Secondary PM2.5 Concentrations for Hypothetical Source

	Precursor	Hypothetical Source Concentration – Norfolk County (μg/m^3)	Hypothetical Source Concentration – Franklin County (μg/m^3)
Daily $PM_{2.5}$	NO_X	0.047	**0.051**
Daily $PM_{2.5}$	SO_2	0.176	**0.248**
Annual $PM_{2.5}$	NO_X	0.004	**0.007**
Annual $PM_{2.5}$	SO_2	**0.010**	0.009

Data reference: MERPs View Qlik web tool https://www.epa.gov/scram/merps-view-qlik

4.11 Background Sources Included in Full Impact Analysis

If a cumulative (full impact) analysis is needed, USEPA's Guideline indicates that nearby sources should be included if they are not adequately represented by ambient background monitoring data (USEPA 2017). Typically, these sources would include those that cause a significant concentration gradient in the vicinity of the proposed source.

There are no major onshore sources located within 31 mi (50 km) of the Lease Area centroid, therefore no onshore sources will be included in the full impact analysis. There are two offshore sources that have recently approved OCS permits: South Fork Wind and Vineyard Wind. The South Fork Wind Lease Area (OCS-A 0517) is 37 mi (60 km) northwest of the Mayflower Wind Lease Area. As recommended by USEPA's Guideline, an assessment of the distance to the offshore projects vs. the value of 10 times the height of project stacks was conducted. If the distances are much greater than 10 times the height of the project stacks, then they are not likely to cause a significant concentration gradient in the area of the source and could therefore be excluded from cumulative modeling for the Project.

Table 4-9 provides the maximum stack heights for emission sources included in the dispersion modeling analysis for each of the SFW and VW projects. The table shows the distance from the Mayflower Wind Lease Area to each of the other offshore wind projects is far greater than ten times the stack height of project sources. As such, in accordance with 40 CFR Part 51 Appendix W Section 8.3.3(b), the magnitude of the concentration gradients associated with each of the South Fork Wind and Vineyard Wind projects is expected to be insignificant in the vicinity of the Mayflower Wind Lease Area. It can therefore be concluded that potential air quality impacts from the Mayflower Wind Project would not overlap with impacts associated with either the SFW or VW projects. Furthermore, emission sources associated with SFW would be located beyond the EPA-approved limit of 50 km for the AERMOD model (the model anticipated to be approved for use in the analysis) and therefore would not be appropriate to include in AERMOD modeling. For these reasons, emission sources associated with the SFW and VW projects will not be included in the cumulative impact analysis for Mayflower Wind.

Table 4-9. Modeled Stack Heights for Recently Permitted Offshore Wind Projects

Project	Tallest Modeled Stack Height (m)	Ten Times Stack Height (m)	Distance to Mayflower Wind Lease Area (m)
South Fork Wind(1)	53	530	60,000
Vineyard Wind(2)	48	480	13,000

Notes:

(1) Jacobs 2020.

(2) Epsilon Associates 2018.

4.12 Additional Impacts Analysis

4.12.1 PSD Class I Area Analyses

The closest Class I area relative to the Project is Lye Brook Wilderness area approximately 204 mi (329 km) northwest of the Lease Area in southern Vermont (Figure 4-8). USEPA Region 1 has contacted the appropriate FLMs regarding the Project and provided them with an earlier version of this modeling protocol. USEPA Region has received confirmation from the U.S. Forest Service that they will not be requesting that Mayflower Wind conduct an analysis of AQRVs (USEPA 2022i).

Regarding Class I area PSD increment analyses, potential Mayflower Wind Project impacts at Lye Brook Wilderness were estimated by scaling impacts at the same location presented by the Vineyard Wind project as a supplemental analysis to their OCS air permit application (Epsilon Associates 2019). Impacts for 24-hour PM_{10}, 24-hour $PM_{2.5}$, and annual NO_2 reported by Vineyard Wind were scaled proportionally according to the ratio of Mayflower Wind emissions to Vineyard Wind emissions. As shown in Table 4-10, the estimated impacts due to the Mayflower Wind Project are less than Class I SILs.

Table 4-10. Estimated Impacts due to the Project at Lye Brook Wilderness

Pollutant	Averaging Period	Vineyard Wind Annual Emissions (tpy)	Mayflower Wind Annual Emissions (tpy)	Emissions Ratio	Vineyard Wind Reported Impacts ($\mu g/m^3$	Mayflower Wind Scaled Impacts ($\mu g/m^3$)	Class I SIL
NO_2	Annual	3,361	8,858	2.6	0.004	0.01	0.1
PM_{10}	24-hour	104	258	2.5	0.02	0.05	0.3
$PM_{2.5}$	24-hour	98	244	2.5	0.097	0.24	0.27

Based on the following reasons, Mayflower proposes that additional Class I area PSD increment analyses are not required as part of the OCS air permit application:

- The analysis presented in Table 4-10 indicates impacts due to the Project would be less than Class I SILs;
- FLMs are not concerned that the Mayflower Wind Project emissions will significantly impact AQRVs, (often more constraining than PSD increment values);
- Lye Brook Wilderness is beyond 300 km away, a distance often used as a threshold for evaluating Class I impacts for onshore industrial facilities such as power plants.

Figure 4-8. Lye Brook Wilderness Class I Area in Proximity to Lease Area

4.12.2 Visibility Analysis

The visibility analysis is an estimate of the impacts due to Project emissions on the visual quality in the area. This analysis is typically an assessment of plume blight and not regional haze that is conducted with the VISCREEN model. The USEPA Guideline recommends the use of the VISCREEN model to assess visibility impairment of the Project emissions on “near field” areas (within 50 km of source emissions). The VISCREEN model will be used to assess visibility impairment at Class II vistas at Nantucket. The VISCREEN user’s guide (USEPA 1992) indicates the maximum short-term emission rates expected during the course of a year should be input to the model. As such, rates associated with the construction scenario that is expected to produce the highest emissions on a daily basis will be used, assuming the emissions are located at the WTG position closest to Nantucket. This is conservative because the sources related to the highest-emitting scenario would only be located at that single WTG position for up to 24-hours. For the remainder of the year, sources producing those emissions would be located at other WTGs, positioned farther from Nantucket.

4.12.3 Soils and Vegetation Analysis

An evaluation for impacts on soils and vegetation will be conducted using screening criteria that are provided in USEPA's *A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils and Animals* (USEPA 1980). The maximum modeled concentrations from the both the construction and O&M phases of the Project will be compared with the threshold values for determining whether an adverse impact will occur to sensitive vegetation, crops, or soil systems due to the Project.

4.12.4 Growth Analysis

A growth analysis examines the potential emissions from secondary sources associated with the proposed Project. While these activities are not directly involved in Project operation, the emissions involve those that can reasonably be expected to occur; for instance, industrial, commercial, and residential growth that will occur in the local area due to the Project itself. Secondary emissions do not include any emissions which come directly from a mobile source, such as emissions from the tailpipe of any on-road motor vehicle or the propulsion of a train. They also do not include sources that do not impact the same general area as the source under review.

A qualitative assessment of the impact of emissions from secondary, associated growth during both the construction and O&M phases of the Project will be provided. The analysis will discuss expected employment, growth and expansion, and whether this secondary growth will cause significant impacts.

5.0 Presentation of Modeling Results

The results of the air quality impact assessment will be documented in the final report that will be submitted to USEPA Region 1 as an appendix to the OCS Air Permit application. The report is expected to contain the following components:

- Description of the assessment methodologies, including documentation of any significant variations from procedures described in the protocol;
- Presentation of all model input data including supporting calculations and assumptions;
- Tabulation of the model results with interpretation;
- For all pollutants and averaging periods, a graphical representation of the extent of the Significant Impact Area (SIA, maximum distance of receptors with concentrations greater than the SIL); and
- Digital archive of all digital modeling files, executables, and processing programs.

6.0 References

Bureau of Ocean Energy Management (BOEM) 2021. BOEM Offshore Wind Energy Facilities Emission Estimating Tool – Version 2.0: User's Guide. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2021-046. Retrieved from https://www.boem.gov/sites/default/files/documents/about-boem/BOEM-Wind-Power-User-Guide-V2.pdf.

Eastern Research Group 2017. BOEM Offshore Wind Facilities Emission Estimating Tool Technical Documentation. Retrieved from https://www.boem.gov/Technical-Documentation-stakeholder/.

Epsilon Associates 2018. Vineyard Wind Air Quality Modeling Report: Operations and Maintenance Emissions.

Epsilon Associates, Inc. 2019. Vineyard Wind Project, Supplemental Information Requested by EPA Region 1, Construction and O&M Stage Modeling.

Jacobs 2020. South Fork Wind Outer Continental Shelf Permit – Air Quality Impact Modeling Report for Operations and Maintenance Emissions. Appendix C of Outer Continental Shelf Permit Application.

Massachusetts Department of Environmental Protection (MassDEP) 2011. Modeling Guidance for Significant Stationary Sources of Air Pollution. MassDEP Bureau of Waste Prevention. June. https://www.mass.gov/doc/modeling-guidance-for-significant-stationary-sources-of-air-pollution/download

Mayflower Wind 2022. Request for use of COARE Bulk Flux Algorithm to Generate Hourly Meteorological Data for use with AERMOD. Letter to Patrick Bird (USEPA). October 17, 2022.

Mayflower Wind 2021.Construction and Operations Plan, Volume 1.Submitted to Bureau of Ocean Energy Management, Office of Renewable Energy Programs. October.

Minnesota Pollution Control Agency (MPCA). 2014. Technical Guidance - Filling Missing Ozone Data for OLM and PVMRM Applications. https://www.pca.state.mn.us/sites/default/files/aq2-69.pdf

United States Environmental Protection Agency (USEPA) 1980. A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals. EPA-450/2-81-078.Office of Air Quality Planning and Standards. Research Triangle Park, NC27711.

USEPA 1990. New Source Review Workshop Manual – Prevention of Significant Deterioration and Non-Attainment Area Permitting. Office of Air Quality Planning and Standards, Research Triangle Park, NC.

USEPA 1992.Workbook for Plume Visual Impact Screening and Analysis (Revised).EPA-68-D9-0067.Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. October.

USEPA 2011a. COARE Bulk Flux Algorithm to Generate Hourly Meteorological Data for Use with the AERMOD Dispersion Program; Section 3.2.2.e Alternative Refined Model Demonstration, Herman Wong (USEPA) to Tyler Fox (USEPA) April 1.

USEPA 2011b. Model Clearinghouse Review of AERMOD-COARE as an Alternative Model for Application in an Arctic Marine Ice-Free Environment, George Bridgers (USEPA) to Herman Wong (USEPA) May 6, 2011

USEPA 2011c. Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO2 National Ambient Air Quality Standard. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. March.

USEPA 2012. User's Manual AERCOARE Version 1.0. EPA Contract No. EP-D-07-102. Prepared by ENVIRON International Corporation - Air Sciences Group. October. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aercoare/AERCOAREv1_0_Users_Manual.pdf

USEPA 2014. Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. September.

USEPA 2015. Technical support document (TSD) for NO2-related AERMOD modifications. EPA- 454/B-15-004. Office of Air Quality Planning and Standards, Air Quality Analysis Division, Air Quality Modeling Group. Research Triangle Park, North Carolina. July.

USEPA 2017.Guideline on Air Quality Models (Revised). Codified in the Appendix W to 40 CFR Part 51. Office of Air Quality Planning and Standards, Research Triangle Park, NC. January.

USEPA 2018c Addendum User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-18-004. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. April.

USEPA 2018e.Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program. Office of Air Quality Planning and Standards, Research Triangle Park, NC. April.

USEPA 2019.Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program. EPA-454/R-19-003. Office of Air Quality Planning and Standards, Research Triangle Park, NC. April.

USEPA 2020. Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions. Transportation and Climate Division. Office of Transportation and Air Quality. September. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10102U0.pdf

USEPA 2022a. Guidance for Ozone and Fine Particulate Matter Permit Modeling. EPA-454-R-22-005.Office of Air Quality Planning and Standards, Research Triangle Park, NC. September.

USEPA 2022b.MERPs View Qlik. *Data Access*. August. https://www.epa.gov/scram/merps-view-qlik.

USEPA 2022c. Email from Careyanne Howlett (USEPA Region 1) to Jennifer Flood (Mayflower Wind). June 28.

USEPA 2022d.The Mesoscale Model Interface (MMIF) Program, version 4.0. Prepared by Ramboll US Consulting. June. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/mmif/MMIFv4.0_Users_Manual.pdf

USEPA 2022e. Email from Careyanne Howlett (USEPA Region 1) to Amanda MacNutt (AECOM). July 27.

USEPA 2022f. Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions. Transportation and Climate Division. Office of Transportation and Air Quality. April. https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance

USEPA 2022g. Air Data Air Quality System (AQS). https://aqs.epa.gov/aqsweb/documents/data_api.html. Accessed August 2022.

USEPA 2022h. Nitrogen Dioxide/Nitrogen Oxide In-Stack Ratio (ISR) Database. https://www.epa.gov/scram/nitrogen-dioxidenitrogen-oxide-stack-ratio-isr-database. Accessed September 2022.

USEPA 2022i. USEPA Comments on the Mayflower Wind Air Quality Modeling Protocol. Letter to Caitlin Fitzpatrick (Mayflower) on September 23, 2022.

ATTACHMENT 1 – Meteorological Data Evaluation

Introduction

This attachment presents a study conducted to select and evaluate a suitable meteorological database to be used for the air quality impact assessment being performed to support the OCS Air Permit application for the Mayflower Wind Project. The study compares observations from nearby meteorological and buoy stations with data obtained from a prognostic meteorological model, the Weather Research and Forecasting model (WRF). Results from the study provide sufficient data comparison to support using three years (2018-2020) of meteorological data from the WRF model to perform the air quality impact assessment for the proposed Project. Specific elements that are part of the evaluation include, comparison of wind patterns and other meteorological variables that impact atmospheric dispersion such as, sea surface temperature, air temperature, relative humidity, cloud cover, and pressure.

Available Meteorological Data

This study analyzed three consecutive years (2018, 2019, and 2020) of Weather Research and Forecasting (WRF) prognostic model data that were obtained from the United States Environmental Protection Agency (EPA). The Mesoscale Model Interface Program (MMIF – Version 4.0) was used to extract the meteorological data from specific grid points located nearest to the Lease Area and observational stations used in the data comparison. The four grid point locations used as input to MMIF are provided in Table 1. Figure 1 shows the locations of the surface observational data used, the corresponding MMIF extraction points, the extraction point for the approximate center of the Mayflower Wind Lease Area, and the Chatham upper air station.

MMIF was used to extract data from multiple WRF grid points for comparing against the observational (OBS) data from an overland station (Martha's Vineyard Airport (KMVY – ID: 94724), and two buoys (Block Island (BI), RI – ID: 44097, and Buzzards Bay (BB), MA – ID: BUZM3). The buoy data were obtained from the National Data Buoy Center (NDBC) (NOAA 2022a), and the airport data were obtained from the National Centers for Environmental Information (NCEI 2022). In addition, MMIF was used to prepare AERMOD-ready surface and profile files for both the KMVY and BB location for the model comparison described in Attachment 1.

AERMET (Version 22112) was used to prepare AERMOD-ready surface and profile files for the three years (2018-2020) for two locations: (1) Martha's Vineyard Airport (KMVY) and (2) the BB Buoy. Corresponding upper air data (Chatham, MA – ID: 14684) was obtained from the NOAA/ESRL Radiosonde Database (NOAA 2022b) and used in the AERMET processing. AERSURFACE (Version 20060) was used (12 sectors and monthly values) to generate land use parameters needed by AERMET.

Each WRF grid point (Table 1) was chosen based on location so a comparison could be made between the observational and WRF datasets. The overland (KMVY and respective WRF grid point) and overwater (two buoys and respective WRF grid points) data were compared for select variables when the OBS data was available. WRF wind speed and direction data was extracted at a height of 32.8 ft (10 m). The BB buoy is located just outside of Buzzards Bay at 41.397 north latitude and 71.033 west longitude approximately 48 nautical miles (89 km) northwest of the Lease Area. The anemometer height and air temperature sensor are at 81.36 ft (24.8 m) and 80.38 ft (24.5 m) above sea level, respectively. The BI buoy (used only for comparison of sea surface temperature) is located at 40.967 north latitude and 71.126 west longitude about 24 nm (44 km) southeast of Block Island and about 38 nm (70 km) west-southwest of the Lease Area. Sea temperature measurements are taken 1.51 ft (0.46 m) below the water line.

Table 1. Meteorological Extraction Points for Input to MMIF

Data	Latitude (°)	Longitude (°)	Comment
Grid point extracted for OCD modeling	40.800	-70.322	~ Center of Lease Area
Grid point extracted for Buzzards Bay Buoy	41.402	-70.985	~ 2.5 nm (4 km) ENE of BB
Grid point extracted for Block Island Buoy	40.985	-71.147	~ 1.7 nm (2.7 km) NW of BI
Grid point extracted for Martha's Vineyard Airport	41.444	-70.667	~ 4.4 nm (7.1 km) NW of KMVY

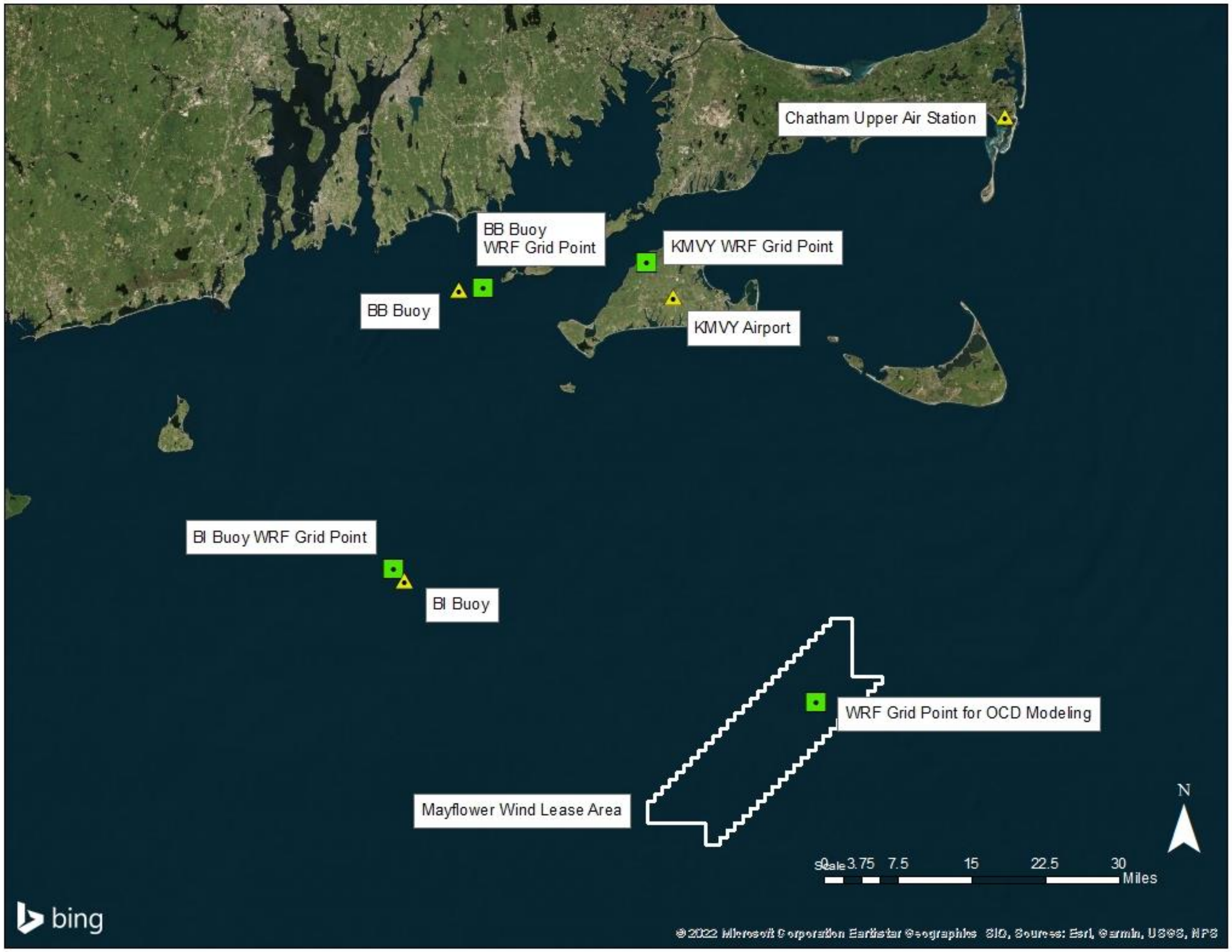


Figure 1. Location of Data Extraction Points

Assessment Approach

The assessment approach utilized a statistical basis for comparing the observed and WRF data sets. The data were evaluated using several approaches with a variety of statistical methods. The assessment approaches include:

> Wind Roses – wind roses (a frequency distribution of wind speed and direction) were generated for a three-year period (2018-2020) on an annual and seasonal basis to compare the observed and WRF data for both overland and overwater locations.
>
> Wind Displacement - the wind displacement computes the difference in the wind vectors for an hourly absolute value basis between the observed and WRF data for both overland and overwater locations.
>
> Water Temperature - Sea surface temperatures from the Block Island Buoy (ID: 44097) were compared to sea surface temperatures obtained from a nearby WRF grid point using the MMIF AERCOARE option.
>
> Comparison of Primary and Calculated Meteorological Parameters – direct comparison using the data from the AERMET surface files produced using AERMET (Version 22112) for KMVY and Buzzards Bay with data produced using a MMIF AERMET surface file for the closet applicable grid points. Eight variables were compared (wind speed, temperature, pressure, relative humidity, heat flux, surface friction velocity (u*), Monin-Obukhov length, and cloud cover). The calculated statistics included: mean bias, fractional bias, RMSE (Root Mean Square Error), and R^2 (coefficient of determination).
>
> Comparison of Dispersion Modeling Output Using Observed and WRF meteorological data - AERMOD (version 22112) was used to compare air dispersion modeling results for 2 different locations: (1) an overland location corresponding to the KMVY airport location and (2) an overwater location corresponding to the location of the Buzzards Bay buoy.

Assessment Results

WIND ROSES

Wind roses (Figures 2 through 5) show a comparison of the OBS and WRF data for both the KMVY overland location and the overwater BB buoy location over the 3-year period. Figures 1 and 3 show the comparison of three-year wind roses between the OBS and WRF data near KMVY and the BB buoy respectively. Overall, there is good agreement between the WRF and OBS data, with the southwest component being dominant in all cases.

Figures 3 and 5 show the breakdown for each season for the OBS and WRF data near KMVY and the BB buoy respectively. There is good seasonal agreement, with the southwest component being dominant in spring and summer. During the autumn and winter the wind direction shifts, with west and northwest winds becoming prevalent.

The WRF overland data was extracted at 32.8 ft (10 m) elevation which matches the 32.8 ft (10 m) anemometer height at the KMVY airport. The anemometer height for the BB buoy data is at 81.36 ft (24.8 m) and the WRF data was extracted at 98.4 ft (30 m) elevation to match the BB buoy data more closely. OBS wind speeds for KMVY are slightly lower than the WRF data, which can likely be attributed to the influence of local topography and wind barriers near the airport. For the overwater data, there is good agreement, with an average wind speed for the OBS and WRF data of 17.74 (7.93) and 17.60 (7.87) mph (m/s), respectively.

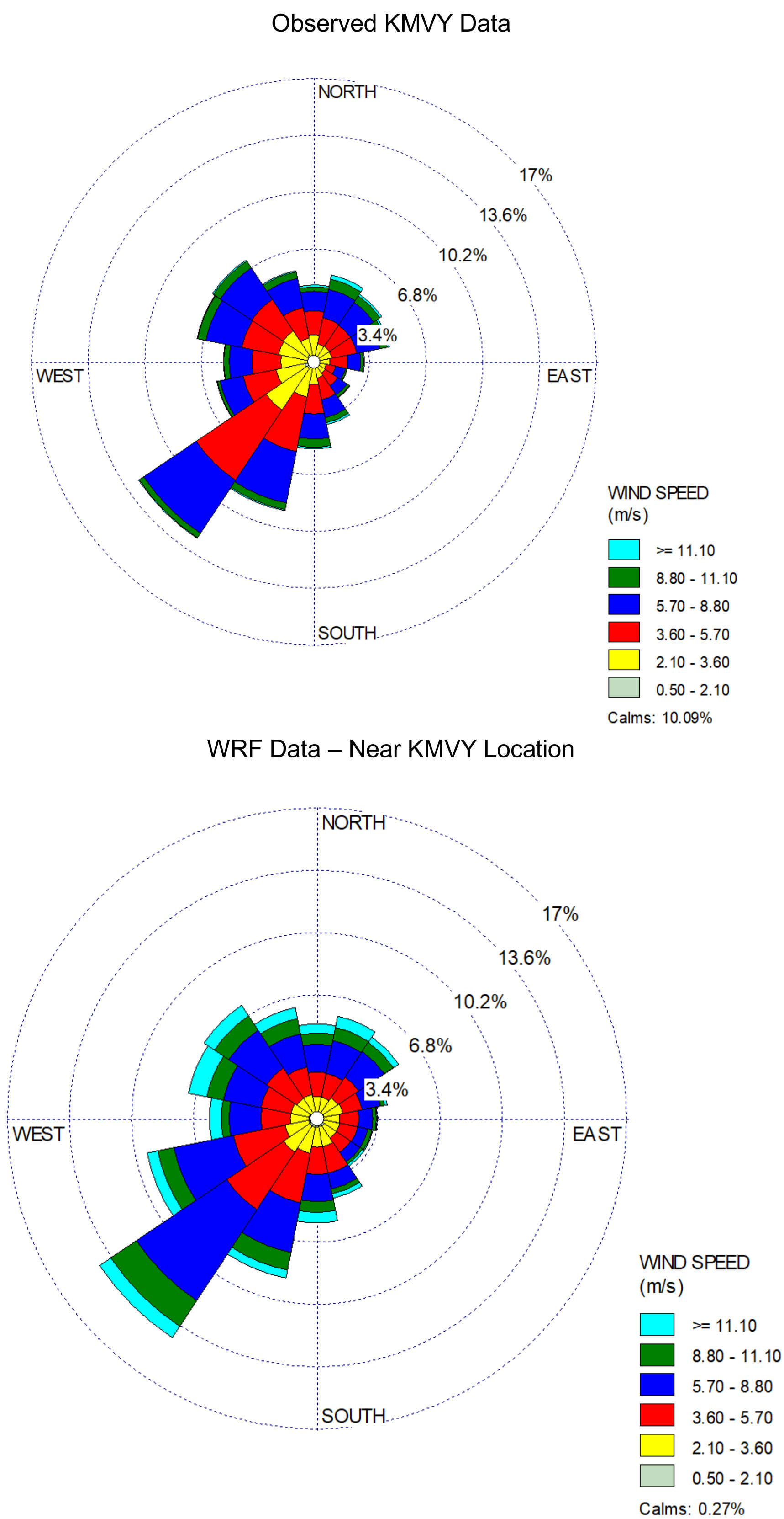


Figure 2. Wind Rose for Land – Observed and WRF Data (KMVY) (2018-2020)

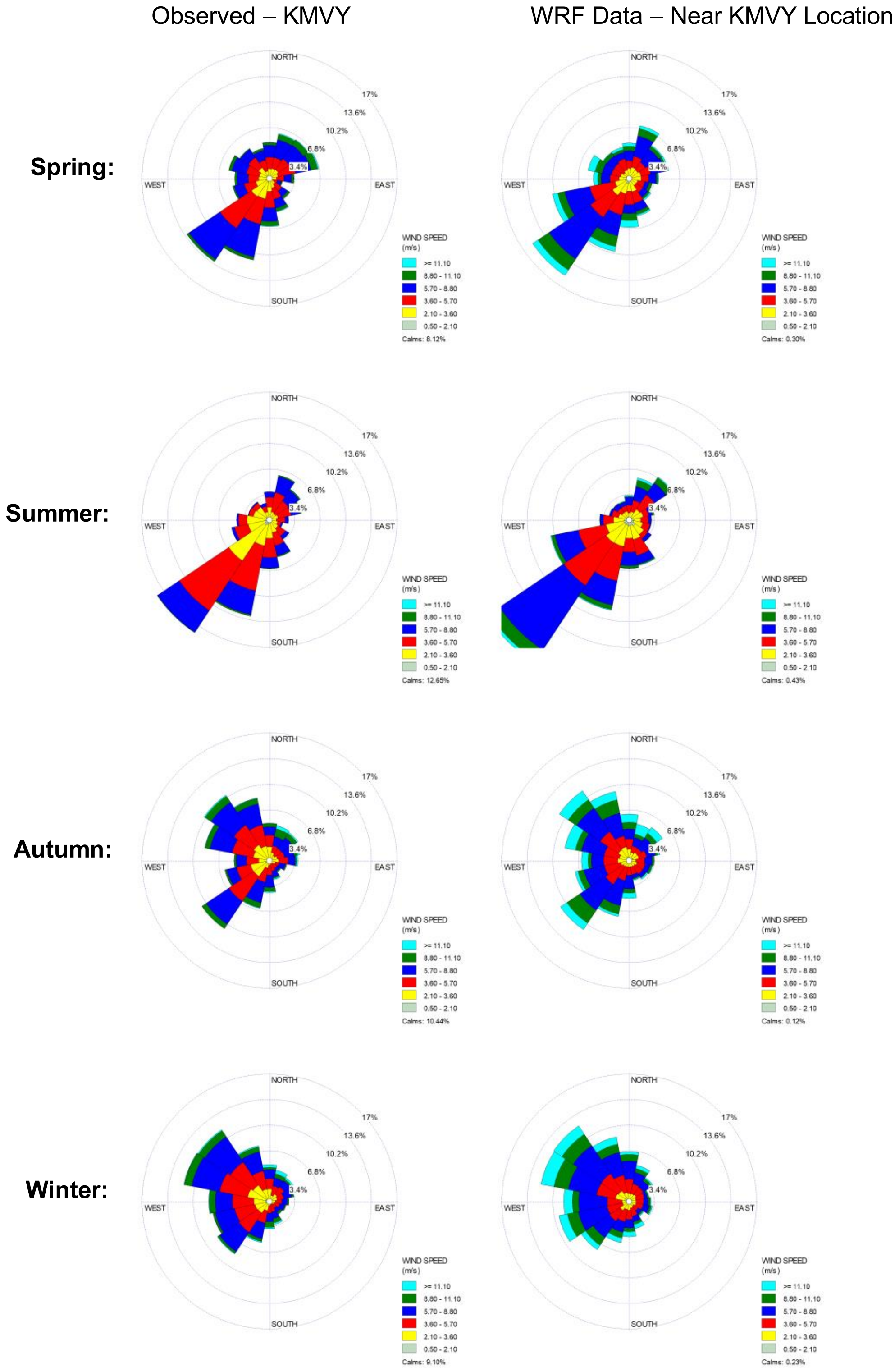
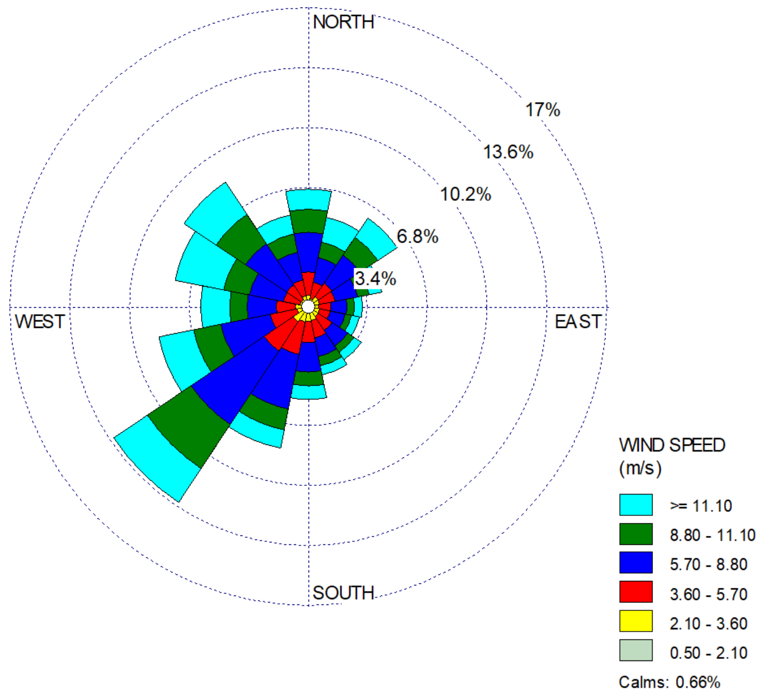


Figure 3. Seasonal Wind Rose for Land – Observed and WRF Data (KMVY) (2018-2020)

Observed – Buzzards Bay



WRF Data – Near Buzzards Bay Location

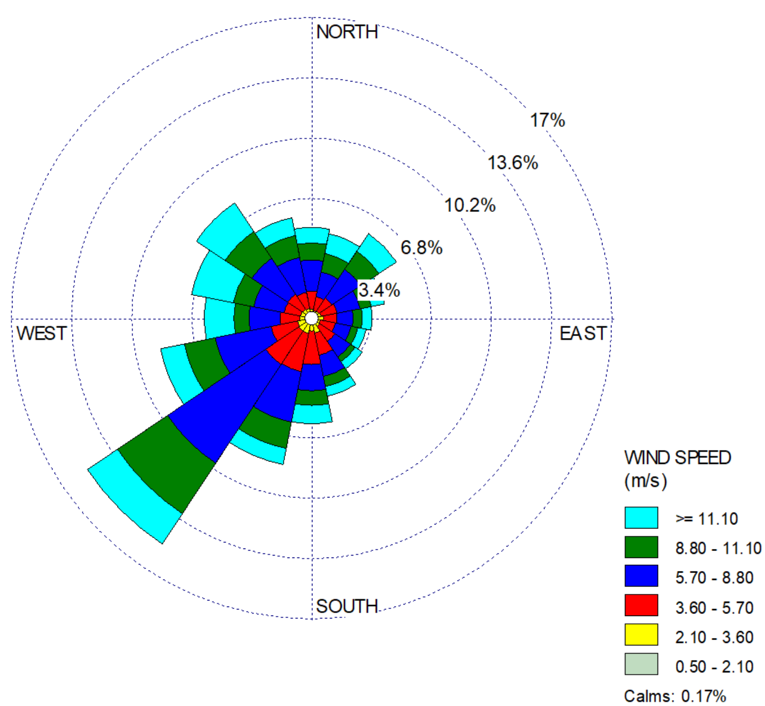


Figure 4. Wind Rose for Overwater – Observed and WRF (Buzzards Bay) (2018-2020)

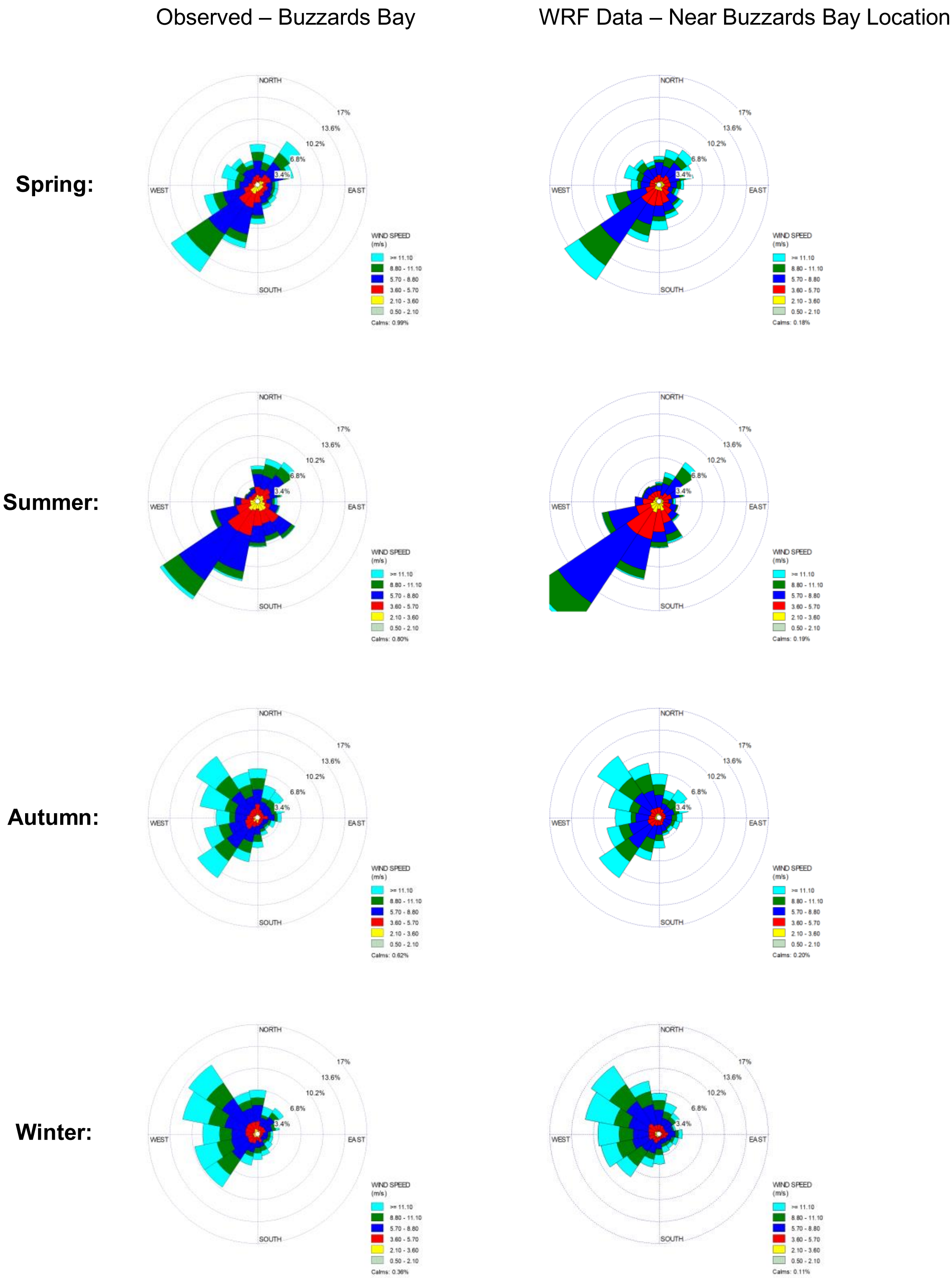


Figure 5. Seasonal Wind Rose for Overwater – Observed and WRF Data (Buzzards Bay) (2018-2020)

WIND DISPLACEMENT

Figure 6 shows the wind displacement which compares the difference in the wind vectors for an hourly absolute value basis between the OBS and WRF data. This assessment was performed for both the overland (KMVY) and overwater (BB) datasets as compared to their applicable WRF data sets. The figure shows the displacement for the year and location so comparisons can be made. The upper and lower limits of the boxes correspond to the 1st and 3rd quartiles, and the "x" and horizontal line in the center of the box represent the average, and median of the values respectively. The upper and lower bars represent the range of the data, with outliers indicated as points. The overland WRF data was extracted at 32.8 ft (10 m) while the overwater WRF data was extracted at 98.4 ft (30 m) to more closely match the BB buoy measurement height (81.4 ft (24.8 m)).

Overall, the overland displacement shows better agreement and lower displacement than the overwater displacement. The overwater wind speeds are higher as illustrated by the wind roses. Higher wind speeds can amplify small differences in the wind direction, resulting in higher displacement. The average wind displacement was 5.9 mi (9.5 km) for the overland data, and 9.9 mi (16.0 km) for the overwater data.

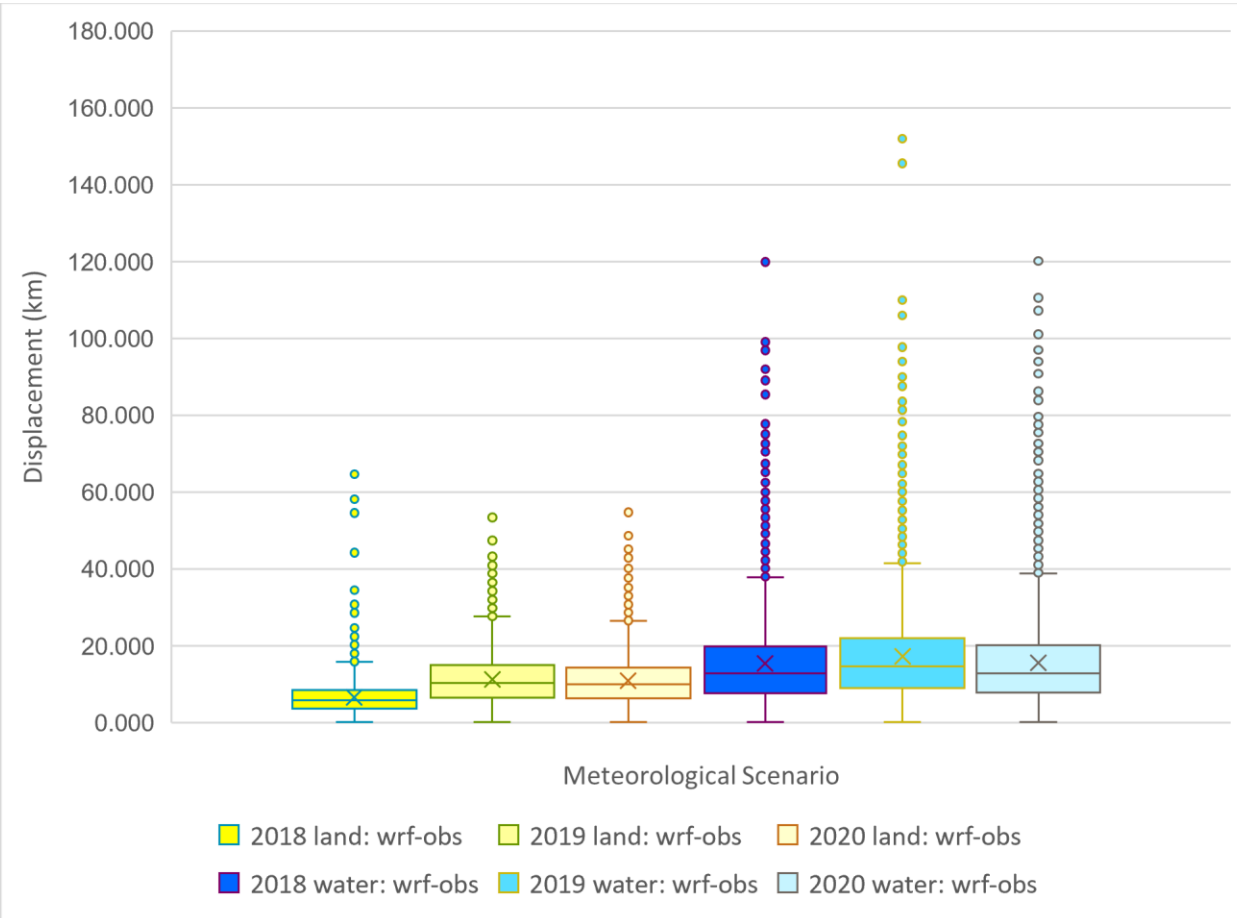


Figure 6. Wind Displacement (km) for Land and Water Data (WRF and Observed)

WATER TEMPERATURE

Sea surface temperatures from the Block Island (BI) Buoy (ID: 44097) were compared to sea surface temperatures obtained from the MMIF AERCOARE option for the corresponding WRF grid point. Since the WRF data was on an hourly basis, and the buoy had data recorded approximately every 30 minutes, only matching hourly values were used. Figure 4-6 shows the OBS and WRF sea surface temperature data plotted on the same graph. The seasonal cycle is evident, and there is good agreement between the data. The buoy data generally had greater diurnal variability with several occurrences of fluctuations of several degrees in just a few hours. This was likely due to local currents that the WRF model did not have the resolution to discern. However, the coefficient of determination (R2) was excellent at 0.992.

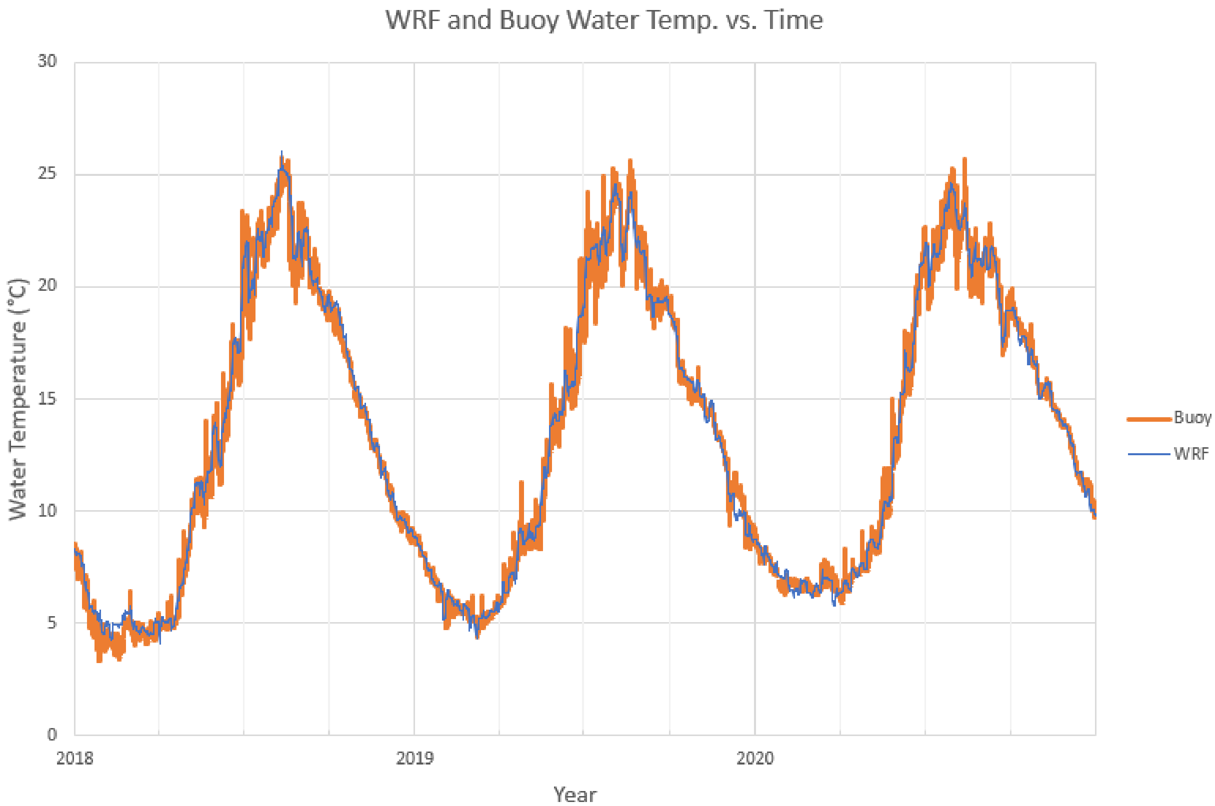


Figure 7. WRF vs. Buoy Water Temperature Data

COMPARISON OF PRIMARY AND CALCULATED METOROLOGICAL PARAMETERS

Table 1 compares statistics between the WRF and OBS data for eight variables (wind speed, temperature, pressure, relative humidity, heat flux, surface friction velocity (u^*), Monin-Obukhov length, and cloud cover. The calculated statistics included: mean bias, fractional bias, RMSE, and R^2.

Due to limited data availability from the BB and BI buoys, the statistics tables only compare OBS data from KMVY to the corresponding WRF grid point. All three years of data were used (2018-2020) to create seasonal comparisons. A comparison was also conducted for two specific hours throughout the whole three-year period (12 p.m. (noon) and 3 a.m.). If OBS data was missing, the corresponding WRF hour(s) were not used in the statistical analysis.

- The wind speed statistics show a modest positive mean bias, meaning that WRF wind speeds were slightly higher than the corresponding OBS values. The average WRF and OBS wind speed was ~ 13.4 (6.0) and 10.5 (4.7) mph (m/s), respectively.
- There is a small positive mean bias for temperature, pressure, and relatively humidity, indicating that the WRF data set has slightly higher values for these variables. The average WRF values were ~ 0.4 K, 2 mb, and 6% higher than the average OBS values for temperature, pressure, and relative humidity, respectively.
- For the heat flux, there is also a positive mean bias indicating that the WRF dataset had higher values than the OBS dataset. AERMET assigns a value of -64 to any available overnight data, while the WRF values are usually greater than this which likely accounts for a portion of this deviation.
- The surface friction velocity had a mean bias of -0.0413, indicating that the observed values are slightly higher than the WRF values (~ 0.43 vs 0.39) which is a relatively small bias for this variable.
- The Monin-Obukhov length is a parameter that can vary widely under similar atmospheric conditions even for the same stability class and is notoriously hard to model. Given the nature of this parameter, it is understandable why there is poor statistical agreement.
- It is very difficult for model analyses to accurately portray the cloud cover category, and surface observations reported manually or by an automated system also can be incorrect due to viewing inhibitions. Despite this, there is reasonably good agreement between data sets, with an average cloud cover category of ~ 4.7 and 5.3 for the OBS and WRF data, respectively.

As mentioned, seasonal statistics were analyzed for the meteorological seasons of spring, summer, autumn, and winter (Tables 2 through 5). The mean bias for the wind speed was lowest in the spring and highest in the winter. Surface friction velocity was comparable for all seasons except winter, with the absolute value of the bias always being under 0.07. For winter, the correlation between the WRF and OBS data was exceptionally good.

As mentioned, two hours were selected (12 p.m. and 3 a.m.) to see if there were any significant diurnal variations between the data (see Tables 6 and 7). Generally, the statistics were similar for both hours, but there were some differences. The difference in the wind speed between the WRF and OBS data (~ 14.1 (6.3) vs. 13.2 (5.9) mph (m/s)) for noon, was smaller than the difference at 3 a.m. (~ 12.5 (5.6) vs. 8.7 (3.9) mph (m/s)). Surface friction velocity has good agreement for both hours, although at night the friction velocity is lower and the correlation between the WRF and OBS data is stronger.

Although there are some differences between the OBS and WRF data, the overall statistical agreement is good. The wind roses also indicate that wind speed and direction values correspond fairly well between the data sets, for both the overland and overwater sites. This aspect of the study confirms WRF data are representative of the Lease Area and are therefore suitable for use in air dispersion modeling.

Table 1. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020)

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.3239	0.2467	2.6274	0.5062
Temperature (K)	0.3609	0.0013	2.5058	0.9170
Pressure (mb)	1.9641	0.0019	2.2119	0.9859
Relative Humidity (%)	5.6911	0.0725	12.3673	0.6339
Heat Flux (W/m^2)	21.8155	0.8737	82.7259	0.1986
Surface Friction Velocity, u* (m/s)	-0.0413	-0.1007	0.1945	0.3525
Monin-Obukhov Length (m)	214.3196	-3.3859	1757.4914	0.0006

Table 2. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Spring

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.0826	0.1855	2.6002	0.4825
Temperature (K)	-0.1333	-0.0005	2.2420	0.8398
Pressure (mb)	1.9983	0.0020	2.3316	0.9855
Relative Humidity (%)	9.7373	0.1272	14.4197	0.6970
Heat Flux (W/m^2)	21.1199	0.8376	73.7831	0.3228
Surface Friction Velocity, u* (m/s)	-0.0621	-0.1387	0.2170	0.3397
Monin-Obukhov Length (m)	357.1605	-3.6184	2125.1180	0.0032

Table 3. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Summer

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.0868	0.2465	2.2558	0.3770
Temperature (K)	0.4463	0.0015	2.5904	0.6861
Pressure (mb)	1.6714	0.0016	1.7617	0.9888
Relative Humidity (%)	3.0057	0.0360	11.6311	0.5321
Heat Flux (W/m^2)	8.5939	0.2069	78.9210	0.3121
Surface Friction Velocity, u* (m/s)	-0.0532	-0.1482	0.1837	0.2786
Monin-Obukhov Length (m)	126.2921	-2.4355	1408.2052	0.0012

Table 4. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Autumn

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.5093	0.2762	2.7494	0.5278
Temperature (K)	0.8234	0.0029	2.8958	0.8283
Pressure (mb)	1.8510	0.0018	2.0056	0.9899
Relative Humidity (%)	3.8405	0.0490	11.8813	0.6159
Heat Flux (W/m^2)	20.3745	1.1304	82.1585	0.1422
Surface Friction Velocity, u* (m/s)	-0.0417	-0.0969	0.1962	0.3812
Monin-Obukhov Length (m)	174.7388	-4.2773	1723.0255	0.0013

Table 5. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Winter

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.6240	0.2816	2.8700	0.5389
Temperature (K)	0.2776	0.0010	2.2347	0.8158
Pressure (mb)	2.3570	0.0023	2.6528	0.9843
Relative Humidity (%)	6.4738	0.0864	11.2628	0.7084
Heat Flux (W/m^2)	39.3413	2.9188	94.8192	0.0359
Surface Friction Velocity, u* (m/s)	-0.0040	-0.0100	0.1787	0.3759
Monin-Obukhov Length (m)	197.5257	-3.2158	1697.8060	0.0019

Table 6. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Noon (12 p.m.)

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	0.3855	0.0629	2.1036	0.5771
Temperature (K)	-1.1327	-0.0040	2.3905	0.9462
Pressure (mb)	2.0051	0.0020	2.3555	0.9805
Relative Humidity (%)	10.5748	0.1517	16.1212	0.5895
Heat Flux (W/m^2)	-2.8270	-0.0288	115.1536	0.1122
Surface Friction Velocity, u* (m/s)	-0.0857	-0.1767	0.2611	0.2548
Monin-Obukhov Length (m)	322.6108	-1.6034	1482.5204	0.0330

Table 7. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Meteorological Variables (WRF-OBS) (2018-2020) – Night (3 a.m.)

Variable	Mean Bias	Fraction Bias	RMSE	R^2
Wind Speed (m/s)	1.7172	0.3618	2.7762	0.5320
Temperature (K)	1.4598	0.0052	3.0517	0.8872
Pressure (mb)	2.1160	0.0021	2.2289	0.9919
Relative Humidity (%)	2.7485	0.0323	9.6859	0.6193
Heat Flux (W/m^2)	39.7406	-2.7006	72.8713	0.0069
Surface Friction Velocity, u* (m/s)	-0.0228	-0.0645	0.1472	0.4611
Monin-Obukhov Length (m)	-59.9295	-0.3501	1382.0127	0.0037

DISPERSION MODELING USING OBS vs. WRF METEOROLOGICAL DATA

AERMOD (version 22112) was used to compare air dispersion modeling results for two different locations:

1) An overland location, corresponding to the KMVY airport location
2) An overwater location, corresponding to the location of the BB buoy

AERMOD was run twice for each location, (1) using the OBS processed AERMET data and (2) using the WRF data as extracted from MMIF in AERMOD-ready surface and profile file format.

The goal of this aspect of the study was to compare the modeled concentrations using an observed data set and a meteorological model data set (OBS and WRF). With this goal in mind, it is appropriate to assign typical source parameters at an arbitrary location for all AERMOD runs. Chosen parameters for the model comparison were as follows:

- Point source at coordinates UTMX = 0, UTMY = 0, and elevation = 0
- Emission rate of 7.94 lb/hr (1 g/s)
- Stack height of 65.62 ft (20 m)
- Gas exit temperature of 80.33 Fahrenheit (300 K)
- Gas exit velocity at 65.62 ft/s (20 m/s)
- Stack diameter of 6.56 ft (2 m)
- Receptor grid with 656.17-ft (200-m) spacing over a 6.21-mi by 6.21-mi (10-km by 10-km domain
- Flat terrain

Concentration values were calculated over the entire three-year period for the whole receptor grid and were sorted highest to lowest. The highest modeled concentrations using the WRF and OBS data were compared and used to generate plots as described below.

Figures 8 through 11 show the comparison between independently ranked concentrations for 1-hour and 24-hour averaging periods for both the overland (KMVY) and overwater (BB) locations. The screening plots (Figures 12 through 15) show the bias of the average and bias of the standard deviation between the 2 data sets. Figures 16 through 19 show the distribution of fractional bias between the OBS and WRF data. The short horizontal lines indicate the 95th, 50th, mean, and 5th percentiles for the fractional bias between the OBS and WRF concentration values.

Overland and Overwater Modeling Results

Figure 8 shows that there is fairly good agreement between the OBS and WRF data, however for the very highest concentrations, the WRF slightly has lower model concentrations relative to the OBS data. Figure 9 indicates very good agreement between the OBS and WRF data for the low values, while the WRF shows slightly higher model concentrations for a majority of the highest model concentrations using the OBS data. However, all the overland data points for the 1-hour and 24-hour period are within the 2x upper and lower lines. Figure 10 and Figure 11 both show a general trend of the WRF with higher model concentrations at all levels. However, most of the data points including all the high concentrations are easily within the 2x upper limit, indicating good agreement.

All the screening plots show a negative mean bias indicating that, on average, the WRF data have higher modeled concentrations. Both the overland mean biases are within the 0.67 box range, indicating good agreement. The overwater screening results reveal a stronger negative bias which is intuitive when considering the corresponding Figures 10 and 11. The bias of the standard deviation is less than +/- 0.4 for all the screening plots (except 24-hour overland), indicating that the difference in deviation between the WRF and OBS data sets is small.

Figures 16 and 17 (overland) show that for most of the data there is a slight to moderate negative fractional bias, indicating that use of the WRF yielded higher model concentrations compared to use of the OBS data, with the magnitude of the bias slightly greater for the 24-hour period. Figures 18 and 19 (overwater) demonstrate a negative bias in all the data, as expected, with the magnitude of the bias being greater than the overland results. The 24-hour period shows the largest negative bias, illustrating the vertical displacement of the data points in Figure 11 above the linear “wrf=obs” line.

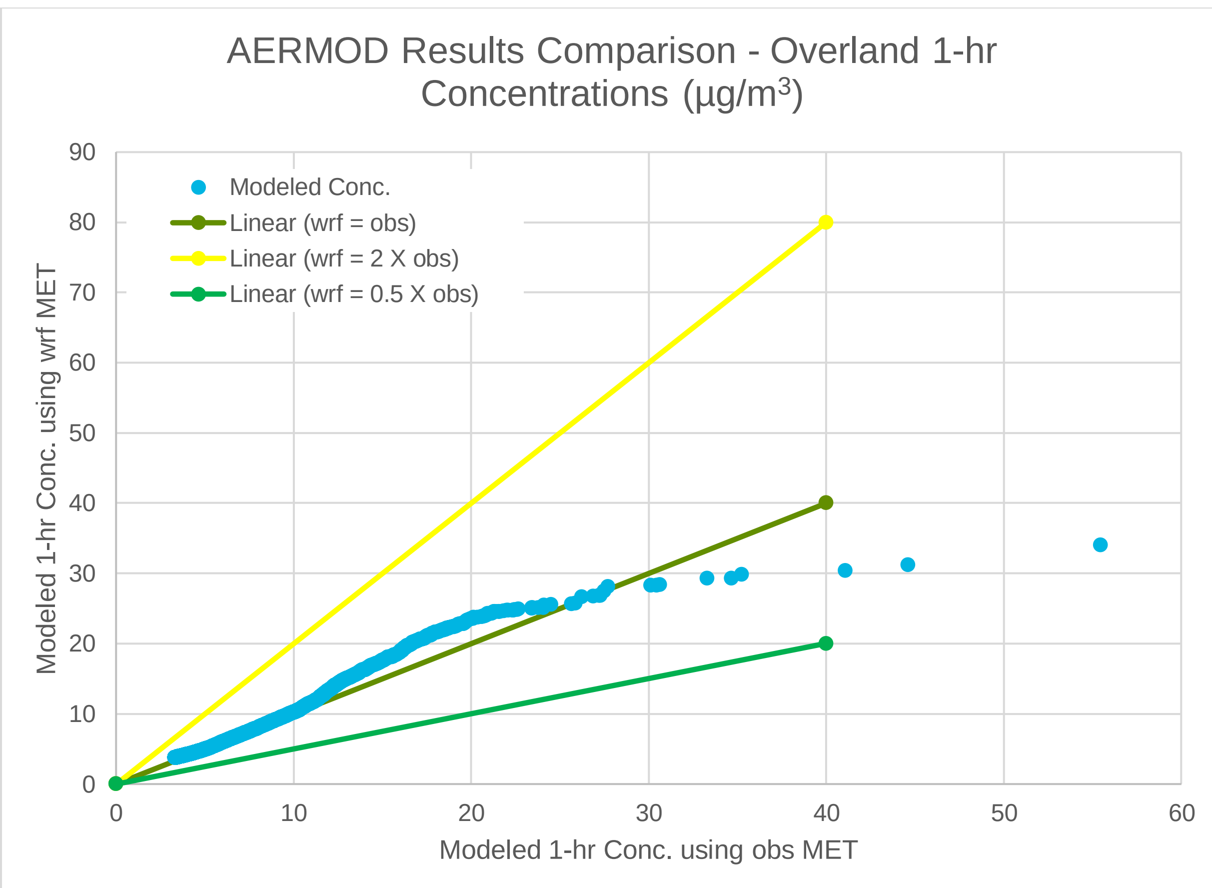


Figure 8. Overland Plot for 1-hour Averages

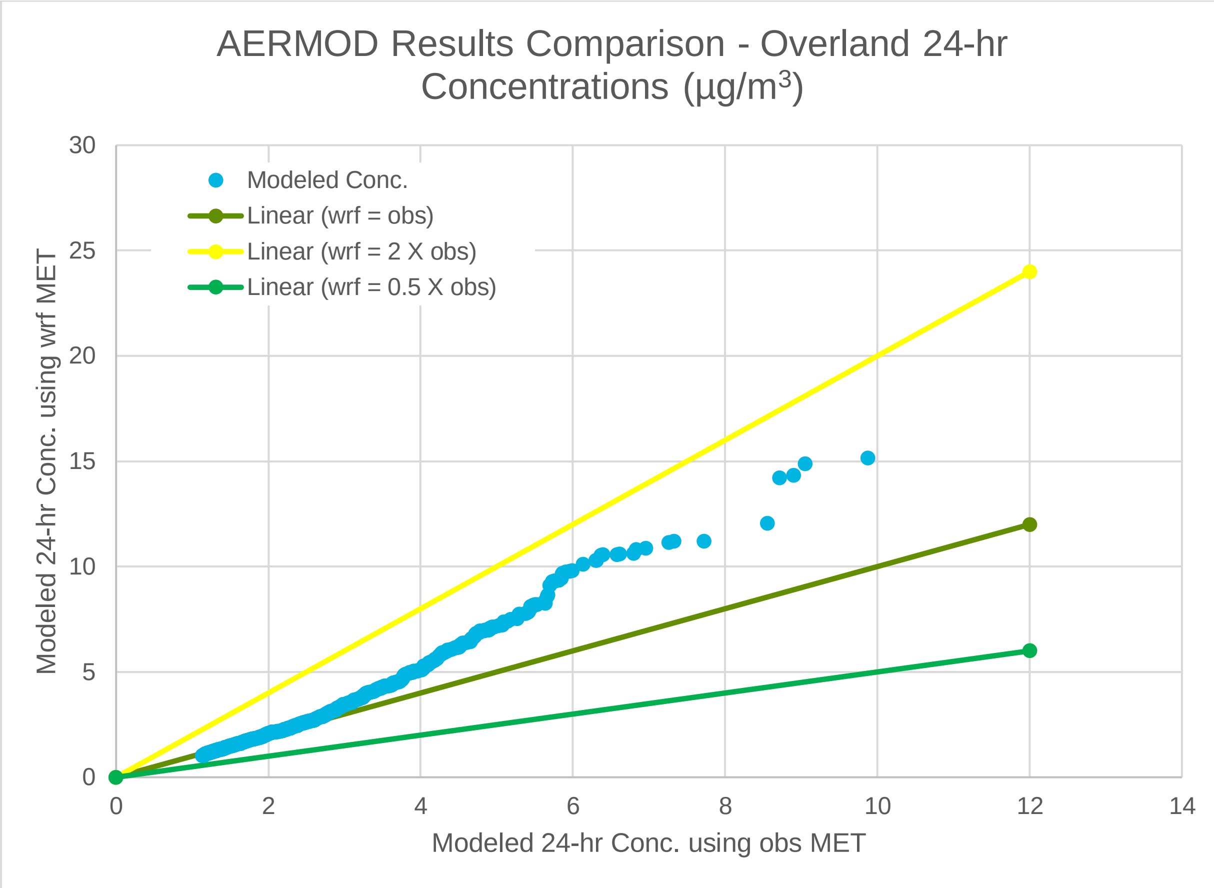


Figure 9. Overland Plot for 24-hour Averages

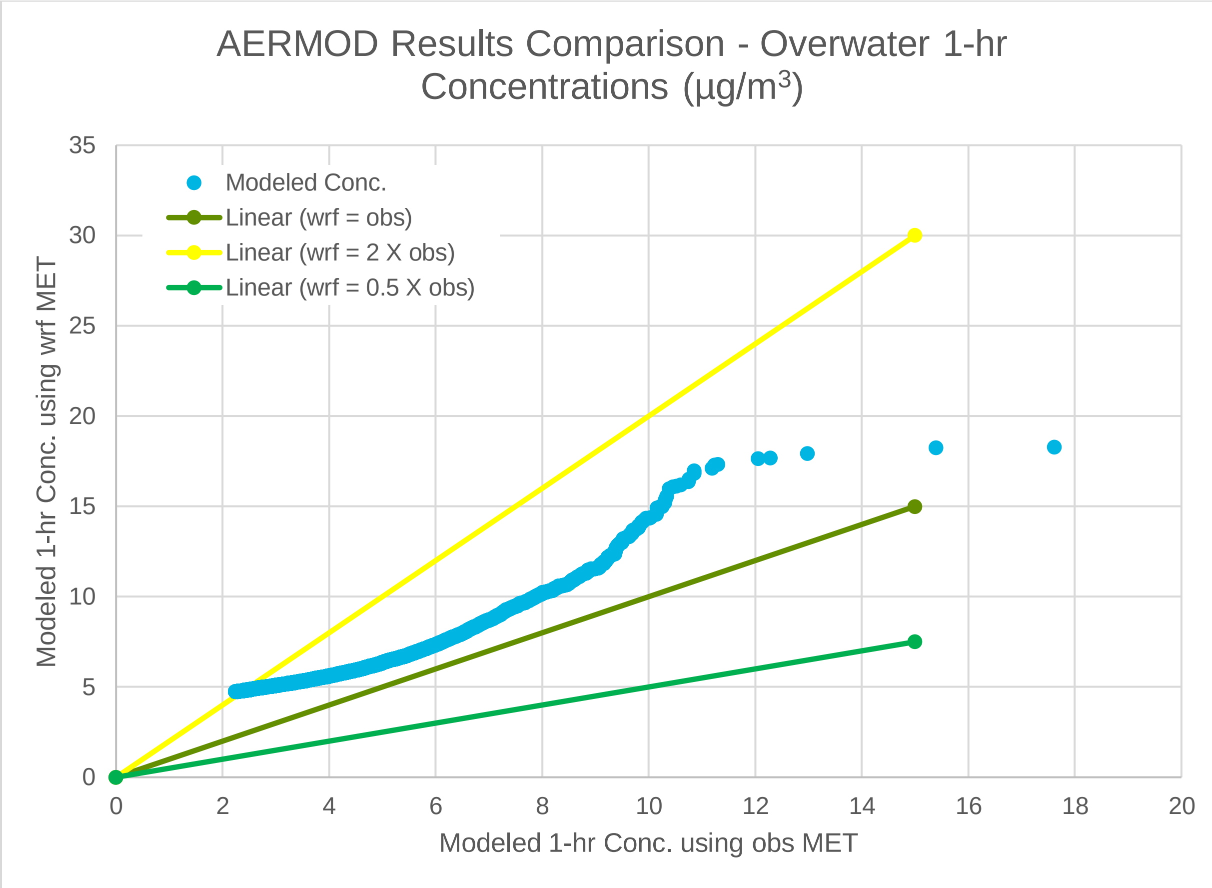


Figure 10. Overwater Plot for 1-hour Averages

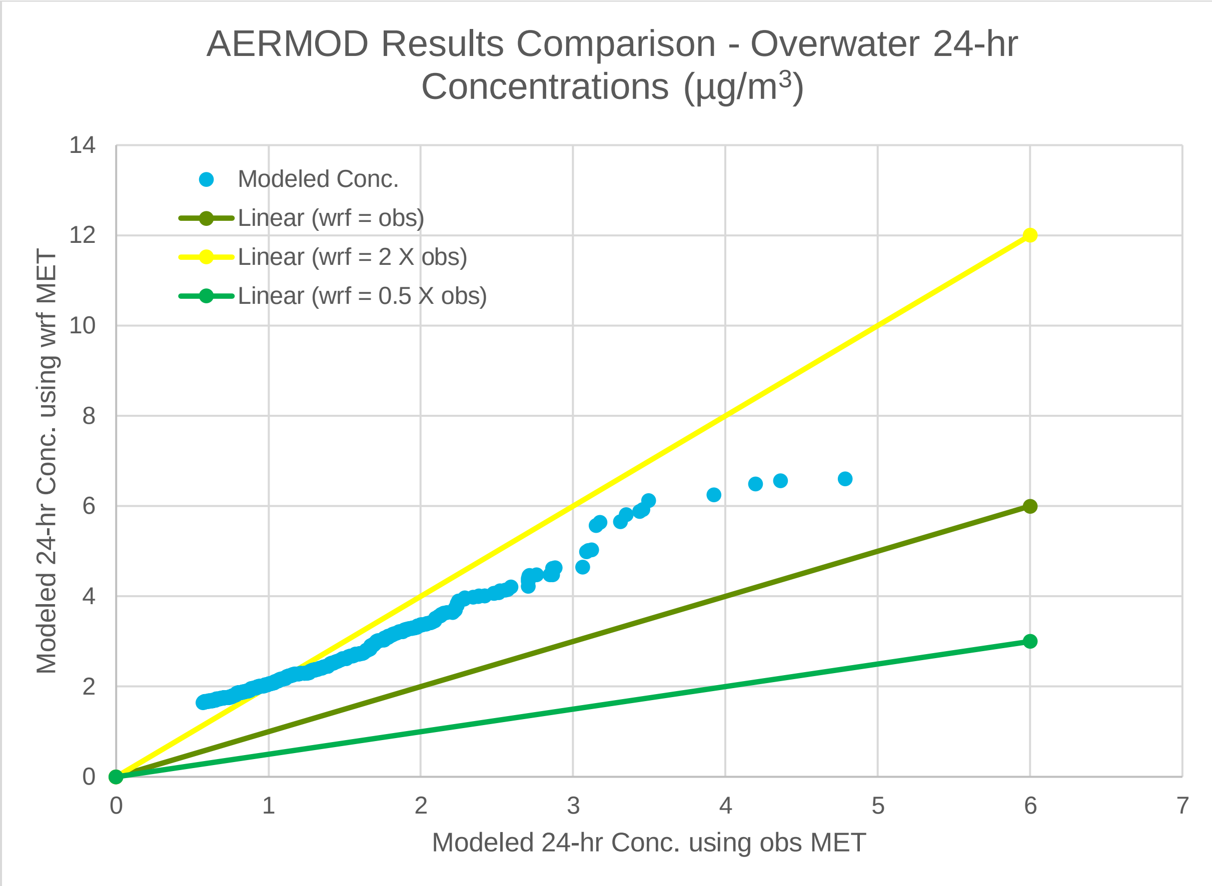


Figure 11. Overwater Plot for 24-hour Averages

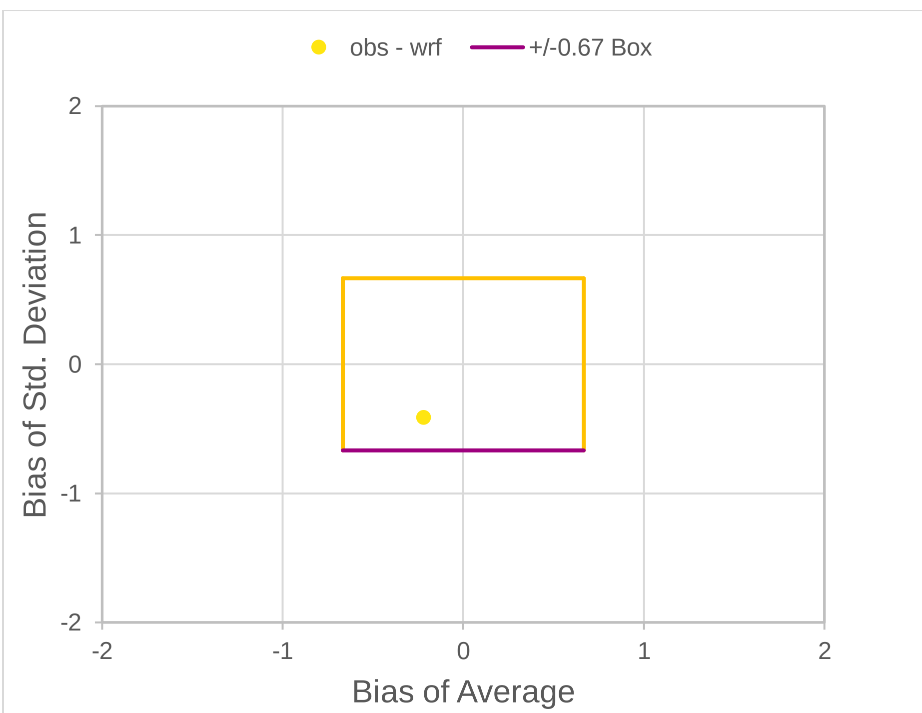


Figure 12. Land 1-hour Average Concentration Screening Results

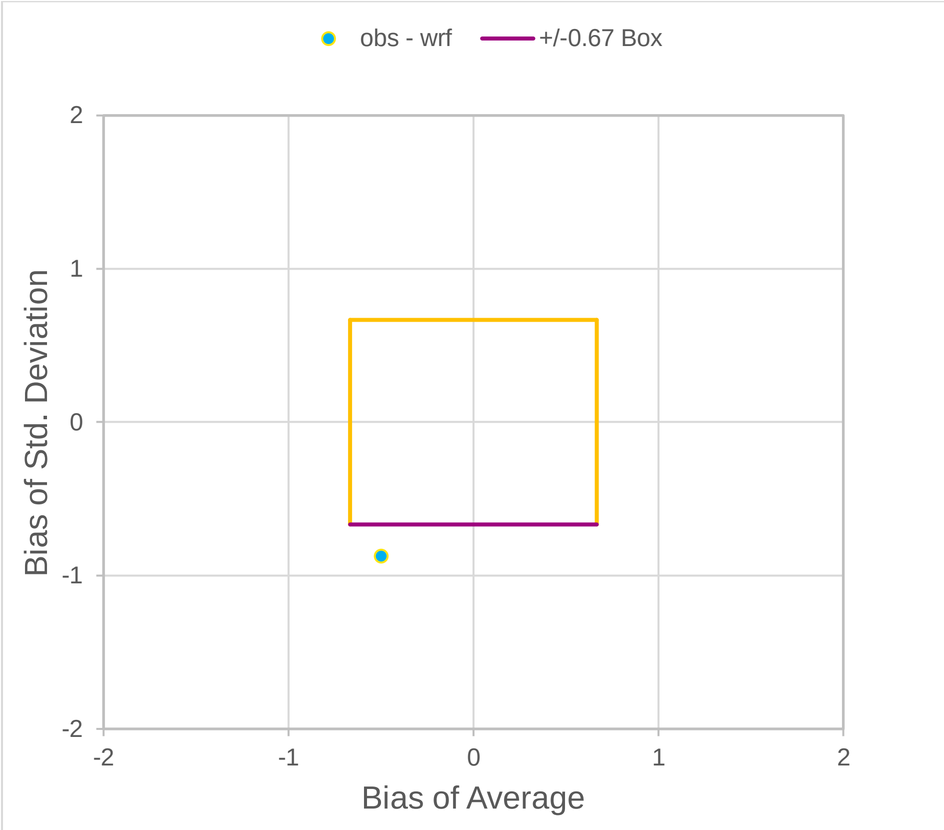


Figure 13. Land 24-hour Average Concentration Screening Results

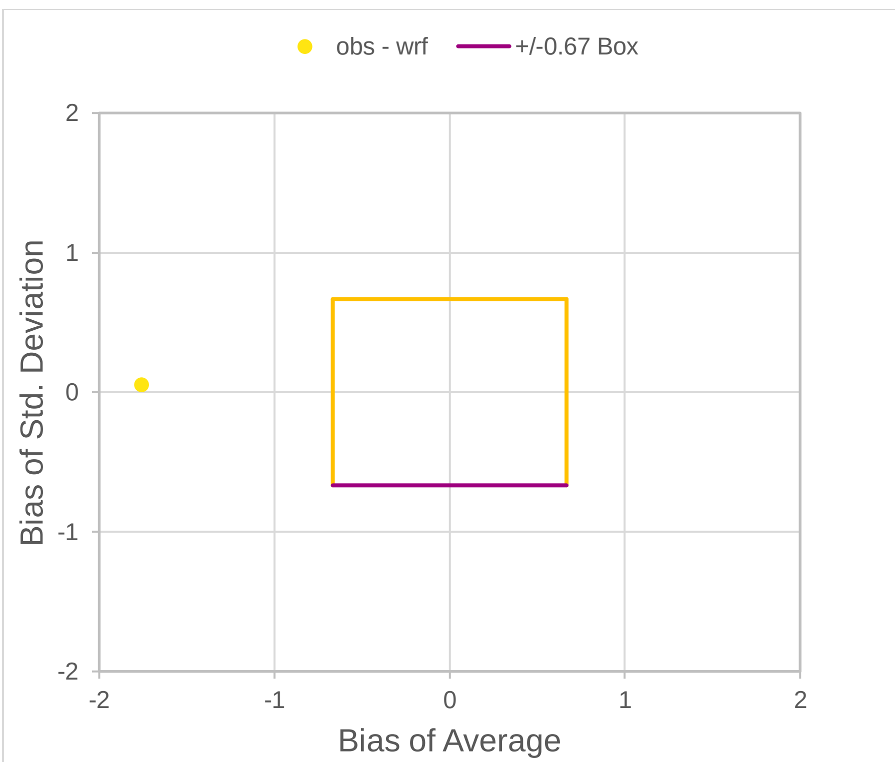


Figure 14. Overwater 1-hour Average Concentration Screening Results

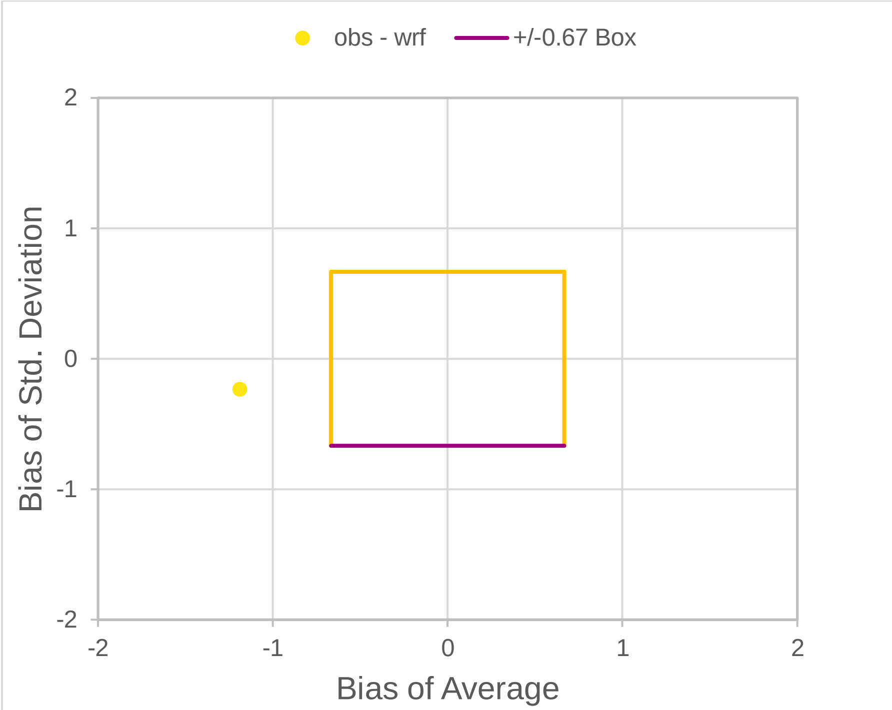


Figure 15. Overwater 24-hour Average Concentration Screening Results

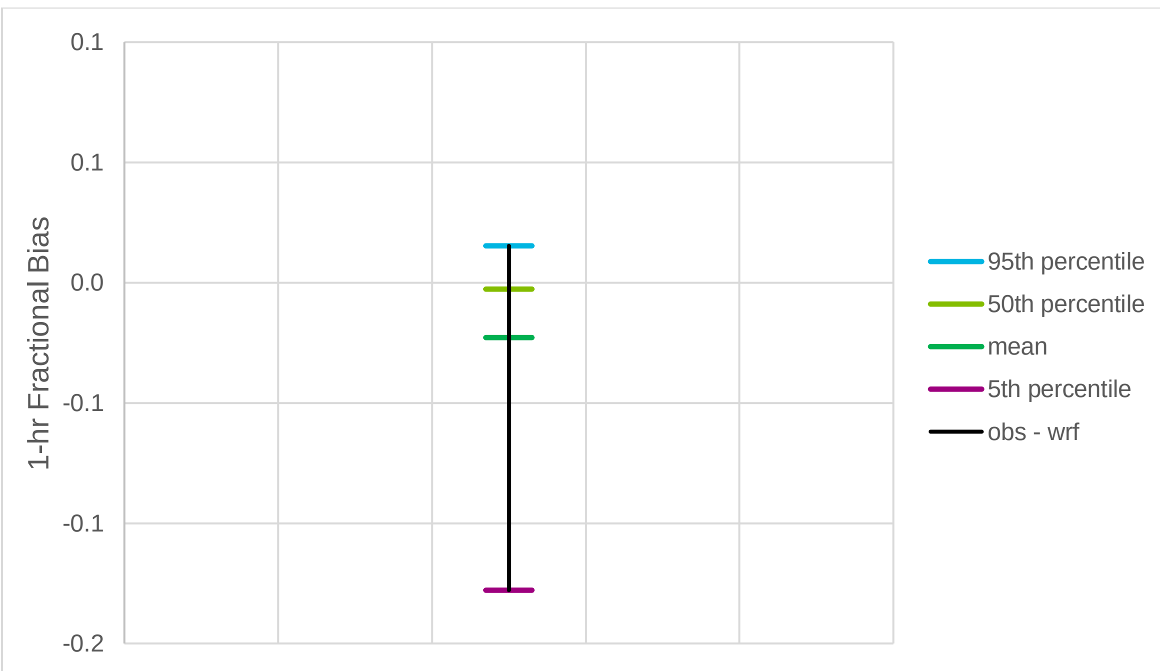


Figure 16. Land Fractional Biases for 1-hour Average Concentrations

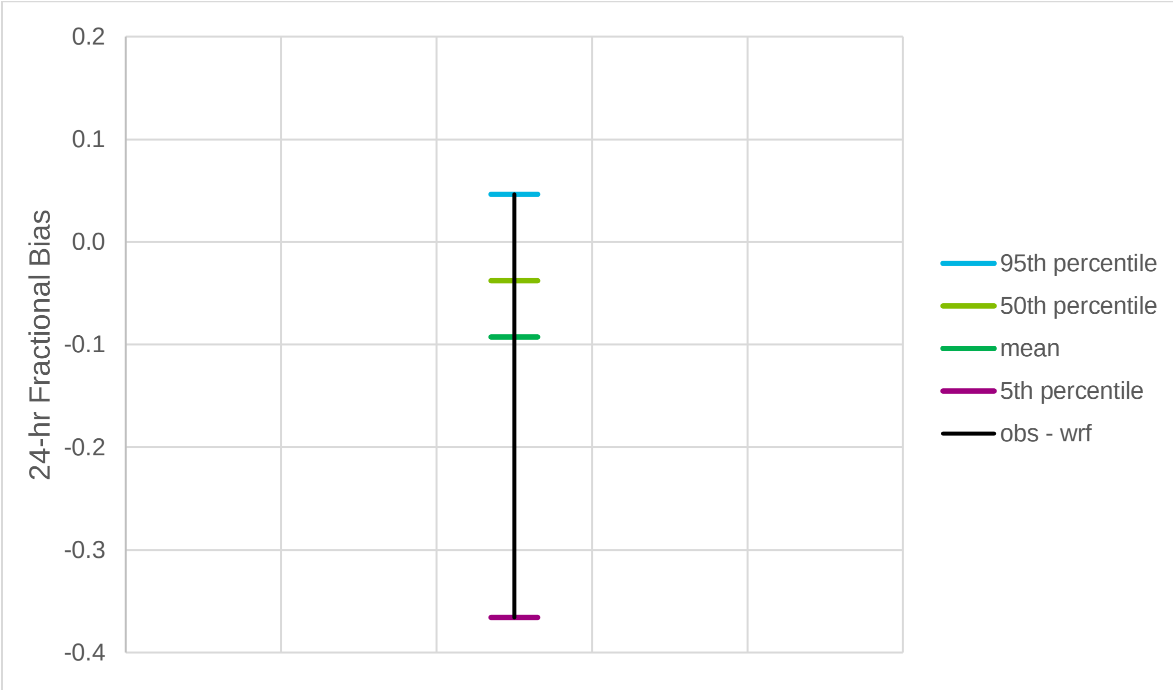


Figure 17. Land Fractional Biases for 24-hour Average Concentrations

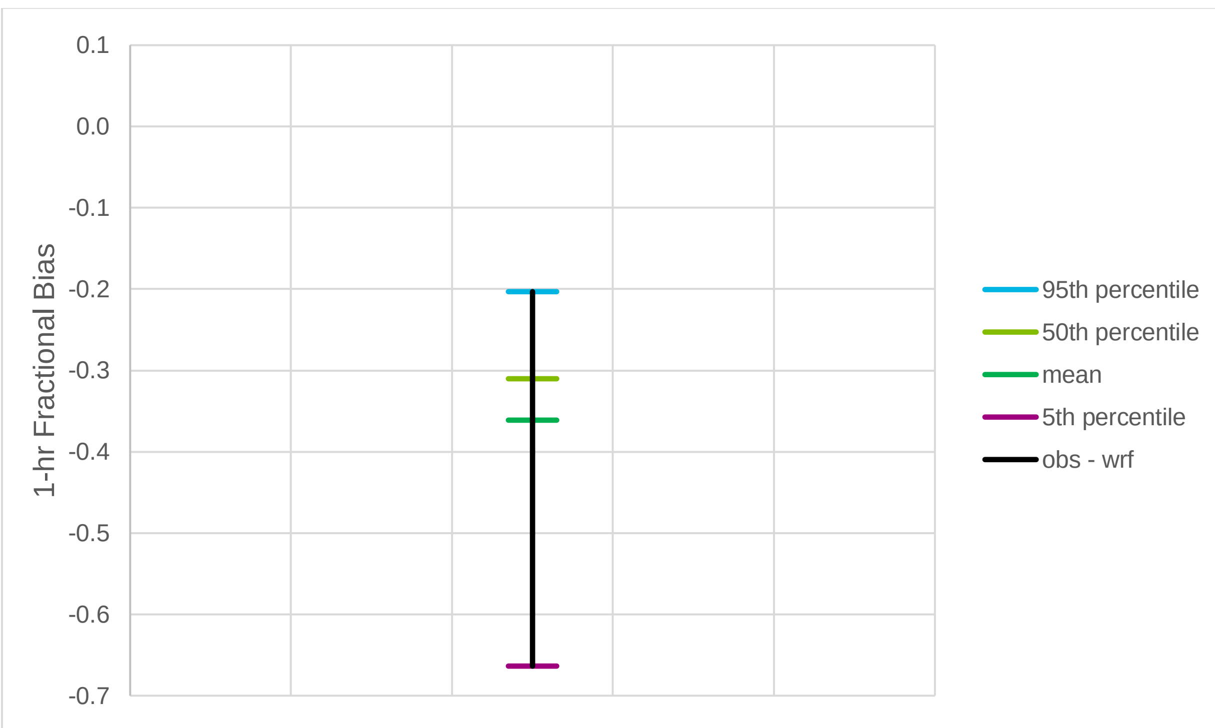


Figure 18. Overwater Fractional Biases for 1-hour Average Concentrations

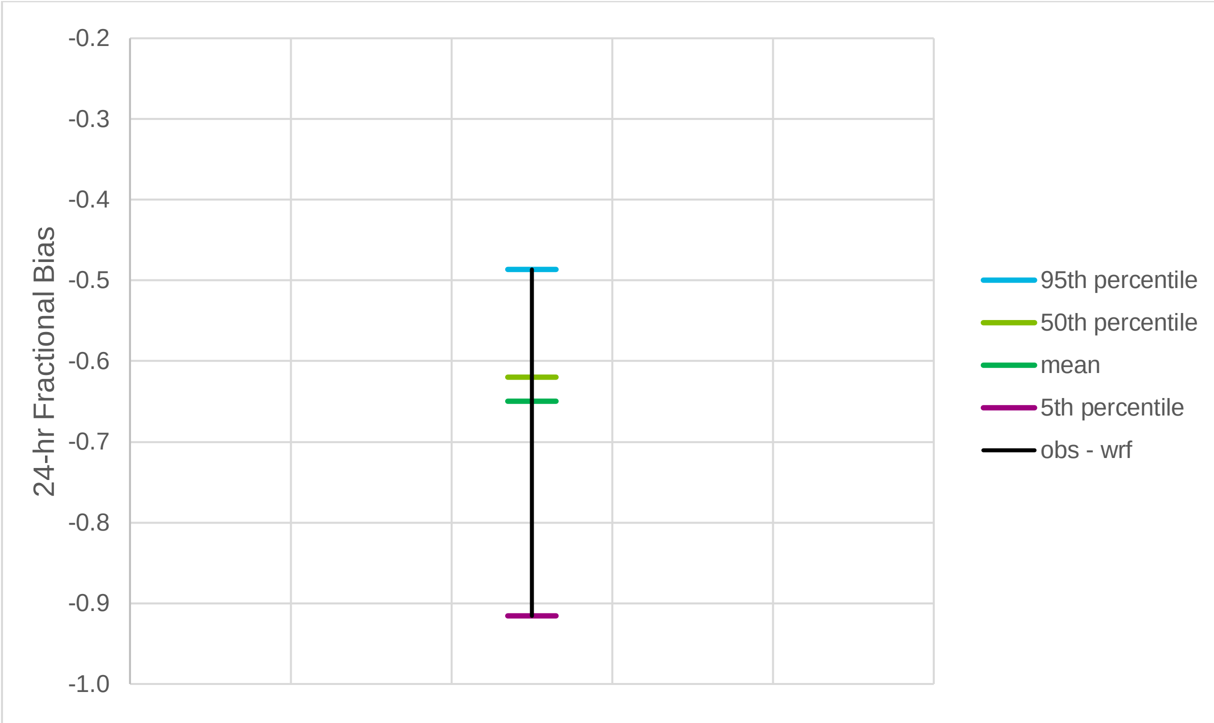


Figure 19. Overwater Fractional Biases for 24-hour Average Concentrations

<u>Dispersion Modeling Analysis Conclusions</u>

Overall, there is good agreement between the concentrations modeled with WRF and OBS datasets with the highest concentrations being between the 2x lines on Figures 8 through 11. As described above, there is some variation depending on the location, averaging time, and concentration, but overall, there is a negative bias. Therefore, the study indicates that using WRF data can be expected to result in slightly higher modeled concentrations in most scenarios.

Furthermore, use of the WRF data within the OCD model is also expected to yield more conservative concentrations when compared to using OBS data. While this study used the AERMOD model, the results are applicable to the OCD model since this analysis only examined the modeled concentrations using different meteorological data for a single point source.

ATTACHMENT 2 – Vessel Information by Scenario

Mayflower Wind Dispersion Modeling Protocol
Attachment 2
Vessel Information by Scenario

Scenario 1 - Scour Protection / Seabed Prep [CONSTRUCTION SCENARIO]				Scenario 2 - Foundation Installation, Monopile [CONSTRUCTION SCENARIO]				Scenario 3 - Foundation Installation, Transition Piece [CONSTRUCTION SCENARIO]			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**
Multipurpose Support Vessel 1	2	24	Seabed prep, pre-installation inspection survey, general support	Airplane	1	1	Crew/materials transport, 1 roundtrip per day	Heavy Lift Crane Installation Vessel 2	1	24	Foundation installation vessel
Scour Protection Installation Vessel	1	24	Scour protection installation	Helicopter	1	1	Crew/materials transport, 1 roundtrip per day	Multipurpose Support Vessel 1	1	24	Grout vessel / general purpose
				Crew Transfer Vessel	1	12	Crew transport	Tugboat 1	2	24	Materials / barge transport
				Heavy Lift Crane Installation Vessel 1	1	24	Foundation installation vessel				
				Multipurpose Support Vessel 1	2	24	Environmental monitoring, Marine observation				
				Multipurpose Support Vessel 2	1	24	Bubble curtain				
				Tugboat 1	2	24	Materials / barge transport				
				Pile-Driving Hammer	1	5	Pile installation				
				Air compressors for noise mitigation	30	6	Noise mitigation, bubble curtain				

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Scenario 4 - Export Cable - Installation Survey and Seafloor Prep [CONSTRUCTION SCENARIO]				Scenario 5 - Export Cable Lay [CONSTRUCTION SCENARIO]			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**
Helicopter	1	1	Crew/materials transport, 1 roundtrip per day	Anchor Handling Tug	1	24	General support
Anchor Handling Tug	1	24	General support	Cable Transport & Lay Vessel 2	1	24	Cable laying
Crew Transfer Vessel	1	12	Crew transport	Multipurpose Support Vessel 2	1	24	General support
Multipurpose Support Vessel 1	1	24	Seafloor survey vessel	Multipurpose Support Vessel 3	1	24	Various installation and burial equipment, cable protection installation
Multipurpose Support Vessel 2	2	24	Seafloor prep, pre-lay grapnel run, obstacle removal	Guard Vessels	5	24	Observation along cable route
Multipurpose Support Vessel 3	1	24	Seafloor prep, pre-lay grapnel run, obstacle removal				

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Scenario 6 - Inter Array Cable - Installation Survey and Seafloor Prep [CONSTRUCTION SCENARIO]				Scenario 7 - Inter Array Cable Lay, Burial, & Termination [CONSTRUCTION SCENARIO]			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**
Helicopter	1	1	Crew/materials transport, 1 roundtrip per day	Cable Transport & Lay Vessel 1	1	24	Cable laying
Crew Transfer Vessel	1	12	Crew transport	Multipurpose Support Vessel 2	1	24	Various installation and burial equipment, cable protection installation
Multipurpose Support Vessel 2	1	24	Seafloor prep, pre-lay grapnel run, obstacle removal	Multipurpose Support Vessel 3	1	24	Various installation and burial equipment, cable protection installation,
Multipurpose Support Vessel 3	1	24	General support / Tug				
Survey Vessel	1	24	Seafloor survey vessel				

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Scenario 8 - OSP Installation [CONSTRUCTION SCENARIO]				**Scenario 9 - OSP Commisioning [CONSTRUCTION SCENARIO]**			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**
Airplane	1	1	Crew/materials transport, 1 roundtrip per day	Helicopter	1	1	Crew/materials tranport, 1 roundtrip per day
Helicopter	1	1	Crew/materials transport, 1 roundtrip per day	Crew Transfer Vessel	1	12	Crew transport
Crew Transfer Vessel	1	12	Crew transport	DP Accomodation Vessel	1	24	Crew accomodations
Heavy Lift Crane Installation Vessel	1	24	OSP installation vessel	Multipurpose Support Vessel 1	1	24	Environmental monitoring, Marine observation
Heavy Lift Transport Vessel	2	24	Transport OSP pieces	2 MVA (Tier 2 generator)	1	24	Aid in commissioing
Multipurpose Support Vessel 1	2	24	Environmental monitoring, Marine observation				
Multipurpose Support Vessel 2	1	24	Bubble curtain				
Tugboat 1	4	24	General support				
Air compressors for noise mitigation	30	12	Noise mitigation, bubble curtain				

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Scenario 10 - WTG Installation [CONSTRUCTION SCENARIO]				Scenario 11 - WTG Commissioning [CONSTRUCTION SCENARIO]			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/ day**	**Purpose**
Airplane	1	1	Crew/materials transport, 1 roundtrip per day	Crew Transfer Vessel	2	12	Crew Transport
Crew Transfer Vessel	1	12	Crew Transport	Multipurpose Support Vessel 2	1	24	General Support
Helicopter	1	1	Crew/materials transport, 1 roundtrip per day	Service Operations Vessel	1	24	Crew accomodations
Jack-up Installation Vessel	1	24	WTG installation vessel	WTG Backup Gens 150 kW	60	24	Backup power generation
Multipurpose Support Vessel 2	1	24	General support				
Service Operations Vessel	1	24	WTG installation, crew accomodations				
Tugboat 2	4	24	General support				

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Scenario 12 - Daily Inspection O&M [O&M SCENARIO]				Scenario 13 - WTG and OSP Maintenance / Major Repair [O&M SCENARIO]			
Emission Source	**# / day**	**Hrs/ day**	**Purpose**	**Emission Source**	**# / day**	**Hrs/day**	**Purpose**
Helicopter	1		Crew/materials transport, 1 roundtrip per day	Crew Transfer Vessel	1	12	Crew Transport
Crew Transfer Vessel	1	12	Crew Transport	Jack-up Vessel	1	24	Crew accomodations
Service Operations Vessel	1	24	Crew accomodations	Service Operations Vessel	1	24	Crew accomodations
				Tugboat 2	2	24	General support, transport of repair equipment
				Multipurpose Support Vessel 2	1	24	General Support

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

ATTACHMENT 3 – Annual Vessel Assumptions

Vessel Annual Assumptions

Package (Short-Term Scenarios Included)	Emission Source	Count[1]	Hrs/day	Est. Days[2]	Est. Trips/ Vessel[3]
FOU (Scenarios 1-3)	Airplane (single-engine helicopter)	1	0.37[4]	57[5]	57
FOU (Scenarios 1-3)	Helicopter (twin heavy)	1	0.31[4]	29[6]	29
FOU (Scenarios 1-3)	Crew Transfer Vessel	1	12	200	200
FOU (Scenarios 1-3)	Heavy Lift Crane Installation Vessel 1	1	24	200	3
FOU (Scenarios 1-3)	Heavy Lift Crane Installation Vessel 2	1	24	200	3
FOU (Scenarios 1-3)	Multipurpose Support Vessel 1	2[7]	24	200	30
FOU (Scenarios 1-3)	Multipurpose Support Vessel 2	1	24	200	30
FOU (Scenarios 1-3)	Scour Protection Installation Vessel	1	24	200	20
FOU (Scenarios 1-3)	Tugboat 1	4	24	200	28
FOU (Scenarios 1-3)	Pile Driving Hammer Engines	3	5	85	--
FOU (Scenarios 1-3)	Air Compressor Engines	30	6	85	--
OEC (Scenarios 4-5)	Helicopter (twin heavy)	1	0.31[4]	30	30
OEC (Scenarios 4-5)	Anchor Handling Tug	2	24	120	8
OEC (Scenarios 4-5)	Cable Transport & Lay Vessel 2	1	24	240	4
OEC (Scenarios 4-5)	Crew Transfer Vessel	1	24	240	64
OEC (Scenarios 4-5)	Multipurpose Support Vessel 2	4	24	240	40
OEC (Scenarios 4-5)	Multipurpose Support Vessel 3	1	24	240	4
OEC (Scenarios 4-5)	Multipurpose Support Vessel 3	1	24	120	16
OEC (Scenarios 4-5)	Guard Vessels	5	24	60	6
IAC (Scenarios 6 - 7)	Helicopter (twin heavy)	1	0.31[4]	30	30
IAC (Scenarios 6 - 7)	Cable Transport & Lay Vessel 1	1	24	225	40
IAC (Scenarios 6 - 7)	Crew Transfer Vessel	1	12	225	40
IAC (Scenarios 6 - 7)	Multipurpose Support Vessel 2	2	24	225	40
IAC (Scenarios 6 - 7)	Multipurpose Support Vessel 3	1	24	225	4
IAC (Scenarios 6 - 7)	Survey Vessel	1	24	60	6
OSP (Scenarios 8 - 9)	Airplane (single-engine helicopter)	1	0.37[4]	4[5]	4
OSP (Scenarios 8 - 9)	Helicopter (twin heavy)	1	0.31[4]	51[6]	51
OSP (Scenarios 8 - 9)	Crew Transfer Vessel	1	12	75	75
OSP (Scenarios 8 - 9)	DP Accomodation Vessel	1	24	360	8
OSP (Scenarios 8 - 9)	Heavy Lift Crane Installation Vessel	1	24	14	3
OSP (Scenarios 8 - 9)	Heavy Lift Transport Vessel	2	24	14	3
OSP (Scenarios 8 - 9)	Multipurpose Support Vessel 1	2	24	14	3
OSP (Scenarios 8 - 9)	Multipurpose Support Vessel 2	1	24	14	3
OSP (Scenarios 8 - 9)	Multipurpose Support Vessel 2	1	24	360	80
OSP (Scenarios 8 - 9)	Tugboat 1	4	24	14	5
OSP (Scenarios 8 - 9)	Air Compressor Engines	30	12	14	--
OSP (Scenarios 8 - 9)	2 MVA Generator	1	24	180	--

Package (Short-Term Scenarios Included)	Emission Source	Count[1]	Hrs/day	Est. Days[2]	Est. Trips/ Vessel[3]
WTG (Scenarios 10 - 11)	Airplane (single-engine helicopter)	1	0.37[4]	69[5]	69
WTG (Scenarios 10 - 11)	Helicopter (twin heavy)	1	0.31[4]	34[6]	34
WTG (Scenarios 10 - 11)	Crew Transfer Vessel	3	12	240	240
WTG (Scenarios 10 - 11)	Jack-Up Installation Vessel	1	24	240	7
WTG (Scenarios 10 - 11)	Multipurpose Support Vessel 2	2	24	240	80
WTG (Scenarios 10 - 11)	Service Operations Vessel	1	24	240	240
WTG (Scenarios 10 - 11)	Tugboat 2	4	24	240	95
WTG (Scenarios 10 - 11)	150 kW Generators	60	24	40	--
O&M (Scenarios 12-13)	Helicopter (twin medium)	1	0.31[4]	60	60
O&M (Scenarios 12-13)	Crew Transfer Vessel	1	12	365	365
O&M (Scenarios 12-13)	Crew Transfer Vessel	1	12	90	90
O&M (Scenarios 12-13)	Jack-Up Installation Vessel	1	24	90	1
O&M (Scenarios 12-13)	Multipurpose Support Vessel 2	2	24	240	80
O&M (Scenarios 12-13)	Service Operations Vessel	1	24	365	12
O&M (Scenarios 12-13)	Service Operations Vessel	1	24	90	12
O&M (Scenarios 12-13)	Tugboat 2	2	24	90	12

FOU - Foundation Installation, OEC - Offshore Export Cable Installation, IAC - Inter-Array Cable Installation,
OSP - OSP Install & Commissioning, WTG - WTG Install & Commissioning,

Notes:

(1) Number of total vessels used per year for all listed scenarios combined.

(2) For construction scenarios, total estimated days during Project 1 construction, assumed to be worst-case year. For O&M scenarios, estimated days/yr.

(3) For construction scenarios, total estimated trips from edge of OCS permit area to Lease Area during Project 1 construction. For O&M scenarios, estimated trips/yr.

(4) Hours/day for aircraft based on BOEM default speeds (BOEM 2021) and duration to reach edge of OCS permit area, assuming up to 1 round trip per day.

(5) Assumes 2 trips/week.

(6) Assumes 1 trip/week.

(7) It is conservatively assumed these vessels could simultaneously support short-term Scenarios 1, 2, & 3 during the same day at different locations even though realistically they would only be able to support one scenario at a time.

	Helicopter Hours/day	
OSC permit area = 25nm =	28.8 mi	time to edge of OCS
Single engin copter	157.5 mph	0.37 hr
twin med copter	182.6 mph	0.32 hr
twin heavy copter	188.2 mph	0.31 hr

ATTACHMENT 4 – Emission Factors and Vessel Characteristics

	Main Engine Specs			Vessel Main Engine Emission Factors (g/kW-hr)					Auxiliary Engine Specs			Vessel Auxiliary Engine Emission Factors (g/kW-hr)				
Vessel Type	Total Rating[(1)] (kW)	EPA Category	Engine Tier	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	Total Rating[(1)] (kW)	EPA Category	Engine Tier	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2
Anchor Handling Tug	9000	2	2	8.33	2.00	0.31	0.30	0.01	425	1	2	6.10	0.90	0.20	0.19	0.01
Cable Lay Vessel 1	22,760	3	2	10.50	1.10	0.19	0.17	0.40	21,830	3	2	10.50	1.10	0.19	0.17	0.40
Cable Lay Vessel 2	20,700	3	2	10.50	1.10	0.19	0.17	0.40	1,300	2	2	8.33	2.00	0.31	0.30	0.01
Cable Lay Barge	600	2	2	8.33	2.00	0.31	0.30	0.01	850	2	2	8.33	2.00	0.31	0.30	0.01
Crew Transfer Vessel	2,352	1	3	1.30	1.10	0.03	0.03	0.01	874	1	3	4.89	0.90	0.08	0.08	0.01
Jack-Up	18,120	3	2	10.50	1.10	0.19	0.17	0.40	895[(3)]	2	2	8.33	2.00	0.31	0.30	0.01
Heavy Crane Vessel 1	89,600	3	2	10.50	1.10	0.19	0.17	0.40	5,400	3	2	10.50	1.10	0.19	0.17	0.40
Heavy Crane Vessel 2	22,380	3	2	10.50	1.10	0.19	0.17	0.40	3020[(2)]	2	2	8.33	2.00	0.31	0.30	0.01
Heavy Lift Transport	12,640	3	1	12.20	1.10	0.19	0.17	0.40	11,000	2	1	10.55	2.48	0.21	0.20	0.01
DP Accommodation Vessel	21,180	3	2	10.50	1.10	0.19	0.17	0.40	3020[(2)]	2	2	8.33	2.00	0.31	0.30	0.01
Multipurpose Support Vessel 1	671	1	2	6.10	1.10	0.12	0.12	0.01	209	1	2	6.10	0.90	0.20	0.19	0.01
Multipurpose Support Vessel 2	3,840	2	2	8.33	2.00	0.31	0.30	0.01	2870	1	2	6.10	0.90	0.20	0.19	0.01
Multipurpose Support Vessel 3	7,670	2	2	8.33	2.00	0.31	0.30	0.01	874[(4)]	2	2	8.33	2.00	0.31	0.30	0.01
Scour Protection Installation Vess	7,300	3	1	12.20	1.10	0.19	0.17	0.40	9966	2	1	10.55	2.48	0.21	0.20	0.01
Service Operations Vessel	4,900	3	2	10.50	1.10	0.19	0.17	0.40	6,640	3	3	2.60	1.10	0.19	0.17	0.40
Survey Vessel	3,900	2	0	13.36	2.48	0.21	0.20	0.01	540	2	0	13.36	2.48	0.21	0.20	0.01
Tugboat 1	5,420	2	2	8.33	2.00	0.31	0.30	0.01	846	1	2	6.10	0.90	0.20	0.19	0.01
Tugboat 2	2,908	2	0	13.36	2.48	0.21	0.20	0.01	110	1	1	9.20	1.80	0.21	0.20	0.01
Tugboat 3	2,237	2	0	13.36	2.48	0.21	0.20	0.01	140	1	1	9.20	1.80	0.21	0.20	0.01

Notes:
(1) Total rating of representative vessel.
(2) Due to lack of information, BOEM Tool default rating for barge type vessel auxiliary engine used (BOEM 2021).
(3) Due to lack of information, BOEM Tool default rating for jack-up type vessel auxiliary engine used (BOEM 2021).
(4) Due to lack of information, BOEM Tool default rating for supply vessel auxiliary engine used (BOEM 2021).

Load Factors:

Engine Type	Activity	Category	Factor	Reference[1]
Main Propulsion	Maneuvering	Cat 3	0.2	BOEM Emissions Tool (2021)[2]
Main Propulsion	Transit	Cat 3	0.82	BOEM Emissions Tool (2021)[2]
Auxiliary Engine	Maneuvering	Cat 3	0.45	USEPA Port Emissions Guidance (2009)[3] (miscellaneous ship, maneuver)
Auxiliary Engine	Transit	Cat 3	0.27	USEPA Port Emissions Guidance (2009)[3] (miscellaneous ship, RSZ)
Main Propulsion	Maneuvering	Cat 1/ Cat 2	0.2	BOEM Emissions Tool (2021)[2]
Auxiliary Engine	Manuevering & Transit	Cat 1/ Cat 2	0.43	USEPA Port Emissions Guidance (2022)[4]

Notes:

(1) Available BOEM and USEPA guidance was considered in order to determine appropriate load factors to assign to vessels during transit to/from the Lease Area as well as maneuvering within the Lease Area during Project-related activities.

(2) The 2022 USEPA Port Emissions guidance outlines a resource-intenstive methodology to develop vessel-specific load factors for main propulsion engines for ocean-going vessels (OGV, generally USEPA Category 3) (USEPA 2022). As an alternative, default load factors from the BOEM Tool 2.0 (BOEM 2021) are proposed.

(3) The 2022 USEPA Port Emissions guidance provides defualt auxiliary engine loads that acounts for the engine size and load factor combined (USEPA 2022). Load factors alone are not provided. Since Mayflower has estimated power ratings for the auxilliary engines for most of the representative Category 3 vessel types intended to be used, another source of load factors alone was sought. The BOEM Tool 2.0 (BOEM 2021) includes a default load factor of 1 for auxiliary engines. This appears to be conservative based on information on auxiliary engine loads provided in both the 2009 and 2022 versions of USEPA Port Emissions guidance (USEPA 2022, USEPA 2009). Since USEPA 2022 does not provide specific load factors, those provided in Table 2-7 of USEPA 2009 (for miscellaneous ship) are proposed.

(4) The 2022 USEPA Port Emissions guidance provides an auxiliary engine load factors of 0.43 for all vessels and operating modes that may be used in lieu of local data (USEPA 2022). This value is proposed for use in the current analysis.

Vessel Emission Factors

Category	Tier	Propulsion/Main Engines (g/kW-hr)					Auxiliary Engines (g/kW-hr)					Reference Notes
		NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	
1	pre-2004	11.0	1.8	0.36	0.35	0.006	11.0	1.8	0.42	0.41	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
1	1	9.2	1.8	0.19	0.18	0.006	9.2	1.8	0.21	0.20	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
1	2	6.1	1.1	0.12	0.12	0.006	6.1	0.9	0.20	0.19	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
1	3	4.8	1.1	0.07	0.07	0.006	4.9	0.9	0.08	0.08	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
1	4	1.3	1.1	0.03	0.03	0.006	1.3	1.1	0.03	0.03	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
2	pre-2004	13.4	2.48	0.21	0.20	0.006	13.4	2.48	0.21	0.20	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
2	1	10.6	2.5	0.21	0.20	0.006	10.6	2.5	0.21	0.20	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
2	2	8.3	2.0	0.31	0.30	0.006	8.3	2.0	0.31	0.30	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
2	3	6.8	2.0	0.30	0.29	0.006	6.8	2.0	0.30	0.29	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
2	4	1.3	2.0	0.05	0.05	0.006	1.3	2.0	0.05	0.05	0.006	EFs from USEPA 2022 NOx: Table H.1, CO: Table H.5, PM10/PM2.5: Table H.2, SO2: Eqn 4.5
3	1	12.2	1.1	0.19	0.17	0.40	12.2	1.1	0.19	0.17	0.40	EFs from USEPA 2022 NOx: Table 3.5, CO: Table 3.8, PM10: Eqn 3.3, SO2: Eqn 3.5, PM2.5: 92% of PM10, MGO / MDO fuel & MSD engine
3	2	10.5	1.1	0.19	0.17	0.40	10.5	1.1	0.19	0.17	0.40	EFs from USEPA 2022 NOx: Table 3.5, CO: Table 3.8, PM10: Eqn 3.3, SO2: Eqn 3.5, PM2.5: 92% of PM10, MGO / MDO fuel & MSD engine
3	3	2.6	1.1	0.19	0.17	0.40	2.6	1.1	0.19	0.17	0.40	EFs from USEPA 2022 NOx: Table 3.5, CO: Table 3.8, PM10: Eqn 3.3, SO2: Eqn 3.5, PM2.5: 92% of PM10, MGO / MDO fuel & MSD engine

Note: All emissions assume MSD and 0.1%S fuel for Cat 3 engines, and that engines will have rating > 37 kW and displacement >0.9 L/cyl

USEPA 2022. Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions. Transportation and Climate Division. Office of Transportation and Air Qual
https://www.epa.gov/state-and-local-transportation/port-emissions-inventory-guidance

Aircraft Emission Factors

Type	Propulsion/Main Engines (g/kW-hr)				
	NO_x	CO	PM_{10} (1)	$PM_{2.5}$ (1)	SO_2
Single Engine Helicopter (Surrogate for airplane)	2.32	0.07	0.07	0.07	0.3
Twin Medium Helicopter (Helicopter during O&M)	7.22	0.2	0.20	0.19	0.78
Twin Heavy Helicopter (Helicopter during construction)	34.66	0.82	0.80	0.78	2.11

Notes:
(1) PM_{10} based on 100% PM, $PM_{2.5}$ based on 97% of PM.

BOEM. 2021. BOEM Offshore Wind Energy Facilities Emission Estimating Tool – Version 2.0: User's Guide. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2021-046.
https://www.boem.gov/sites/default/files/documents/about-boem/BOEM-Wind-Power-User-Guide-V2.pdf.

Vessel Stack Parameters

Vessel	Stack Height[1] (m)	Stack Temp[2] (K)	Stack Diameter[2] (m)	Stack Exit Velocity[2] (m/s)	Deviation from vertical[3] (degrees)	Elevation of Platform Base[4] (m)
Anchor handling tug - Main Engines	17.0	555.2	0.6	10.3	45	0.0
Anchor handling tug - Aux Engines	17.0	555.2	0.2	1.8	45	0.0
Cable Transport & Lay Vessel 1 - Main Engines	44.6	555.2	0.3	20.2	45	0.0
Cable Transport & Lay Vessel 1 - Aux Engines	42.5	555.2	0.3	42.8	45	0.0
Cable Transport & Lay Vessel 2 - Main Engines	53.9	555.2	0.3	20.2	45	0.0
Cable Transport & Lay Vessel 2 - Aux Engines	53.9	555.2	0.3	42.8	45	0.0
Crew transfer vessels - Main Engines	4.8	555.2	0.2	21.5	90	0.0
Crew transfer vessels - Aux Engines	4.8	555.2	0.1	8.9	90	0.0
Jack-up vessels - Aux Engines (jacked-up)	43.0	555.2	0.6	11.4	45	7.2
Jack-up vessels - Main Engines (in transit)	35.8	879.3	0.6	6.5	45	0.0
Jack-up vessels - Aux Engines (in transit)	35.8	555.2	0.6	11.4	45	0.0
Heavy lift crane installation vessel 1 - Main Engines	89.5	555.2	1.0	5.1	0	0.0
Heavy lift crane installation vessel 1 - Aux Engines	89.5	555.2	1.0	6.8	0	0.0
Heavy lift crane installation vessel 2 - Main Engines	38.7	555.2	1.0	5.1	0	0.0
Heavy lift crane installation vessel 2 - Aux Engines	38.7	555.2	1.0	6.8	0	0.0
Heavy transport vessels - Main Engines[5]	22.6	555.2	1.0	5.1	45	0.0
Heavy transport vessels - Aux Engines[5]	22.6	555.2	1.0	6.8	45	0.0
DP Accomodation vessel - Main Engines[5]	31.5	555.2	1.0	5.1	90	0
DP Accomodation vessel - Aux Engines[5]	31.5	555.2	1.0	6.8	90	0

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Emission Factors and Vessel Characteristics

Vessel	Stack Height(1) (m)	Stack Temp(2) (K)	Stack Diameter(2) (m)	Stack Exit Velocity(2) (m/s)	Deviation from vertical(3) (degrees)	Elevation of Platform Base(4) (m)
Multi-purpose support vessel 1 - Main Engines	8.0	610.2	0.6	4.9	45	0.0
Multi-purpose support vessel 1 - Aux Engines	8.0	836.8	0.2	23.1	45	0.0
Multi-purpose support vessel 2 - Main Engines	17.5	555.2	0.3	9.3	45	0.0
Multi-purpose support vessel 2 - Aux Engines	17.5	555.2	0.2	9.5	45	0.0
Multi-purpose support vessel 3 - Main Engines	26.8	555.2	0.3	9.3	45	0.0
Multi-purpose support vessel 3 - Aux Engines	26.8	555.2	0.2	9.5	45	0.0
Scour protection installation vessels - Main Engines	23.0	555.2	1.7	1.9	45	0.0
Scour protection installation vessels - Aux Engines	23.0	555.2	1.7	0.6	45	0.0
Service operations vessel - Main Engines	26.8	555.2	0.6	8.5	45	0.0
Service operations vessel - Aux Engines	26.8	555.2	0.5	7.8	45	0.0
Survey vessels - Main Engines	29.6	664.3	0.2	14.5	45	0.0
Survey vessels - Aux Engines	29.6	712.0	0.2	13.3	45	0.0
Tugboat 1 - Main Engines	15.2	610.2	0.6	4.9	45	0.0
Tugboat 1 - Aux Engines	15.2	836.8	0.2	23.1	45	0.0
Tugboat 2 - Main Engines	10.7	610.2	0.6	4.9	45	0.0
Tugboat 2 - Aux Engines	10.7	836.8	0.2	23.1	45	0.0
Tugboat 3 - Main Engines	22.5	610.2	0.6	4.9	45	0.0
Tugboat 3 - Aux Engines	22.5	836.8	0.2	23.1	45	0.0
Helicopter(6)	48	373	0.30	6	90	0.0

Notes:
(1) Stack heights based on that for representative vessels selected for the Project.
(2) Unless otherwise noted, parameters are based on those used in the Vineyard Wind project (VW 2018) for similar vessel types.
(3) Deviation from vertical based on that for representative vessels selected for the Project.
(4) Base elevations for marine vessels assumed to be equal to mean sea level. Jack-up back elevation is 7.2 m when jacked-up, but 0 m when in transit.
(5) Assume stack parameters are similar to that for a heavy lift crane vessel.
(6) Airplane conservatively modeled as single engine helicopter, thus modeling for both helicopter and airplane will use the listed stack parameters.

This information is preliminary. Final estimates will be provided in the air permit application and will be based on the most up-to-date project design data.

Engine Emissions and Stack Parameters

Engine	Regulatory Tier	Vessel/Structure Height above Water (m)	Engine Stack Height (m)	Total Stack Height above Water	Stack Diameter (m)	Stack Velocity (m/s)	Stack Temp (K)	Emission Factors (g/kWh)[3]				
								CO	NO_X	PM_{10}[2]	$PM_{2.5}$	SO_2
150 kW generator on WTGs[1]	Tier 4	WTG Height = 55 m	3.05	58.05	0.15	25.0	644	3.50	0.40	0.020	0.019	0.0074
2 MVA generator on OSP[1]	Tier 2	OSP Height = 67 m	3.05	70.05	0.46	32.2	700	3.50	6.40	0.20	0.19	0.0074
747 kW pile driving hammer engine[1]	Tier 2	n/a	27.5	27.5	0.15	116.6	555.2	3.50	6.40	0.20	0.19	0.0074
429 kW air compressor engines[1]	Tier 2	Vessel Height = 1 m	3.05	4.1	0.15	33.7	699.8	3.50	6.40	0.20	0.19	0.0074

Notes:

(1) Stack height estimated as typical for the equipment. Listed WTG/OSP height above MLLW based on Mayflower COP (2021). Deck height of vessel carrying compressor engines assumed to be 1 m above water. Stack parameters based on generator assumptions below.

(2) PM_{10} based on 100% PM, $PM_{2.5}$ based on 97% of PM.

(3) CO, NO_X, PM_{10}, $PM_{2.5}$ Emission factors based on NSPS non-road compression engine exhaust emission standards. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA05.pdf. SO_2 emission factors based on USEPA AP-42 Table 3.4-1, assuming ULSD.

Mayflower Wind 2021.Construction and Operations Plan, Volume 1.Submitted to Bureau of Ocean Energy Management, Office of Renewable Energy Programs. October.

Generator Assumptions

	150 kW engine	2 MVA engine	747 kW engine	429 kW engine	Reference
Rating, kW	150	1600	747	429	*Operator, conversion of MVA to kW assuming power factor of 0.8*
Rating, hp	201	2146	1002	575	*Standard conversion factor*
BSFC, Btu/hp	7,000	7,000	7,000	7,000	*AP-42 Table 3.3-1, footnote a*
Rating, MMBtu/hr	1.41	15.02	7.01	4.03	*Calculated*
Fd Factor	9,190	9,190	9,190	9,190	*Table 19-2 of EPA Method 19, for oil*
Exhaust % O2	10	10	10	10	*Typical value for diesel engine*
Exhaust % H2O	6	6	6	6	*Typical value for diesel engine*
Exhaust Flow, scfh	26,396	281,554	131,450	75,492	*Calculated*
Exhaust Temperature, F	700	800	700	700	*Assumed values based on other typical diesel engines*
Exhaust flow, acfh	57,990	671,890	288,793	165,853	*Assumes no adjustment for actual atmospheric pressure*
Exhaust flow, acmh	1,642	19,026	8,178	4,696	*Standard conversion factor*
Stack Diameter, m	0.1524	0.4572	0.3048	0.254	*Assumed values based on other typical diesel engines*
Stack Velocity, m/s	25.0	32.2	31.1	25.7	*Calculated*

ATTACHMENT 5 – Emission Source Layouts

INTRODUCTION

The descriptions and layouts presented in this attachment depict how Mayflower Wind proposes to model different construction and O & M activties. It should be noted that nearly all modeled sources will not be stationary and will be moving to some degree throughout the work area. The layouts provided herein present a conservative estimate of the approximate locations that vessels will be. Typical activities performed by the vessels, vessel size, and allowance for adequate clearance between the sometimes numerous vessels were taken into account in selecting their modeled locations. **As there is not set configuration for each activity, the actual positions and movements of the vessels may vary from what is presented here**.

Note that 1-hour, 3-hour, and 8-hour averaging periods will all use the 1-hour source layout, while the 24-hour averaging period will use the 24-hour layout.

Scenario 1 - Scour Protection / Seabed Prep

Description of Source Locations for 1-Hour Averaging Period

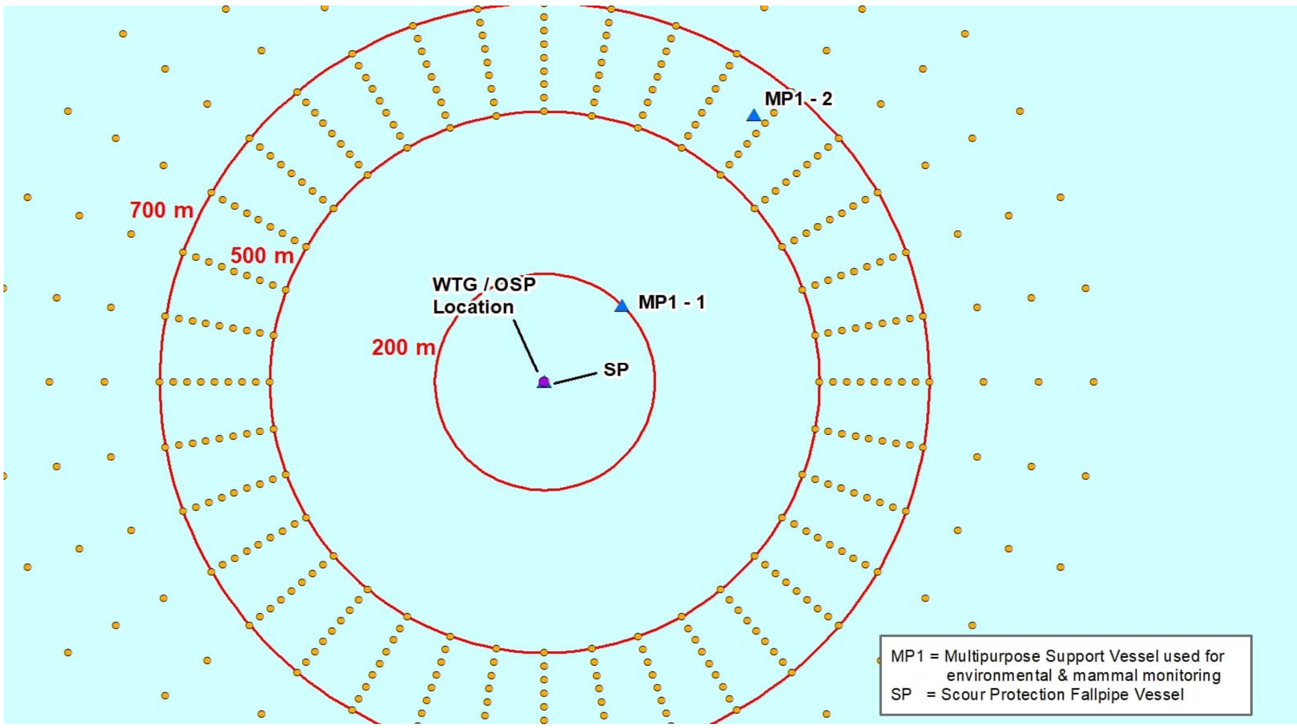
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Multipurpose Support Vessel Type 1 (2) Seabed prep, inspection survey, general support	200 m, 600 m from WTG / OSP location	One vessel will be in the vicinity of WTG / OSP. 2nd vessel expected to be farther away.
Scour Protection Fall Pipe Vessel (1)	WTG / OSP location	Vessel will be installing scour protection at WTG / OSP location

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG / OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 1 - Scour Protection / Seabed Prep

Description of Source Locations for 24-Hour Averaging Period (same as 1-hour)

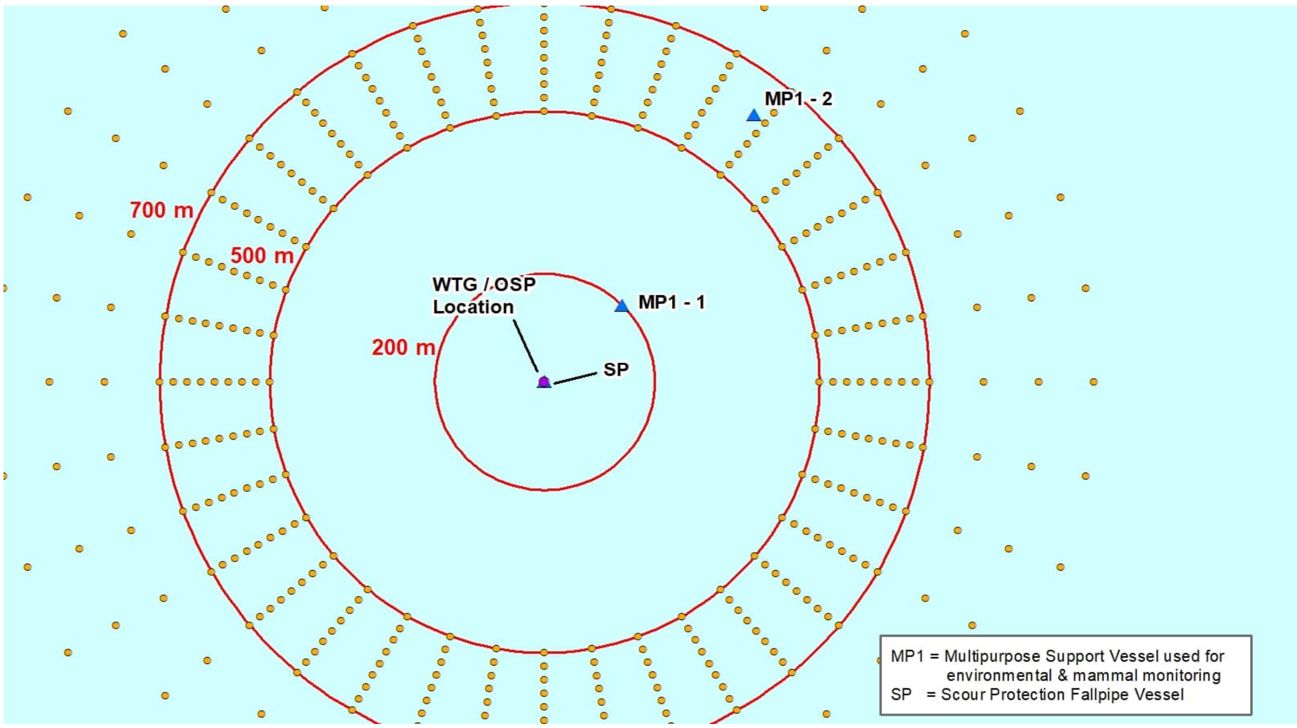
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Multipurpose Support Vessel Type 1 (2) Seabed prep, inspection survey, general support	200 m, 600 m from WTG / OSP location	One vessel will be in the vicinity of WTG / OSP. 2nd vessel expected to be farther away.
Scour Protection Fall Pipe Vessel (1)	WTG / OSP location	Vessel will be installing scour protection at WTG / OSP location

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG / OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 2 - Monopile or Pin Pile Installation

Description of Source Locations for 1-Hour Averaging Period

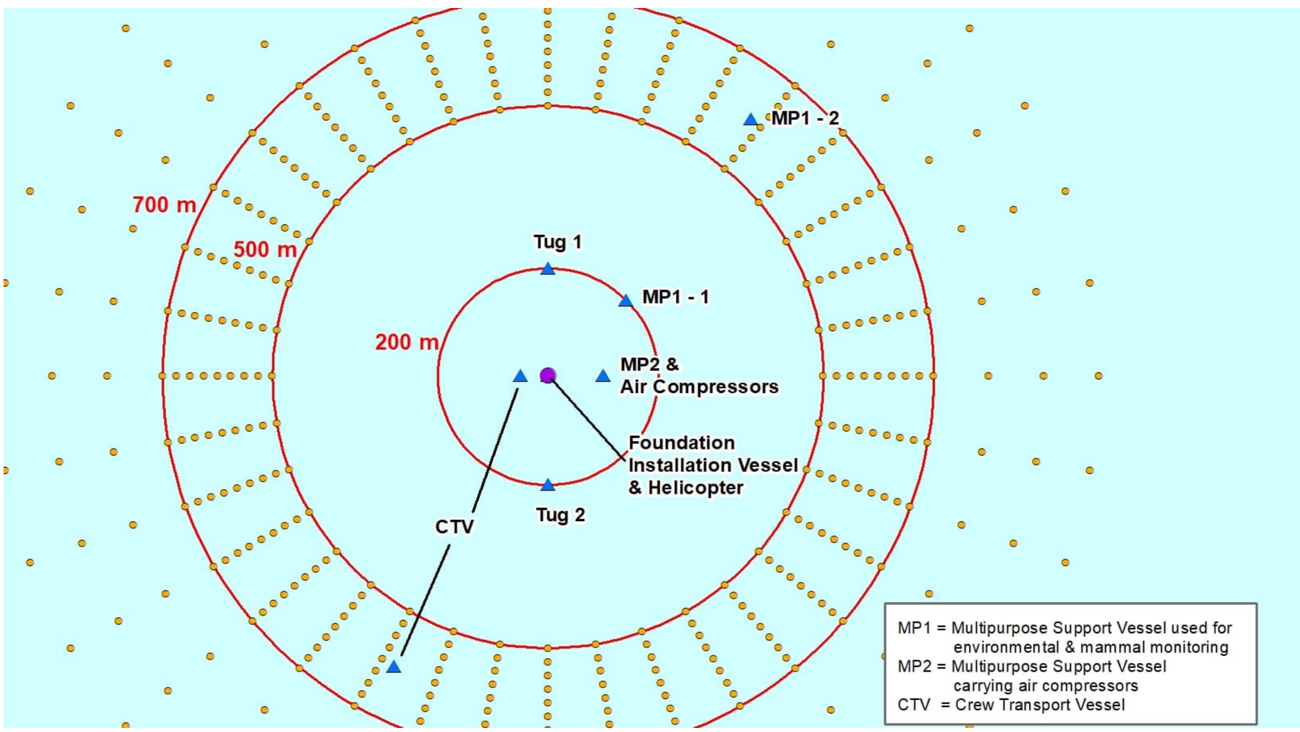
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG.
Foundation Installation Vessel (1)	WTG Location	Vessel will be installing WTG foundation.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from WTG	One vessel will be in the vicinity of WTG, but likely not right next to it. 2nd vessel expected to be farther away from WTG.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	100 m from WTG	Vessel next to WTG location while air compressors are operating.
Tug (2)	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
Air Compressors	100 m from WTG	Vessel next to WTG location while air compressors are operating.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely. Airplane may also be used but will not be during same hour as CTV/helicopter and emissions are less so not included here.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 2 - Monopile or Pin Pile Installation

Description of Source Locations for 1-Hour Averaging Period

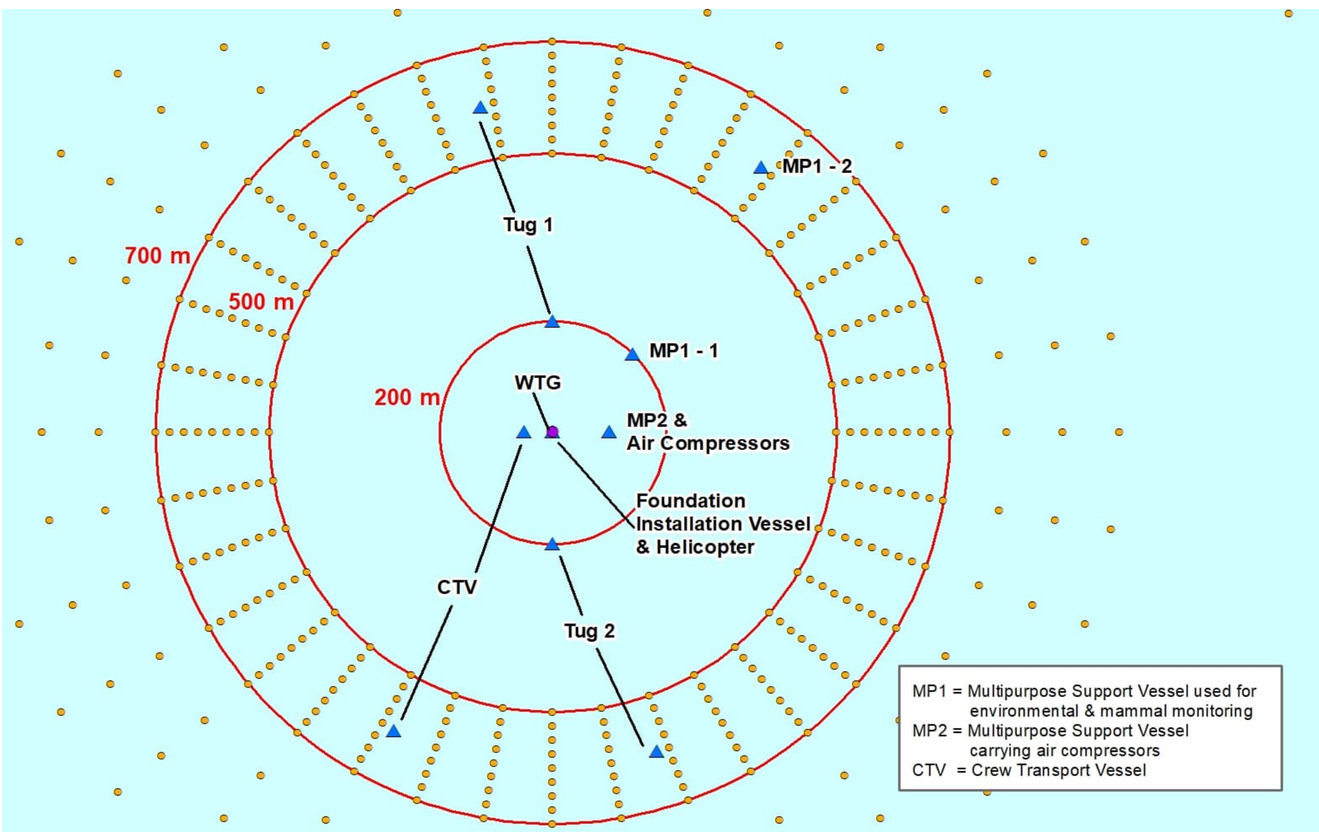
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off & picks up workers at installation vessel for 30 min each (total 1 hr), spends the remaining 11 hr away from WTG.
Foundation Installation Vessel (1)	WTG Location	Vessel will be installing WTG foundation.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from WTG	One vessel will be in the vicinity of WTG, but likely not right next to it. 2nd vessel expected to be farther away from WTG.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	100 m from WTG	Vessel next to WTG location while air compressors are operating.
Tug (2)	200 m, 600 m from WTG	Vessels expected to split time during the course of the day between the vicinity of WTG and farther away.
Air Compressors	100 m from WTG	Vessel next to WTG location while air compressors are operating.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers. Airplane may also be used but will not be on same day as CTV/helicopter and emissions are less so not included here.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 3 - Transition Piece or Jacket Installation

Description of Source Locations for 1-Hour Averaging Period

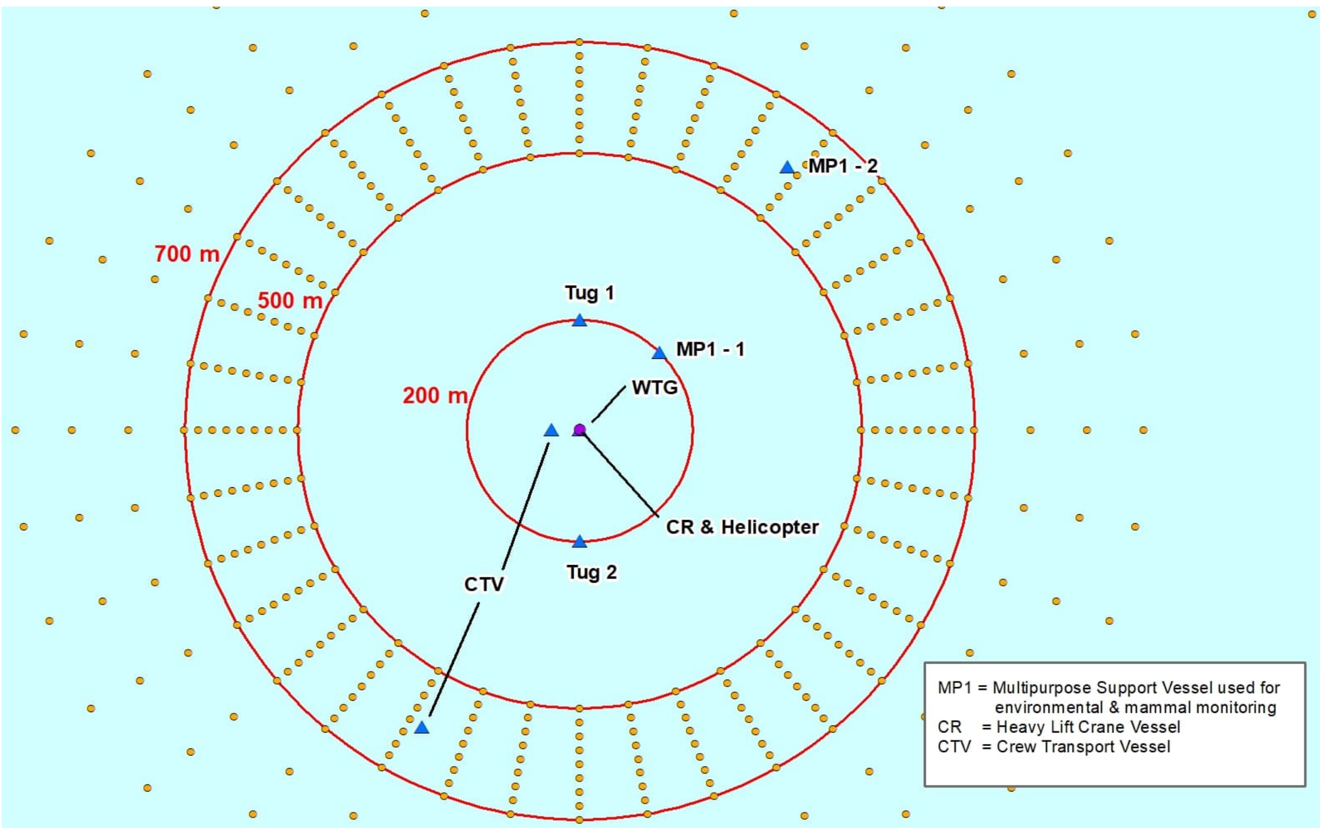
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG.
Heavy Lift Crane Vessel (1)	WTG Location	Vessel will be installing transition piece or jacket.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from WTG	One vessel will be in the vicinity of WTG, but likely not right next to it during the hour. 2nd vessel expected to be farther away from WTG.
Tug (2)	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 3 - Transition Piece or Jacket Installation

Description of Source Locations for 24-Hour Averaging Period

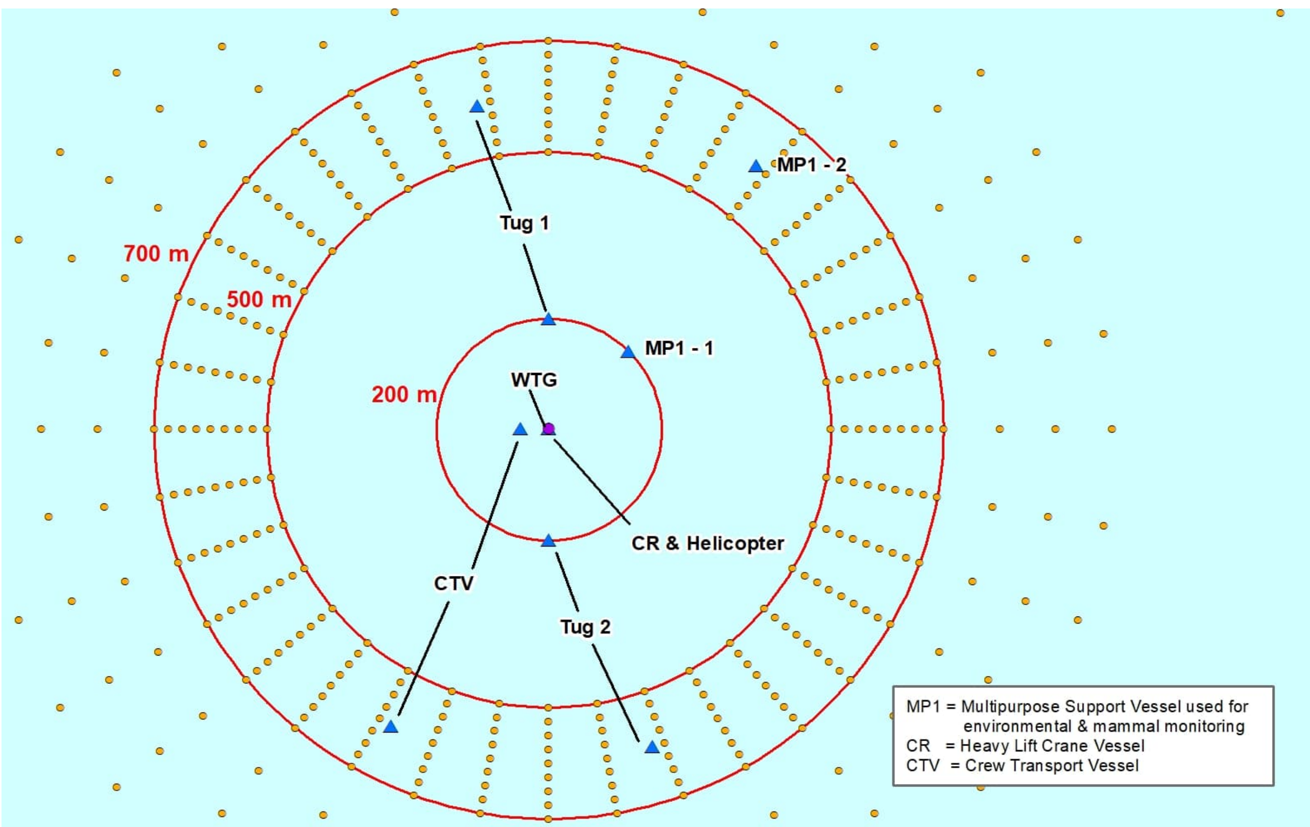
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off & picks up workers at installation vessel for 30 min each (total 1 hr), spends the remaining 11 hr away from WTG
Heavy Lift Crane Vessel (1)	WTG Location	Vessel will be installing transition piece or jacket.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from WTG	One vessel will be in the vicinity of WTG, but likely not right next to it during the hour. 2nd vessel expected to be farther away from WTG.
Tug (2)	200 m, 600 m from WTG	Vessels will split time during the course of the day between the vicinity of WTG and farther away.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 6 - Inter Array Cable - Installation Survey and Seafloor Prep

Description of Source Locations for 1-Hour Averaging Period

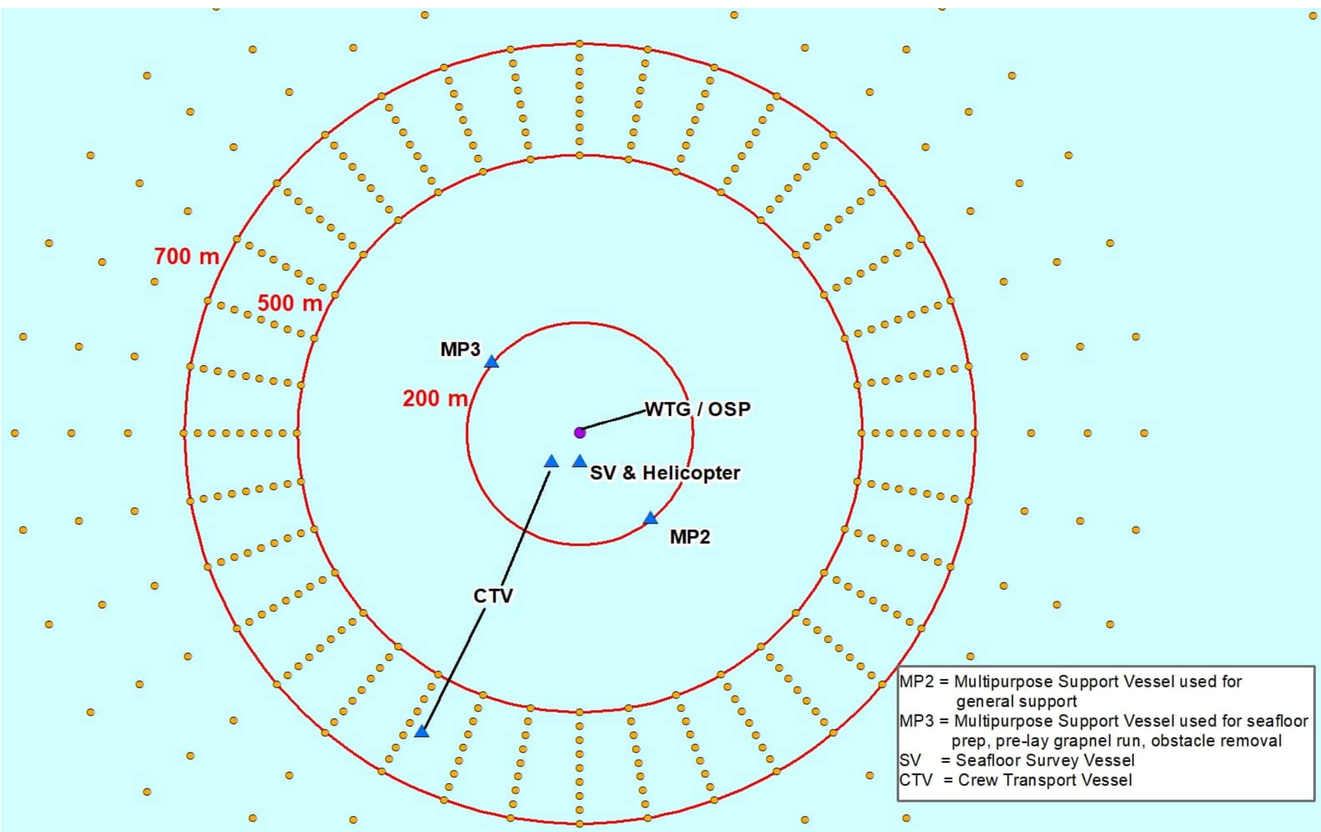
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at survey vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Survey Vessel (1)	100 m from WTG / OSP	Assume vessel is in the vicinity of the WTG / OSP and near the CTV to maximize potential 1-hour emissions overlap.
Multipurpose Support Vessel Type 2 (1) General Support	200 m from WTG / OSP	Vessels will be in the vicinity of WTG providing general support.
Multipurpose Support Vessel Type 3 (1) Seafloor prep, pre-lay grapnel run, obstacle removal	200 m from WTG / OSP	Vessels will be moving in the vicinity of WTG / OSP. Assuming stationary position is conservative.
Helicopter	100 m from WTG / OSP	Lands on survey vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG / OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 6 - Inter Array Cable - Installation Survey and Seafloor Prep

Description of Source Locations for 24-Hour Averaging Period

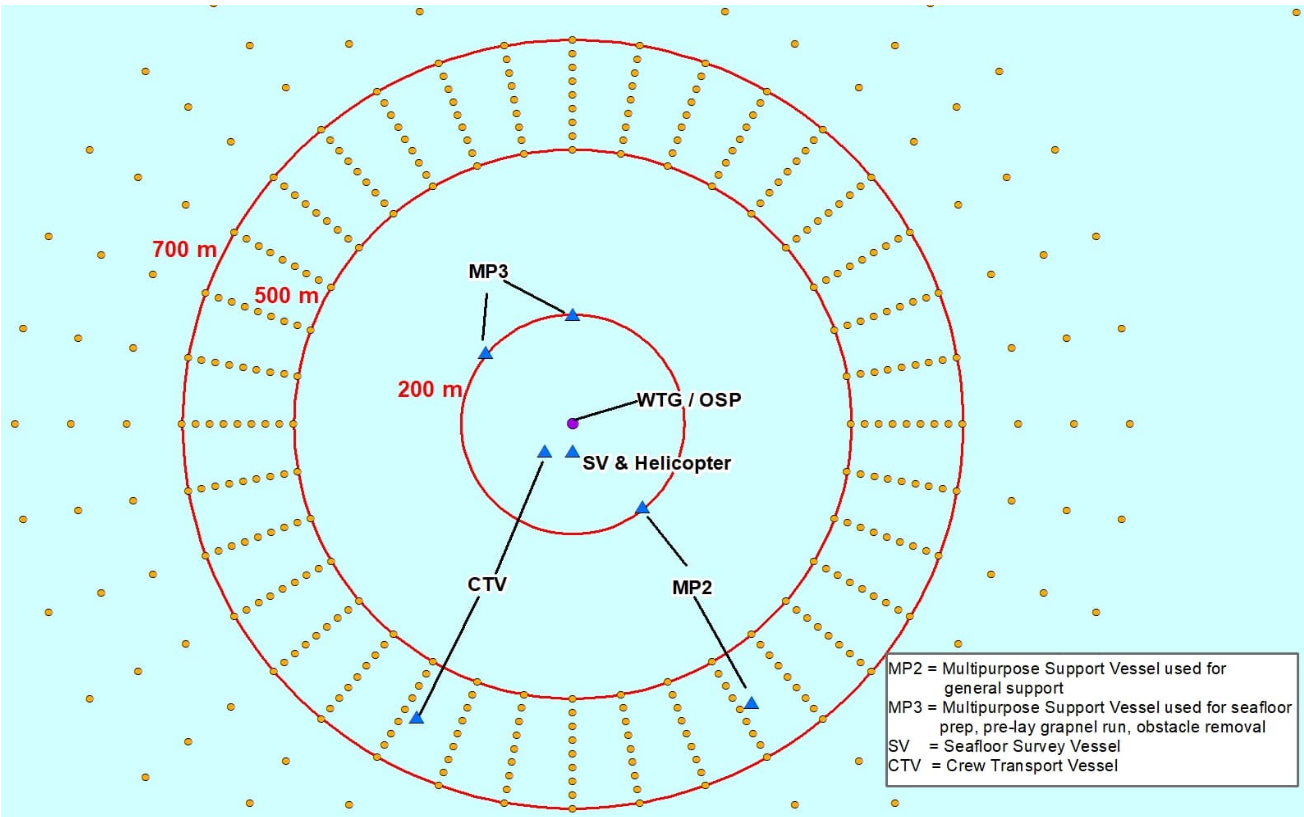
Vessel Type (count)	Modeled Location(s)(1)	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at survey vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Survey Vessel (1)	100 m from WTG / OSP	Assume vessel is in the vicinity of the WTG / OSP and near the CTV to maximize potential 1-hour emissions overlap.
Multipurpose Support Vessel Type 2 (1) General Support	200 m, 600 m from WTG / OSP	Vessels will split time during the course of the day between the vicinity of WTG and farther away.
Multipurpose Support Vessel Type 3 (1) Seafloor prep, pre-lay grapnel run, obstacle removal	200 m from WTG / OSP	Vessels will be moving in the vicinity of WTG / OSP. Assuming 2 positions for the period is conservative.
Helicopter	100 m from WTG / OSP	Lands on survey vessel for drop off/pick of workers.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG / OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations

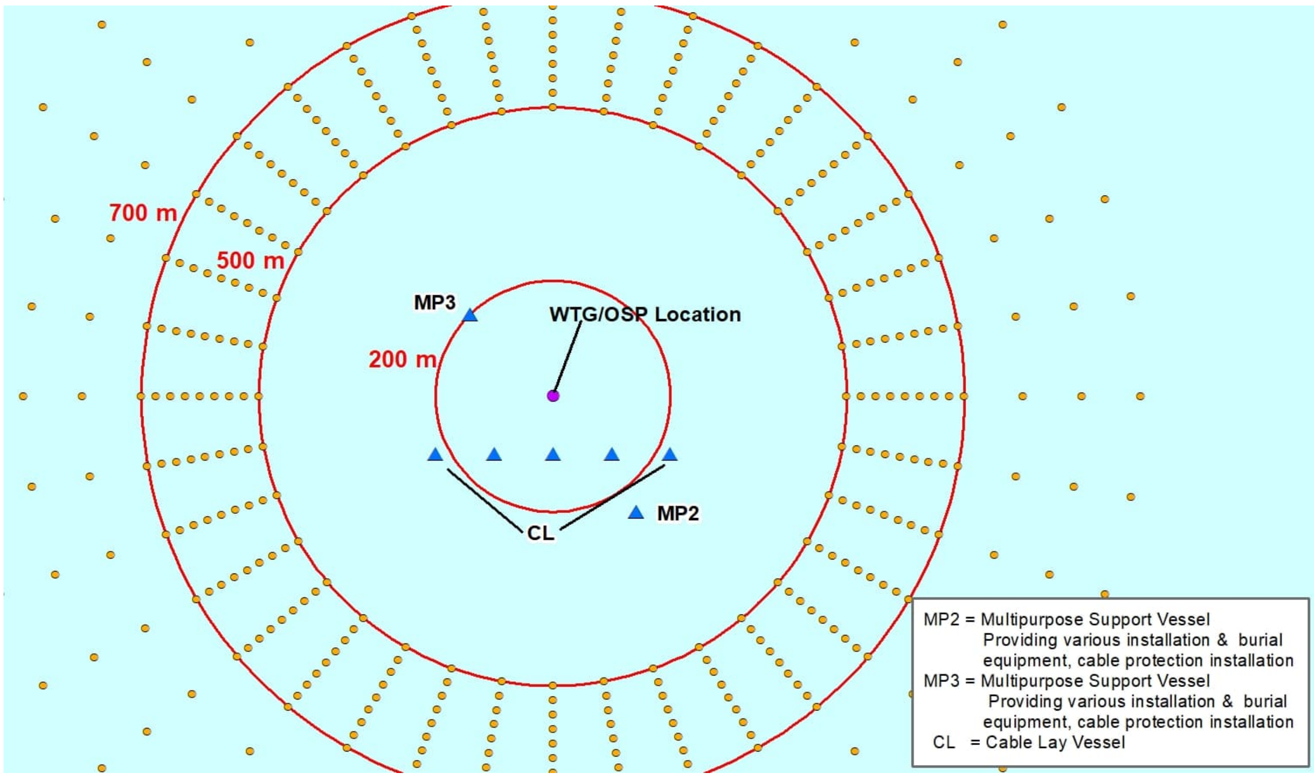


Scenario 7 - Inter Array Cable -
Cable Lay, Burial, Termination

Description of Source Locations for 1-Hour Averaging Period

Vessel Type (count)	Modeled Location(s)(1)	Basis
Cable Lay Vessel (1)	5 locations, near WTG / OSP, spaced 100 m apart to represent movement thoughout the hour	Assume vessel is laying cable in the vicinity of the WTG / OSP
Multipurpose Support Vessel Type 2 (1) Providing various installation and burial equipment, cable protection installation	100 m from Cable Laying Vessel	Assume one multipurpose support vessel is near the cable lay vessel. Vessel will likely be moving throughout the period but will conservatively be modeled stationary.
Multipurpose Support Vessel Type 3 (1) Providing various installation and burial equipment, cable protection installation	200 m from WTG / OSP	Vessel will be in the vicinity of WTG aiding cable laying, but not necessarily next to cable lay vessel. Vessel will likely be moving throughout the period but will conservatively be modeled stationary.

Representation of Modeled Layout
Orange dots = model receptor locations

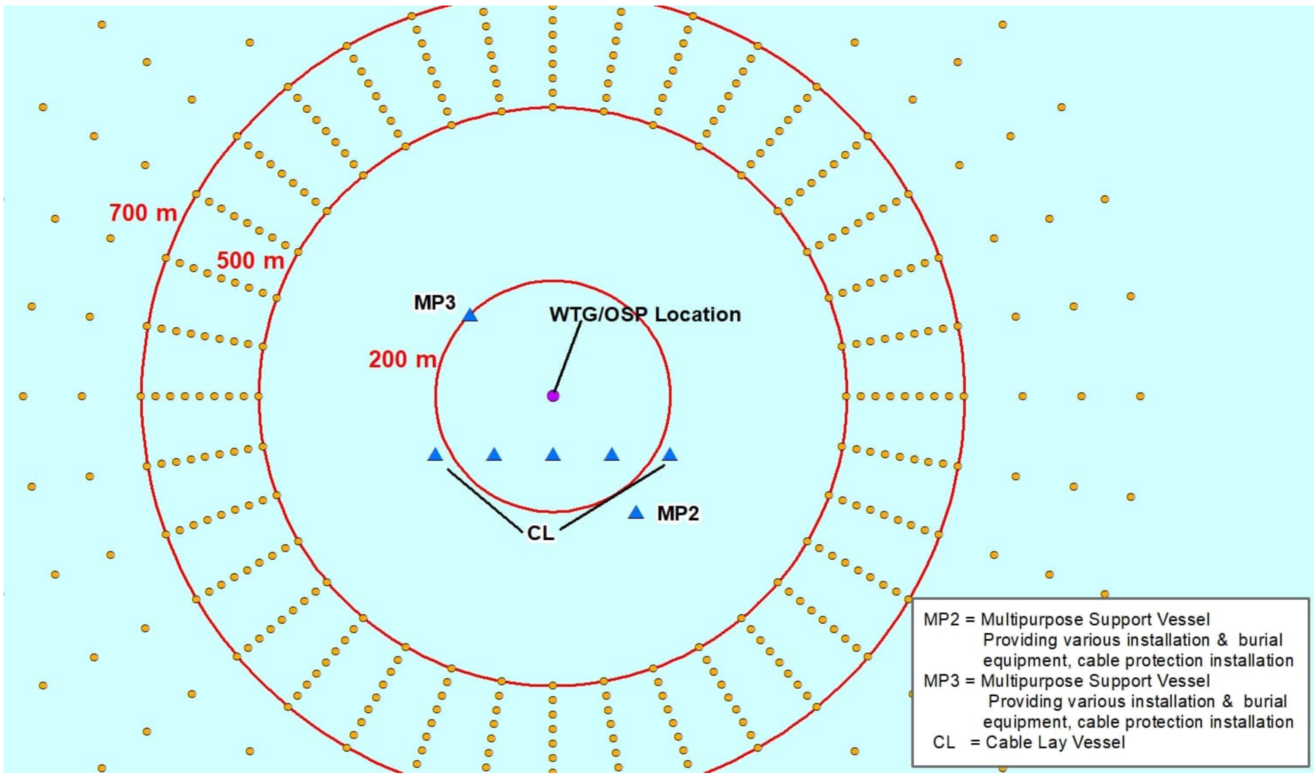


Scenario 7 - Inter Array Cable -
Cable Lay, Burial, Termination

Description of Source Locations for 24-Hour Averaging Period (same as 1-hour)

Vessel Type (count)	Modeled Location(s)(1)	Basis
Cable Lay Vessel (1)	5 locations, near WTG / OSP, spaced 100 m apart to represent movement thoughout the hour	Assume vessel is laying cable in the vicinity of the WTG / OSP
Multipurpose Support Vessel Type 2 (1) Providing various installation and burial equipment, cable protection installation	100 m from Cable Laying Vessel	Assume one multipurpose support vessel is near the cable lay vessel. Vessel will likely be moving throughout the period but will conservatively be modeled stationary.
Multipurpose Support Vessel Type 3 (1) Providing various installation and burial equipment, cable protection installation	200 m from WTG / OSP	Vessel will be in the vicinity of WTG aiding cable laying, but not necessarily next to cable lay vessel. Vessel will likely be moving throughout the period but will conservatively be modeled stationary.

Representation of Modeled Layout
Orange dots = model receptor locations



Scenario 8 - OSP Installation

Description of Source Locations for 1-Hour Averaging Period

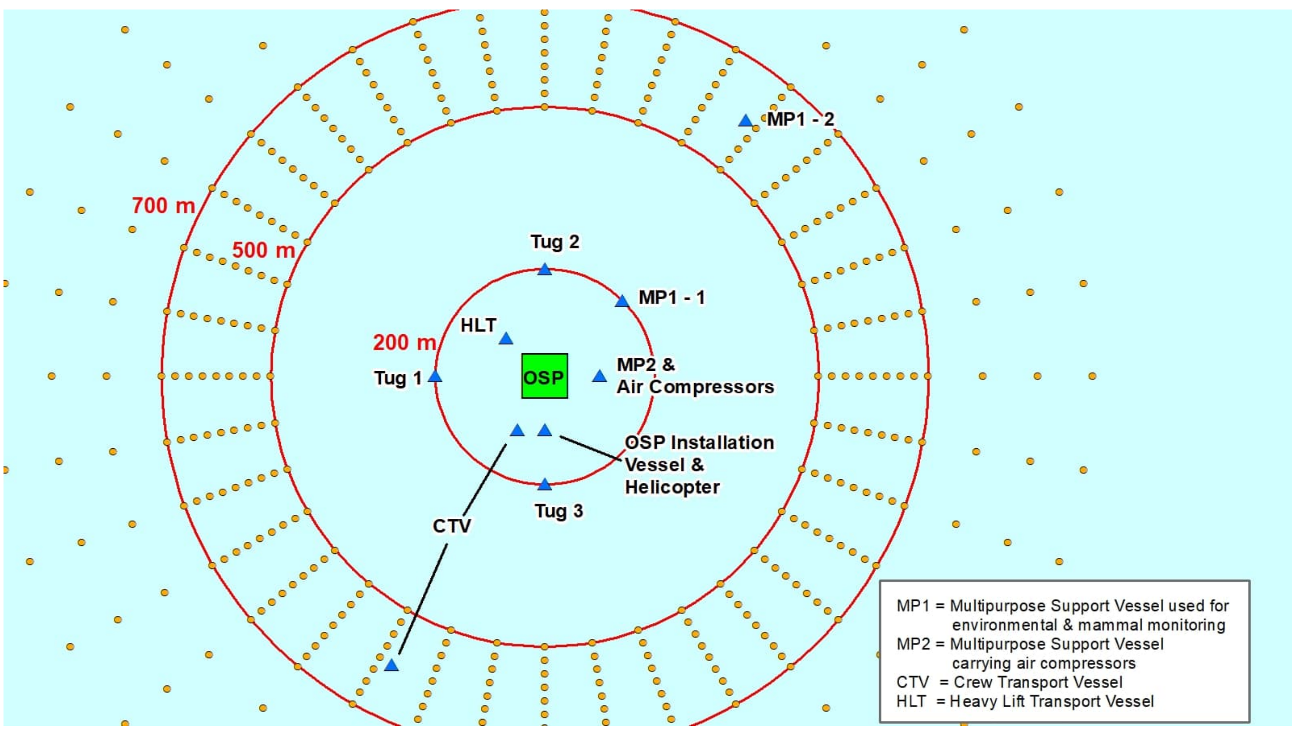
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from OSP center	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from OSP.
OSP Installation Vessel (1)	100 m from OSP center	Vessel will be constructing the OSP throughout period. 100 m distance allows for clearance of the large vessel.
Heavy Lift Transport Vessel (1)	100 m from OSP center	Vessel will be in vicinity of OSP delivering parts for OSP install. 100 m distance allows for clearance of the large vessel.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from OSP center	One vessel will be in the vicinity of OSP, but likely not right next to it during the hour. 2nd vessel expected to be farther away from OSP.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	100 m from OSP center	Vessel next to OSP while air compressors are operating.
Tug (3)	200 m from OSP center	Vessels will be in the vicinity of OSP providing general support.
Air Compressors	100 m from OSP center	Vessel next to OSP while air compressors are operating.
Helicopter	100 m from OSP center	Lands on installation vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely. Airplane may also be used but will not be during same hour as CTV/helicopter and emissions are less so not included here.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the OSP.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 8 - OSP Installation

Description of Source Locations for 24-Hour Averaging Period

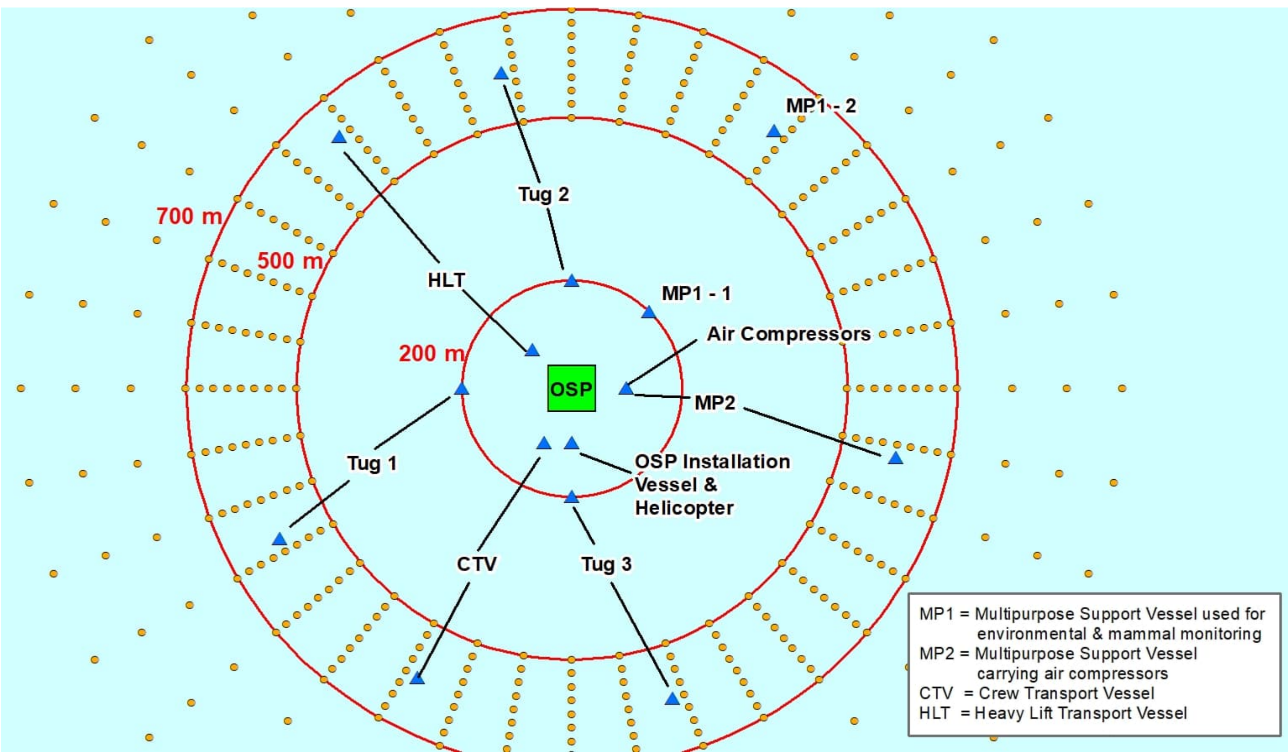
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	100 m, 600 m from OSP center	Assume CTV drops off & picks up workers at installation vessel for 30 min each (total 1 hr), spends the remaining 11 hr away from
OSP Installation Vessel (1)	100 m from OSP center	Vessel will be constructing the OSP throughout period. 100 m distance allows for clearance of the large vessel.
Heavy Lift Transport Vessel (1)	100 m, 600 m from OSP center	Vessel will split time between the OSP location delivering parts for install and away from the OSP before/after delivery.
Multipurpose Support Vessel Type 1 (2) Environmental monitoring,	200 m, 600 m from OSP center	One vessel will be in the vicinity of OSP, but likely not right next to it during the hour. 2nd vessel expected to be farther away from OSP.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	100 m, 600 m from OSP center	Vessel next to OSP for 12 hrs while air compressors are operating. When air compressors not operating, vessel will be farther away.
Tug (3)	200 m, 600 m from OSP center	Vessels expected split time during the course of the day between the vicinity of OSP and farther away.
Air Compressors	100 m from OSP center	Vessel next to OSP while air compressors are operating.
Helicopter	100 m from OSP center	Lands on installation vessel for drop off/pick of workers. Airplane may also be used but will not be on same day as CTV/helicopter and emissions are less so not included here.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the OSP.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 9 - OSP Commissioning

Description of Source Locations for 1-Hour Averaging Period

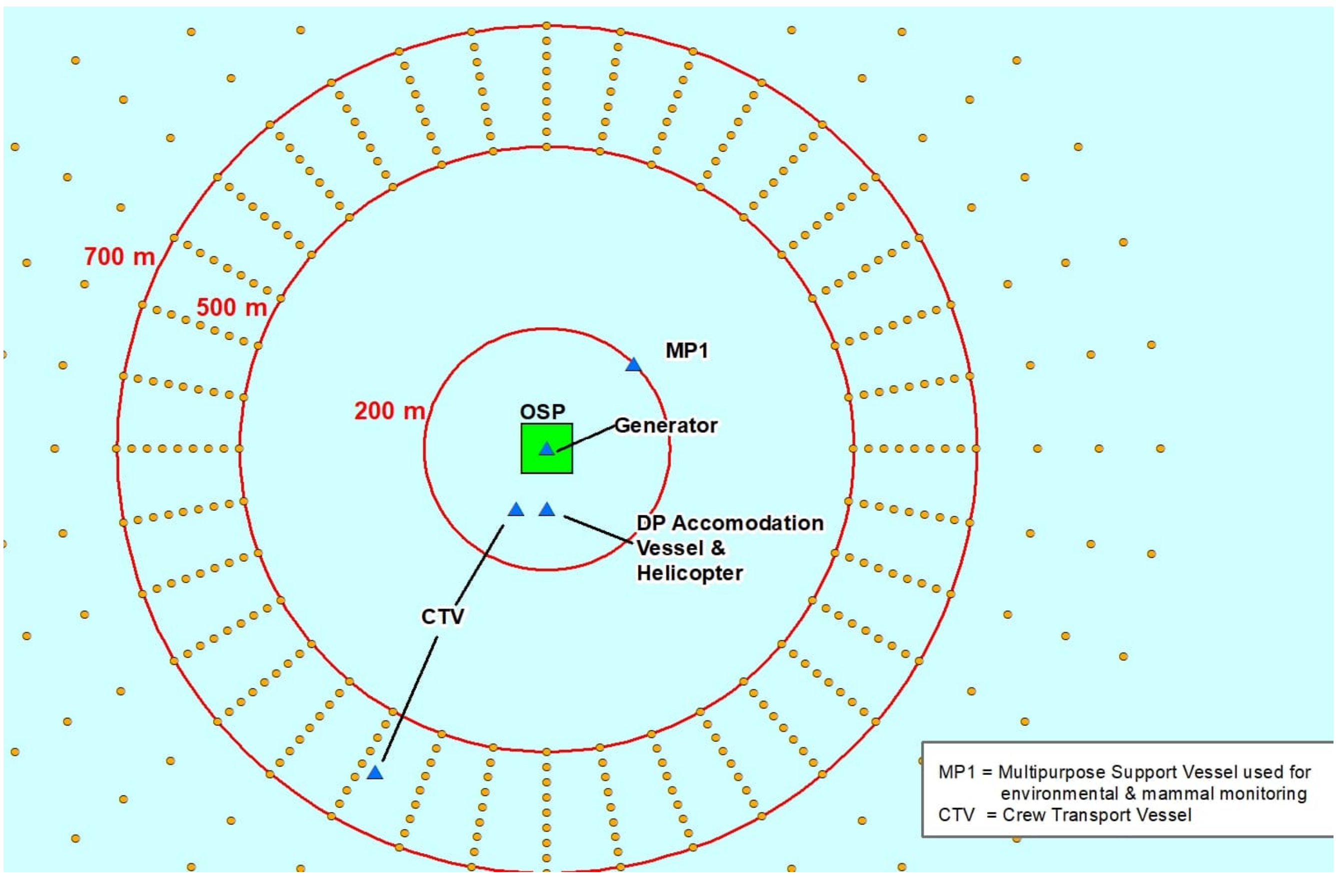
Vessel Type (count)	Modeled Location(s)[1]	Basis
Crew Transport Vessel (1)	100 m, 600 m from OSP center	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from OSP
DP Accomodation Vessel (1)	100 m from OSP center	Vessel will be at the OSP throughout period. 100 m distance allows for clearance of the large vessel.
Multipurpose Support Vessel Type 1 (1) Environmental monitoring,	200 m, 600 m from OSP center	One vessel will be in the vicinity of OSP, but likely not right next to it during the hour. 2nd vessel expected to be farther away from OSP.
2 MVA Generator	OSP center	Generator will operate on OSP.
Helicopter	100 m from OSP center	Lands on DP Accomodation Vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the OSP.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 9 - OSP Commissioning

Description of Source Locations for 24-Hour Averaging Period (same as 1-hour)

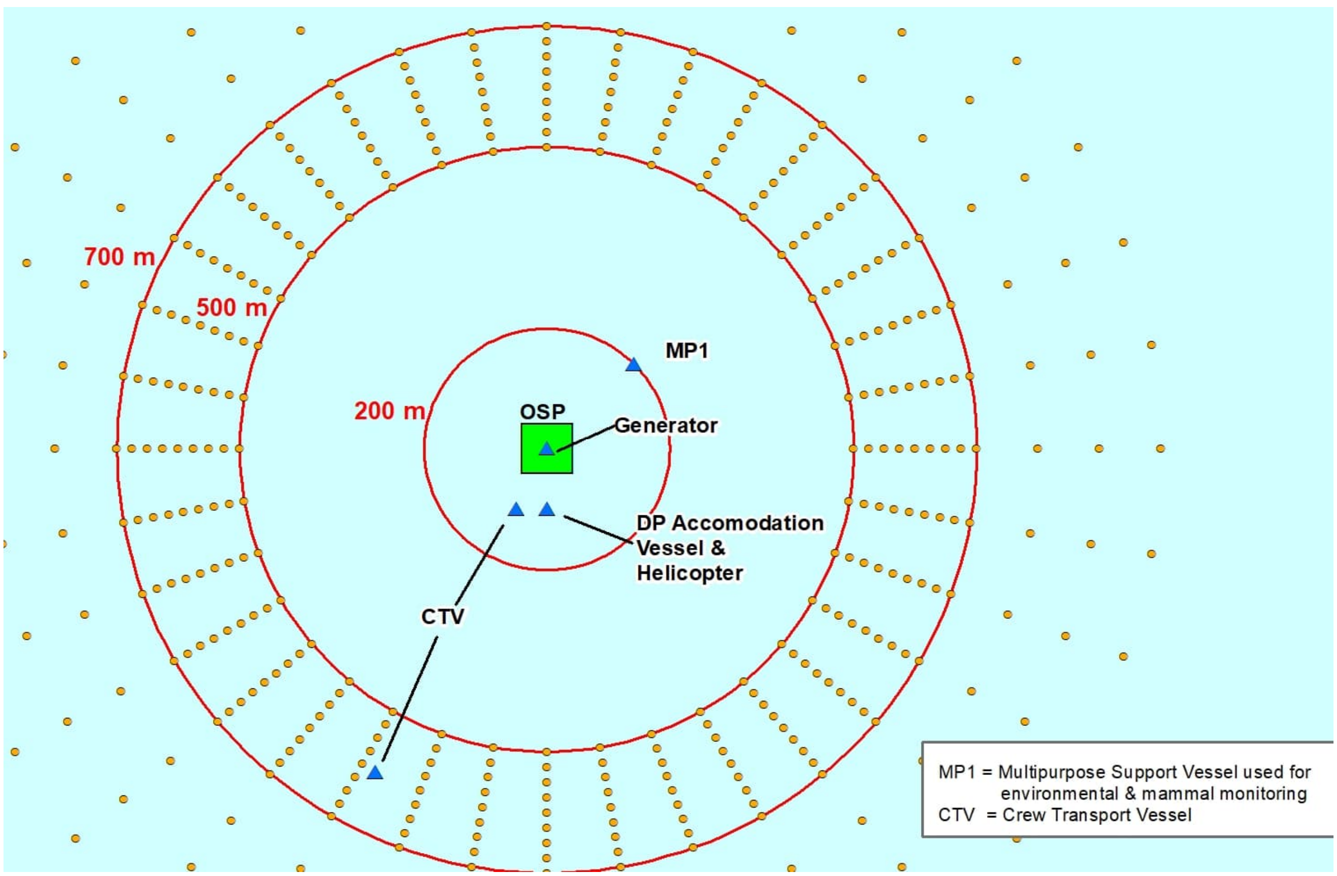
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	100 m, 600 m from OSP center	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from OSP
DP Accomodation Vessel (1)	100 m from OSP center	Vessel will be at the OSP throughout period. 100 m distance allows for clearance of the large vessel.
Multipurpose Support Vessel Type 1 (1) Environmental monitoring,	200 m, 600 m from OSP center	One vessel will be in the vicinity of OSP, but likely not right next to it during the hour. 2nd vessel will be farther away from OSP.
2 MVA Generator	OSP center	Generator will operate on OSP.
Helicopter	100 m from OSP center	Lands on DP Accomodation Vessel for drop off/pick of workers.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from OSP because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the OSP.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 10 - WTG Installation

Description of Source Locations for 1-Hour Averaging Period

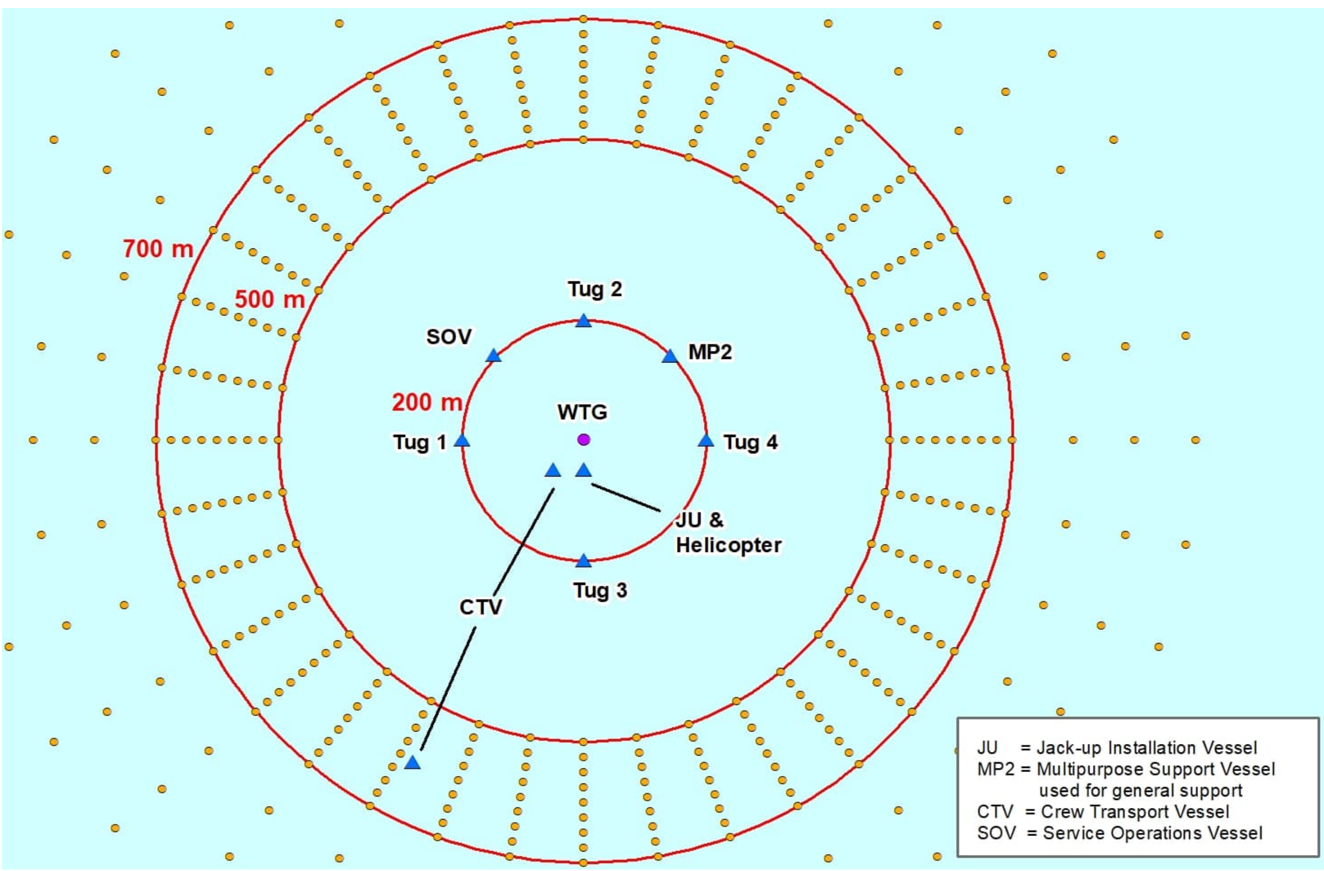
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG.
Jack-up Installation Vessel (1)	100 m from WTG	Vessel will be constructing the WTG. 100 m distance allows for clearance of the large vessel.
Service Operations Vessel (1)	200 m from WTG	Vessel will be in vicinity of WTG but not likely to be right next to it.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
Tug (4)	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 10 - WTG Installation

Description of Source Locations for 24-Hour Averaging Period

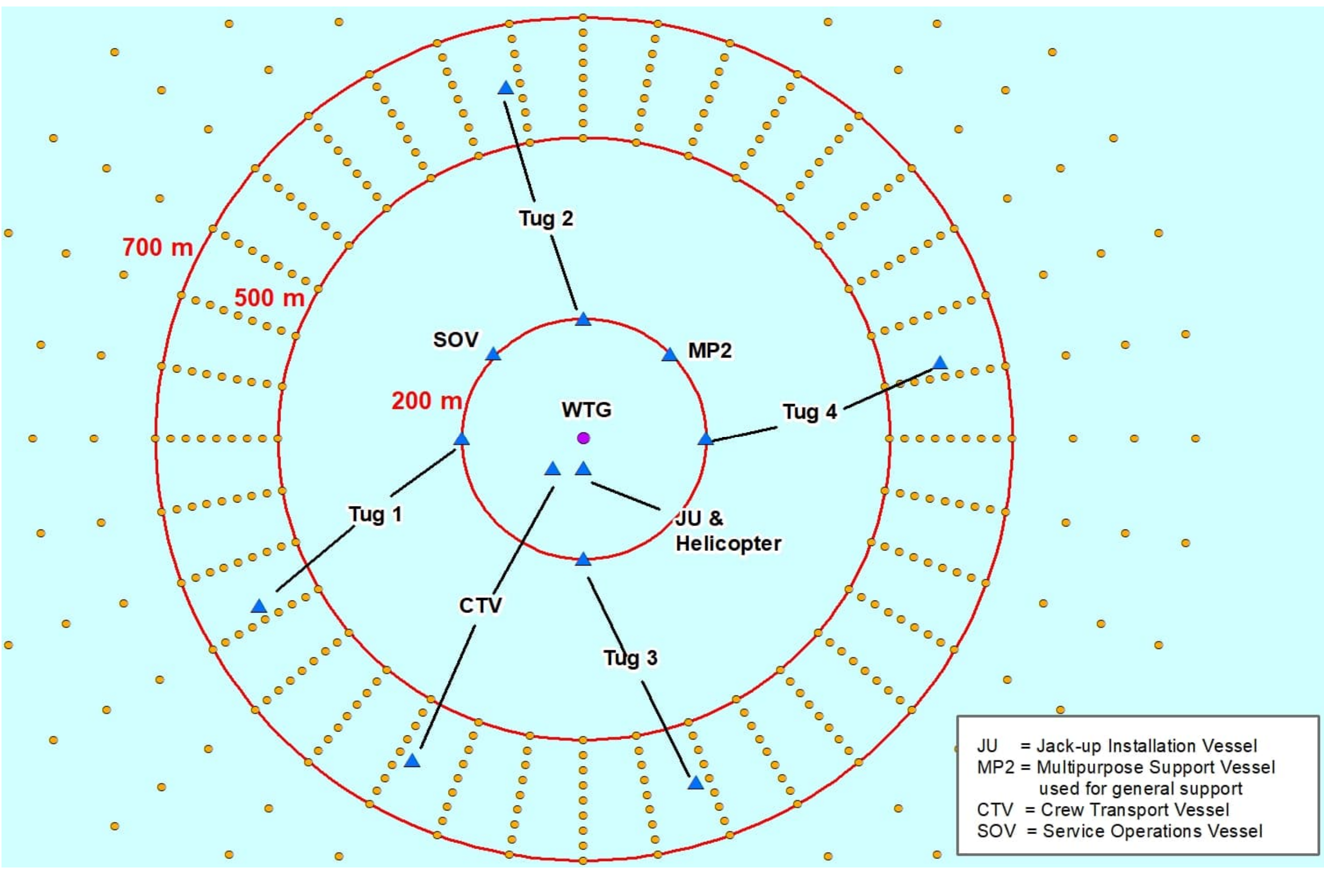
Vessel Type (count)	Modeled Location(s)(1)	Basis
Crew Transport Vessel (1)	100 m, 600 m from WTG	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG.
Jack-up Installation Vessel (1)	100 m from WTG	Vessel will be constructing the WTG. 100 m distance allows for clearance of the large vessel.
Service Operations Vessel (1)	200 m from WTG	Vessel will be in vicinity of WTG but not likely to be right next to it.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	200 m, 600 m from WTG	Vessel expected to split time during the course of the day between the vicinity of WTG and farther away.
Tug (4)	200 m, 600 m from WTG	Vessels expected split time during the course of the day between the vicinity of WTG and farther away.
Helicopter	100 m from WTG	Lands on installation vessel for drop off/pick of workers.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 11 - WTG Commissioning

Description of Source Locations for 1-Hour Averaging Period

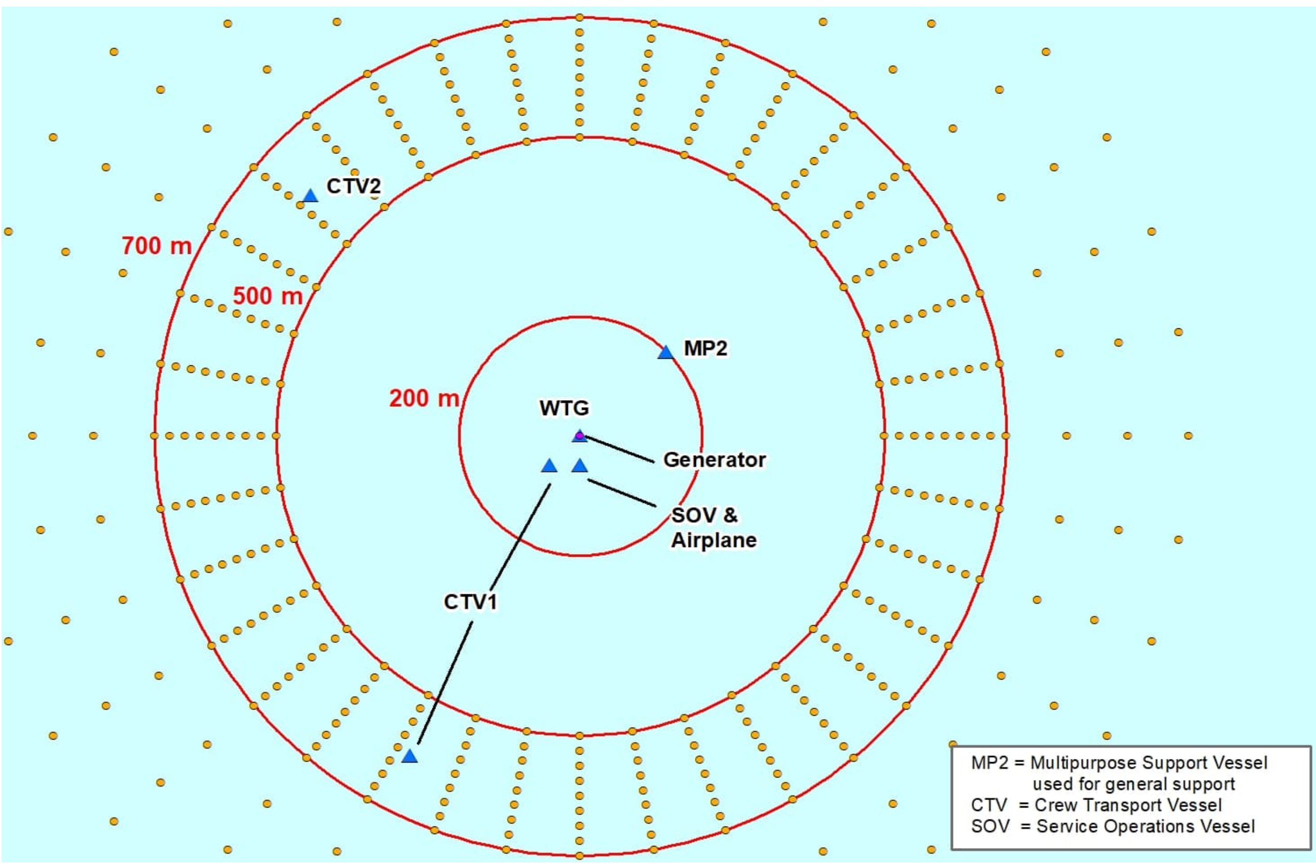
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (2)	100 m, 600 m from WTG	Assume only one CTV will be near WTG during this period. CTV will drop off/pick up workers at service operations vessel for 30 min, spends the remaining 30 min away from WTG. 2nd CTV will be away from WTG.
Service Operations Vessel (1)	100 m from WTG	Vessel will be near WTG.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
150 kW Generator	On WTG	Generator will operate on WTG.
Airplane	100 m from WTG	Lands near service operations vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 11 - WTG Commissioning

Description of Source Locations for 24-Hour Averaging Period

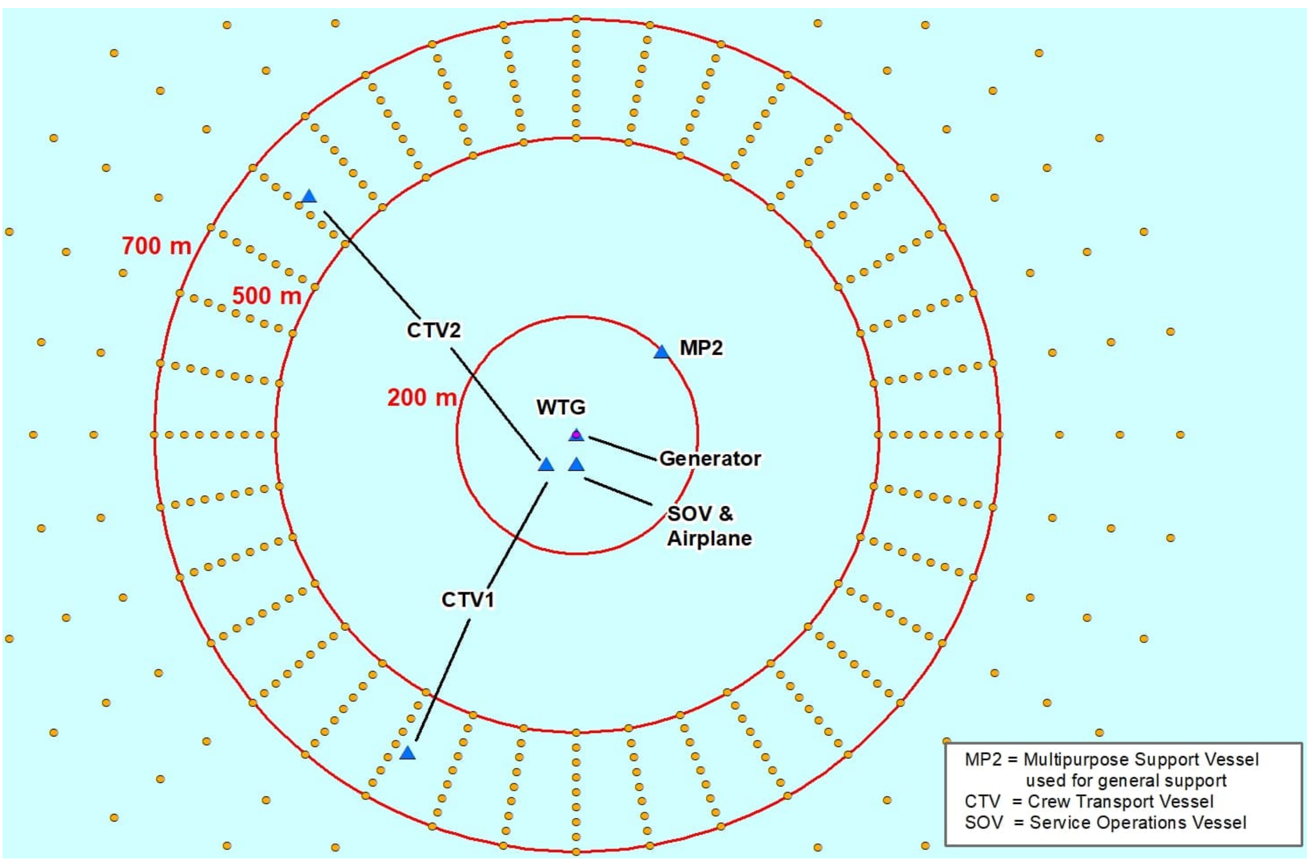
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (2)	100 m, 600 m from WTG	CTVs will drop off/pick up workers at service operations vessel for 30 min each for total of 1 hour, then spend the remaining 11 hr away from WTG.
Service Operations Vessel (1)	100 m from WTG	Vessel will be near WTG.
Multipurpose Support Vessel Type 2 (1) Carrying Air Compressors	200 m from WTG	Vessels will be in the vicinity of WTG providing general support.
150 kW Generator	On WTG	Generator will operate on WTG.
Airplane	100 m from WTG	Lands near service operations vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 12 - Routine Operations and Maintenance

Description of Source Locations for 1-Hour Averaging Period

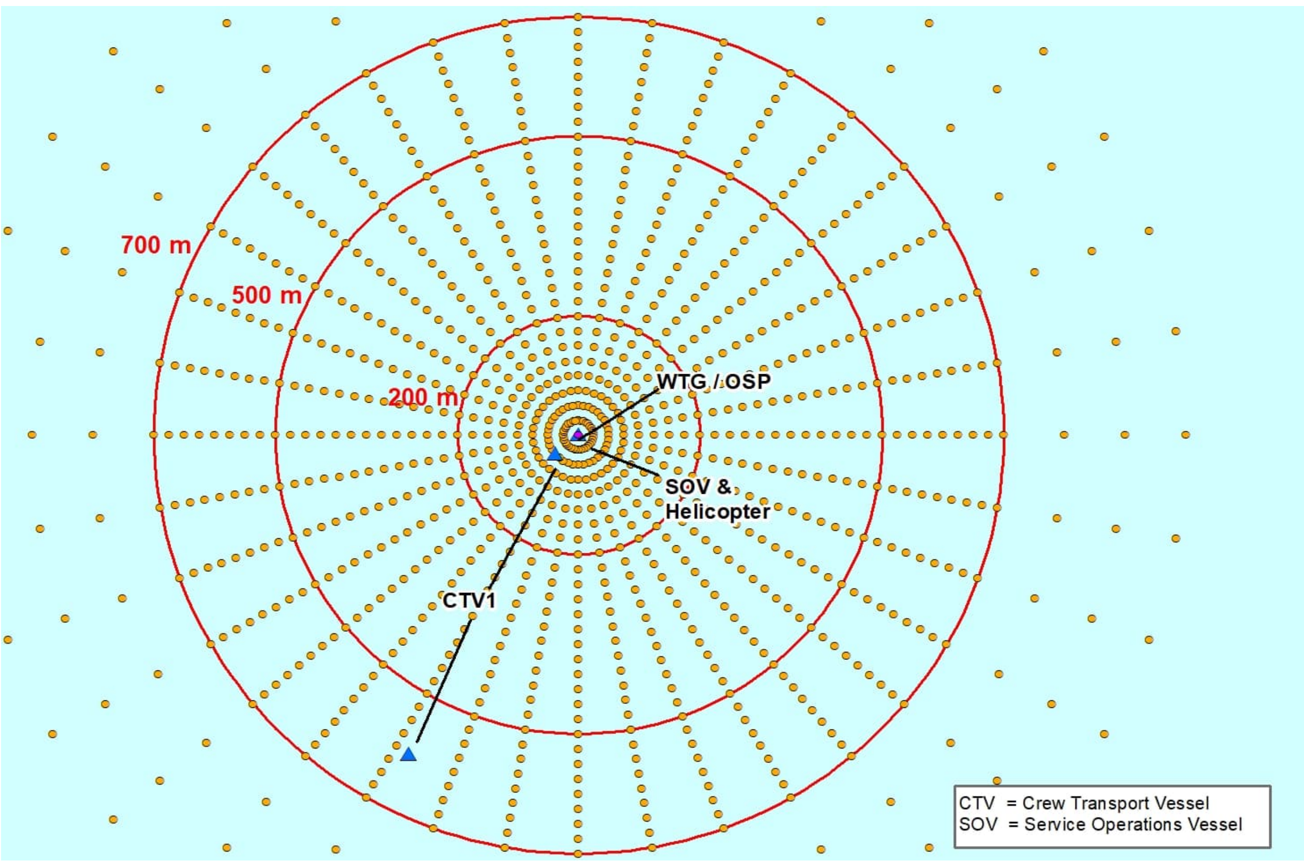
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	50 m, 600 m from WTG / OSP	Assume CTV drops off/picks up workers at service operations vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Service Operations Vessel (1)	At WTG / OSP	Vessel will be near WTG / OSP.
Helicopter	At WTG / OSP	Lands on service operations vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 12 - Routine Operations and Maintenance

Description of Source Locations for 24-Hour Averaging Period (same as 1-hour)

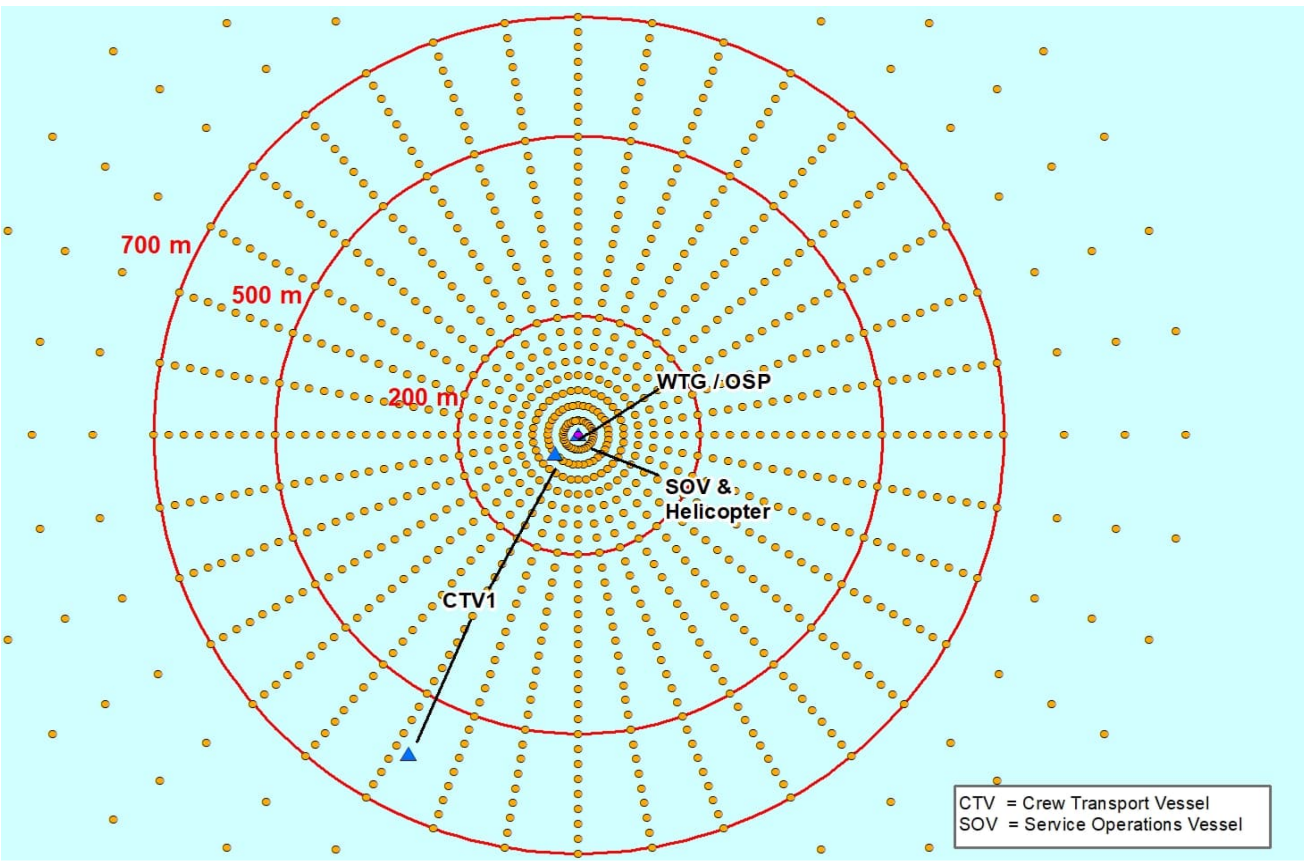
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	50 m, 600 m from WTG / OSP	Assume CTV drops off/picks up workers at service operations vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Service Operations Vessel (1)	At WTG / OSP	Vessel will be near WTG / OSP.
Helicopter	At WTG / OSP	Lands on service operations vessel for drop off/pick of workers. Conservatively assuming occuring during the same hour as CTV but not likely.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured.. Vessels realistically could be much farther away from the WTG.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 13 - Operations and Maintenance - Major Repair

Description of Source Locations for 1-Hour Averaging Period

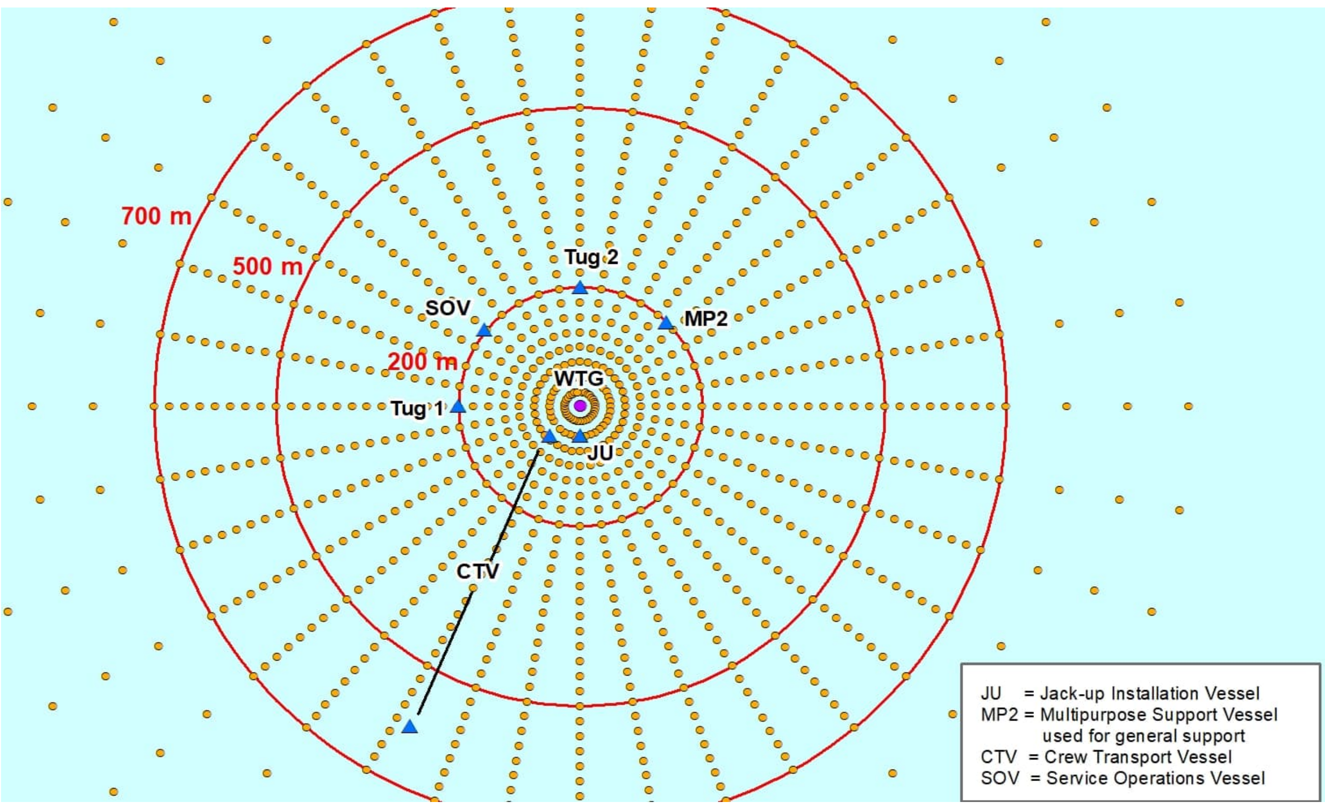
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	50 m, 600 m from WTG / OSP	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Jack-up Installation Vessel (1)	50 m from WTG / OSP	Vessel will be constructing the WTG / OSP. 100 m distance allows for clearance of the large vessel.
Service Operations Vessel (1)	200 m from WTG / OSP	Vessel will be in vicinity of WTG / OSP but not likely to be right next to it.
Multipurpose Support Vessel Type 1 (1) General Support	200 m, 600 m from WTG / OSP	Vessel expected be in the vicinity of WTG / OSP, but likely not right next to it.
Tug (2)	200 m from WTG / OSP	Vessels will be in the vicinity of WTG / OSP providing general support.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Scenario 13 - Operations and Maintenance - Major Repair

Description of Source Locations for 24-Hour Averaging Period (same as 1-hour)

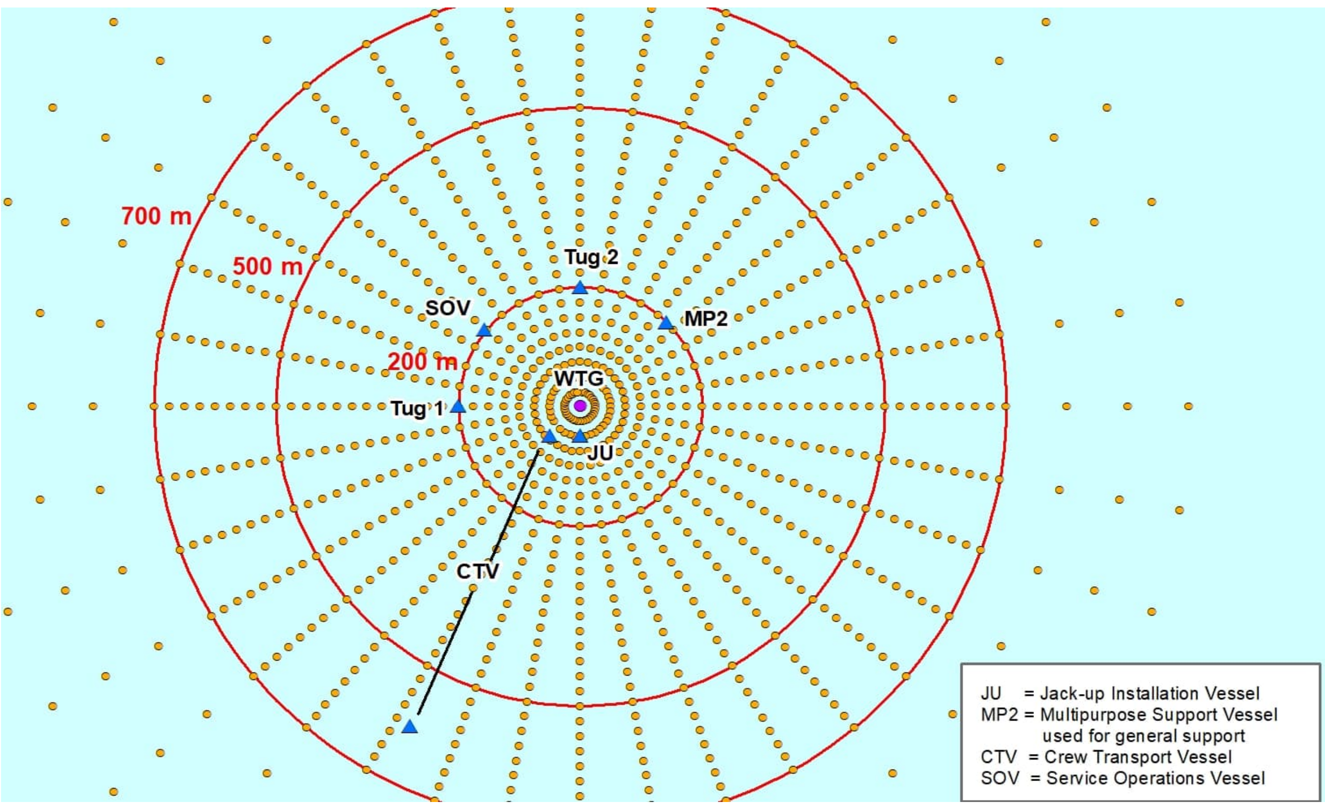
Vessel Type (count)	Modeled Location(s)[(1)]	Basis
Crew Transport Vessel (1)	50 m, 600 m from WTG / OSP	Assume CTV drops off/picks up workers at installation vessel for 30 min, spends the remaining 30 min away from WTG / OSP.
Jack-up Installation Vessel (1)	50 m from WTG / OSP	Vessel will be constructing the WTG / OSP. 100 m distance allows for clearance of the large vessel.
Service Operations Vessel (1)	200 m from WTG / OSP	Vessel will be in vicinity of WTG / OSP but not likely to be right next to it.
Multipurpose Support Vessel Type 1 (1) General Support	200 m, 600 m from WTG / OSP	Vessel expected be in the vicinity of WTG / OSP, but likely not right next to it.
Tug (2)	200 m from WTG / OSP	Vessels will be in the vicinity of WTG / OSP providing general support.

Notes:

(1) 600 m is selected as the distance when vessels are "away" from WTG because it lies within the 25-m spaced receptors and therefore maximum impacts due to the vessel would be captured. Vessels realistically could be much farther away.

Representation of Modeled Layout

Orange dots = model receptor locations



Annual Sources

Description of Source Locations for Annual Averaging

Vessel Type	Modeled Location(s)[1]	Basis
All Transit Vessels	Assuming the same direction as expected travel route, conservatively set to begin at WTG / OSP location	Sources spaced every 3 km to reduce total number of modeled sources. All emissions will be divded evenly among the source locations.
All offshore export cable laying vessels	Assuming the same direction as expected route to Brayton Point, conservatively set to begin at WTG / OSP location	Sources spaced every 1.8 km to reduce total number of modeled sources. All emissions will be divded evenly among the source locations.
All other vessels associated with contruction of WTG an OSP	Sources will be co-located at the WTG / OSP location.	Total annual emissions will be divded evenly among all WTG/OSP location,

Representation of Modeled Layout

Orange dots = model receptor locations