UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

MEMORANDUM

SUBJECT: Concurrence Request for Approval of Alternative Model AERCOARE in Conjunction with AERMOD, in Support of Outer Continental Shelf PSD air permitting of the Empire Wind offshore wind power project

FROM: Neha Sareen, Regional Air Quality Modeler
Permitting Section, Air Programs Branch, Air and Radiation Division
EPA Region 2, New York, New York

Neha Sareen
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Date: 2022.07.13 10:54:59 -04'00'

THRU: Rick Ruvo, Director
Air and Radiation Division
EPA Region 2, New York, New York

Richard Ruvo
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Date: 2022.07.13 12:36:46 -04'00'

TO: George Bridgers, Director of Model Clearinghouse
Air Quality Modeling Group, Office of Air Quality Planning and Standards

The U.S. Environmental Protection Agency (EPA) Region 2 seeks concurrence from the Model Clearinghouse regarding the prospective EPA Region 2 approval of an alternative model for an Outer Continental Shelf (OCS) Prevention of Significant Deterioration (PSD) permitting effort. The AERCOARE meteorological data preprocessor program will be used in conjunction with AERMOD (AERCOARE/AERMOD) to conduct an air quality modeling analysis as part of the OCS air permit application for the proposed Empire Wind Offshore LLC's Empire Wind project to be located off the coast of New York, south of Long Island. Empire Wind Offshore LLC has sought approval to allow the use of the AERCOARE/AERMOD model for their air quality modeling analysis, under 40 CFR Part 51, Appendix W §3.2.2(b), Condition (3), for the project's OCS permit application. Under Condition (3), an alternative model may be used if the Regional Office finds the conditions specified in Appendix W §3.2.2(e) are satisfied.

Empire Wind Offshore LLC submitted their revised alternative model request on June 29, 2022. The request provided evidence and justifications supporting approvability of the modeling approach under Appendix W §3.2.2(b), Condition (3). An initial alternative model request was submitted by Empire Wind Offshore LLC to Region 2 on May 5, 2022, but the initial request was subsequently replaced by the June 29, 2022 revised request, to include additional arguments. EPA's prior approvals of the AERCOARE/AERMOD, using measured meteorological measurements from buoys or prognostic meteorological data, are well documented in the Model Clearinghouse's public database.

EPA Region 2 has conducted a thorough review of the request and intends to approve the use of AERCOARE/AERMOD as an alternative model to conduct the air quality modeling analysis as part of the Empire Wind OCS air permit application. We have found the proposed application of the model is satisfactory under the requirements of §3.2.2(e).

A technical analysis summarizing our review and the June 29, 2022 alternative model request submitted by Empire Wind LLC are included below for your consideration. Please feel free to contact Neha Sareen of my staff at (212) 637-4074 if you have any questions regarding the request.

Technical Review of the Empire Wind Offshore LLC Request to Use the AERCOARE Meteorological Data Preprocessor Program in conjunction with AERMOD in support of its Outer Continental Shelf (OCS) Permit Application for the Empire Wind project

1. Background and Project Overview

Empire Offshore Wind LLC (Empire) is proposing to construct an offshore windfarm on the Outer Continental Shelf (OCS) off the coast of Long Island, New York in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0512 to provide electricity to New York. Empire will develop the lease area in two wind farms – Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2) – collectively referred to hereafter as the Project. Both EW 1 and EW 2 are covered under the permit application and this request. EW 1 (816 MW) and EW 2 (1,260 MW) will be electrically isolated and independent from each other. The Project will consist of 138 wind turbine generators (WTGs), each capable of generating 15 MW, 9 additional 15 MW WTGs for overplanting, and 2 offshore substations. The proposed OCS windfarm requires an OCS air permit under 40 CFR Part 55 and section 328 of the Clean Air Act (CAA). The requirements of EPA's Prevention of Significant Deterioration (PSD) at 40 CFR Part 52.21, including air quality modeling requirements, apply to the Empire Wind Project.

The Project will trigger PSD review for nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter (PM) with diameter 10 microns or less (PM_{10}); and PM with diameter 2.5 microns or less ($PM_{2.5}$), and greenhouse gases (GHGs). The Project will trigger Nonattainment New Source Review (NNSR) for the ozone precursors, oxides of nitrogen (NOx) and volatile organic compounds (VOCs).

Empire has requested to use an alternative model, as provided in §3.2 of the Guideline on Air Quality Models (40 CFR Part 51, Appendix W, hereafter referred to as the *Guideline*), to conduct its PSD air quality modeling analysis. Specifically, Empire has requested to use the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm, as implemented in the AERCOARE meteorological data preprocessor program, to prepare meteorological data for use in the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) dispersion program to assess ambient impacts in a marine environment. Empire submitted their initial request to initiate the alternative model approval process on May 5, 2022. Based on subsequent discussions between Empire, EPA Region 2, OAQPS, and New York State Department of Environmental Conservation (NYSDEC) regarding the proposed project and the associated modeling approach, the applicant provided a revised alternative model request on June 29, 2022 (Attachment 1).

In its June 29, 2022 request, Empire indicated its preference to utilize the AERCOARE/AERMOD alternative modeling approach over the EPA's guideline model, the Offshore and Coastal Dispersion (OCD) model. Empire's June 29, 2022 request presented twelve technical reasons, options, and/or features available in the alternative model to support its request. The presented criteria are listed below:

1. The OCD modeling system was developed in the 1980-90s and as such the dispersion algorithms are outdated and have not been updated to account for advancements in dispersion modeling since that time. In contrast, AERMOD is frequently updated (the latest version was issued in 2022) and is considered the state-of-the-art for nearfield dispersion modeling.

2. The AERMOD model utilizes the Plume Rise Model Enhancements (PRIME) downwash algorithms to assess impacts in the cavity and wake regions of structures. For offshore wind projects, the vessels themselves may affect the wind flow in the area and cause aerodynamic downwash. This effect can be treated in AERMOD using the vessels as structures in the PRIME algorithms. In contrast, the OCD model only provides downwash for platform structures and is based on more simplistic algorithms.

3. Unlike OCD, AERMOD does not specifically evaluate downwash conditions for platform structures. Therefore, the Project's OSS platform structures will be conservatively evaluated with BPIPPRM by assuming the platform structures extend all the way down to the sea. This is a very conservative assumption since in reality air will flow under these structures.

4. AERMOD has the capability to treat missing or calm wind hours by implementing the calm wind processing procedures recommended in the Guideline. In contrast, OCD does not have the ability to process either missing or calm hours and to address this in accordance with the recommended Guideline procedures, a postprocessor would need to be developed.

5. AERMOD incorporates options for the treatment of the conversion from oxides of nitrogen (NOx) to nitrogen dioxide (NO_2). Multiple tier NO_X to NO_2 conversion techniques are available to the modeler in AERMOD. The OCD model does not employ any NO_2 conversion techniques and only assumes full conversion of NOx to NO_2. Some of the NO_2 conversion methods available in AERMOD could be applied to the OCD predicted concentrations in a postprocessing step, but to account for the Tier 2 ARM2 technique or Ozone Limiting Method (OLM), a custom postprocessor for OCD must be developed. The Plume Volume Molar Ratio Method (PVMRM) could not be implemented in a postprocessing step, as the adjustments to the predicted concentrations are internal to the AERMOD model calculations that are dependent on the plume characteristics.

6. AERMOD incorporates options for the inclusion of varying ambient background concentrations during the model run. In contrast, OCD does not have an option to incorporate ambient background concentrations within the model. Ambient background concentrations could be applied to the OCD predicted concentrations in a postprocessing step. A custom postprocessor for OCD must be developed.

7. AERMOD can generate the output concentrations in the form required for comparison to the newer multi-year averaged statistically based NAAQS, namely the 1-hour NO_2, 1-hour SO_2, and 24-hour and annual $PM_{2.5}$ NAAQS. OCD cannot output any statistical or multi-year average results, so for a proper comparison to the NAAQS, a custom postprocessor for OCD must be developed.

8. The AERCOARE meteorological processor utilizes the COARE algorithm that uses air-sea temperature difference, overwater humidity and wind speed to estimate the heat fluxes in the atmosphere over water. AERCOARE is expected to be appropriate for use in marine conditions

at all ice-free latitudes. For this application of modeling offshore sources, the use of AERCOARE to prepare the meteorological data for use in AERMOD is more appropriate than using AERMET, the regulatory meteorological processor that is part of the AERMOD modeling system.

9. Modeling of the temporally and spatially varying construction emission sources will be done with an hourly emissions input scheme that will necessitate many unique emission points. OCD limits the number of stationary sources to 8,500. AERMOD does not limit the number of sources.

10. The very large project area footprint will necessitate a substantial number of receptors be defined to ensure maximum impact concentrations are determined. OCD limits the number of receptors (3,000 discrete, 720 polar, and 1,600 cartesian). AERMOD does not place a limit on the number of receptors.

11. Unlike OCD, AERMOD does not specifically treat angled stack exhaust emissions. AERMOD is configured to treat vertical or horizontal venting stacks, but not angled stacks (between vertical and horizontal). Since many of the vessels that make up the Project emissions source inventory will include angled stacks, the modeling will conservatively treat the exhaust emissions from these stacks by using the horizontal stack options. This is a conservative approach which effectively takes credit for the plume rise due to buoyancy but does not take any credit for the momentum plume rise.

12. Unlike OCD, AERMOD does not include algorithms to evaluate shoreline fumigation conditions. However, shoreline fumigation is not expected to be an important impact consideration for the Project emission sources. Shoreline fumigation can occur when plumes traveling in relatively stable air near the shoreline encounter the thermal internal boundary layer (TIBL) and fumigate downward, potentially resulting in elevated pollutant concentrations at the ground. The TIBL is the boundary layer that can form between the more stable over-water air mass and the less stable over-land air mass and typically forms during sea breeze conditions. EPA modeling guidance indicates that shoreline fumigation can be an important phenomenon on and near the shoreline of bodies of water for sources with tall stacks located on or just inland of a shoreline. However, the Project emissions (primarily vessels) are emitted from stacks with low release heights that will generally be located far offshore (the Project site is located approximately 22 km or more offshore). Exhaust plumes are expected to be substantially dispersed before encountering the TIBL and potential fumigation conditions. Therefore, shoreline fumigation is not expected to be an important impact condition for Project emissions and is not proposed to be specifically evaluated for the air quality analysis.

    To confirm this understanding, test modeling has been conducted with the OCD model (which includes algorithms to assess shoreline fumigation conditions). The OCD test modeling was based on a representative Project vessel emission source and a year of meteorological data (2019 hourly meteorological data from the New York Harbor Entrance Buoy (#44065) in OCD overwater format and overland format data from JFK airport meteorological station with upper air observations from Brookhaven) for which the wind direction for every hour have been artificially adjusted to blow due north toward the nearest coast (Long Island). Receptors were placed to the north from the coastline at 100-meter intervals out to approximately 5 kilometers to predict inland concentrations in the area where fumigation conditions could potentially increase predicted concentrations. This modeling shows that maximum 1-hour predicted concentrations decrease in magnitude along the string of receptors that extend from the coastline inland and does not show any indication of concentrations increasing. A set of four OCD test runs were made, first for a full year (2019) of meteorological conditions, then with the case study option turned on for the individual hours (three of them) that produced the maximum impacts at the 50 receptors in the full year run. The case study output lists the plume rise and dispersion parameters at each receptor. The case study output showed that a TIBL did form during these stable hours and the plume did intersect the TIBL, however the predicted concentrations decreased due to the TIBL intersection. This is likely because the plume is substantially dispersed before encountering the TIBL and is further diluted when it is fumigated to the ground and uniformly mixed. This demonstrates that shoreline fumigation is not a concern with emission sources having an emissions configuration consistent with the marine vessels to be used for project construction and located far offshore the coast. The electronic modeling files for the OCD test runs will be provided to EPA for review upon request.

EPA Region 2 has reviewed the applicant's alternative model request and determined that the use of the proposed alternative model is acceptable.

2. Modeling Approach

Empire has not yet submitted its OCS application for the Empire Wind Project, which will include an air quality impact analysis report, as required under 40 CFR Part 52.21 and 40 CFR Part 55. These regulations have been incorporated into the NY State Implementation Plan (SIP) under 51.166. On April 28, 2022, Empire provided EPA with a proposed modeling protocol (Protocol) for the Empire Wind Project in which AERCOARE/AERMOD was proposed as an alternative modeling platform for near-field impact assessment. Meteorological data collected at Buoy Station #44065 (New York Harbor Entrance /Ambrose Light - 15 nautical miles southeast of Breezy Point, NY) will be processed with AERCOARE to create the overwater meteorological data files for each of the years (2015-2019) for input to AERMOD. Secondary formation of PM2.5 and ozone will be determined using EPA's Modeled Emission Rate for Precursors (MERP) methodology based on low-level stack modeling results for nearby representative hypothetical sources. Empire proposes to perform an initial assessment of Class I area impacts at a nominal 50-km distance using the AERCOARE/AERMOD modeling system, in accordance with the screening technique outlined in §4.2 of the *Guideline*.

3. Alternative Model Proposal Review

a. Regulatory Analysis and Background

40 CFR Part 51.166(l) states that all applications of air quality modeling shall be based on the applicable models specified in the *Guideline*. However, Part 51.166(l) also provides that on a case-by-case basis a modification or substitution of an air quality model may be used following written approval. In addition, the use of a modified or substituted model is subject to notice and opportunity for public comment. The alternative model approval process and conditions are outlined in Section 3.2 of the *Guideline*. Section 3.2.2(a) specifies that the determination of acceptability of an alternative model is a Regional Office responsibility in consultation with EPA's Model Clearinghouse (MCH). An alternative model may be used subject to Regional Office approval if found to satisfy the requirements listed in Section 3.2.2. Section 3.2.2(b) states the alternative model shall be evaluated from both a theoretical and performance perspective before regulatory use and outlines the three separate conditions where an alternative model may be approved. Condition 3

under Section 3.2.2(b), where there is no preferred model for the specific project, applies to this case where Empire has requested the use of the AERCOARE/AERMOD.

The *Guideline* specifies the preferred model for overwater sources is the OCD model. OCD is a straight-line Gaussian model developed to determine the impacts of offshore emissions from point, area, or line sources on the air quality of coastal regions. Some of the key features of OCD potentially applicable to offshore sources are the inclusion of platform building downwash and continuous shoreline fumigation. However, as discussed in Section 1 of this document, OCD does have limitations, as described by Empire in its request to use an alternative model for its air quality modeling analyses. The following limitations are of particular importance to the Project:

(1) OCD does not provide for the multi-tiered screening approach for NO2 modeling (specifically the Tier 2 or Tier 3 screening approaches);
(2) OCD does not contain options to generate outputs in the statistical forms consistent with current NAAQS;
(3) OCD does not account for calm wind conditions when calculating predicted pollutant concentrations;
(4) OCD limits the number of stationary sources and receptors that can be defined in a model run; and
(5) OCD does not account for current advancements in dispersion theory.

In addition, the key features of OCD not provided in AERCOARE/AERMOD are either not applicable to the Project, or AERCOARE/AERMOD provides a more appropriate and conservative approach. The Project emissions are emitted from stacks with low release heights that are generally located far off shore (approximately 22 km or more off shore). Due to this, the controlling concentrations will occur close to the facility at overwater receptors, and hence OCD's feature regarding shoreline fumigation further away onshore is not an issue. The Project has conducted additional OCD test runs to confirm that shoreline fumigation is not a concern. Regarding downwash features, while OCD accounts for platform downwash, Empires' proposed use of AERCOARE/AERMOD as an alternative model will utilize the PRIME downwash algorithm, which will provide conservative results by treating the proposed platform structure as a solid structure that extends downward to the sea surface.

For these reasons, Empire has requested the use of an alternative model (AERCOARE/AERMOD) via Condition 3 under Section 3.2.2(b) and provided justification for the alternative model consistent with the requirements listed in Section 3.2.2(e).

Section 3.2.2(e) sets forth the five elements that must be satisfied for alternative model approval under Condition 3 of Section 3.2.2(b):

I. The model or technique has received a scientific peer review.
II. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis.
III. The databases which are necessary to perform the analysis are available and adequate.
IV. Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application.
V. A protocol on methods and procedures to be followed has been established.

The EPA has approved use of AERCOARE/AERMOD as an alternative model in the past under §3.2.2(b). The first approval was in 2011, where EPA Region 10 approved the use of the

AERCOARE/AERMOD system for a project in the Arctic Ocean off the north coast of Alaska.[1] EPA Region 6 approved the use of AERCOARE/AERMOD for a project off the coast of Texas in the Gulf of Mexico in 2019.[2] EPA Region 1 approved the use of AERCOARE/AERMOD in two instances for windfarm projects - Park City Wind on January 28, 2022[3] and New England Wind Phase 2 on July 5, 2022[4].

The following section of this technical review document provides an examination of Empire's justification for the approval of AERCOARE/AERMOD for its overwater source with respect to the requirements of Section 3.2.2(e).

b. **Evaluation of Approach under Section 3.2.2(e)**

In its alternative model request, Empire referenced the April 2011 EPA Region 10 approval and EPA MCH concurrence with the use of AERCOARE/AERMOD for an Arctic marine ice-free environment on the basis that the alternative model satisfied the five criteria contained in Section 3.2.2(e) of the Guideline. The April 2011 EPA MCH concurrence memorandum stated the Region 10 approval did not constitute a general approval of AERCOARE/AERMOD for other applications. However, the memorandum did state that the April 2011 Region 10 approval concurrence request did provide "a good basis for consideration of AERCOARE/AERMOD for other applications, subject to Regional Office approval based on an assessment of the appropriateness of the performance evaluations (3.2.2(e), element 4) and the availability of the necessary data bases (3.2.2(e), element 3) on a case-by-case basis." In addition, the request references the EPA Region 1 and Region 6 AERCOARE/AERMOD approvals, that do not constitute a generic approval of this alternative model system, but do provide a good basis for such considerations provided technical justifications are provided. Therefore, the justification for the use of AERCOARE/AERMOD for the Empire Wind modeling analysis addressed each of the five elements in Section 3.2.2(e), with emphasis on elements 3 and 4, as discussed below.

I. *The model or technique has received a scientific peer review.*

As detailed in the April 2011 Region 10 approval, the science behind the COARE algorithm, which has been incorporated into AERCOARE, has been published in scientific peer review journals. Information pertaining to the scientific peer review can be found at: http://www.coaps.fsu.edu/COARE/.

II. *The model or technique can be demonstrated to be applicable to the problem on a theoretical basis.*

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[1]The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the April 2011 Region 10 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=11-X-01
[2]The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the November 2019 Region 6 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=19-VI-01
[3] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the January 2022 Region 1 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-I-01
[4] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the July 2022 Region 1 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-I-02

The EPA has previously found the AERCOARE/AERMOD approach to be applicable, on a theoretical basis, for the simulation of pollutant dispersion in the marine atmospheric boundary layer. In the April 2011 Region 10 alternative model approval, EPA deemed AERCOARE/AERMOD to be appropriate for use in the Arctic marine ice-free environment. In the 2019 Region 6 approval of AERCOARE/AERMOD, EPA determined the model was also appropriate on a theoretical basis for use in the subtropical marine environment off the coast of Louisiana. In the 2022 AERCOARE/AERMOD approvals, EPA Region 1 deemed it was appropriate on a theoretical basis for use in the marine environment off the coast of Massachusetts. In addition, EPA's current user manual for AERCOARE[5] indicates that AERCOARE is expected to be appropriate for marine conditions at all latitudes.

III. The databases which are necessary to perform the analysis are available and adequate.

This element of §3.2.2 of the Guideline refers to the databases collected to develop and verify the proposed modeling methodology. The marine meteorological databases used to develop the COARE algorithm are available publicly in the scientific literature, as listed in Fairall et al.[6] Datasets from dispersion experiment campaigns have been used to verify the accuracy of the AERCOARE/AERMOD modeling approach. There are a limited number of historical overwater dispersion datasets available in the record that involve study of air pollutant dispersion in the marine atmospheric boundary layer. Historically, four robust tracer studies from the 1980s have been used in the performance evaluations of OCD, CALPUFF, and AERCOARE-AERMOD that are discussed in the request by Empire and also in the Region 10, Region 6, and Region 1 approvals of AERCOARE/AERMOD.

Similar to the Region 1 approvals, Empire has provided additional information related to the meteorological parameters measured at the New York Harbor Entrance buoy station (#4406), located near the Project area. These sufficiently demonstrate that that the referenced tracer studies were representative of the marine environment off the coast of New York.

IV. Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application.

In their request, Empire noted EPA's prior Region 10 approval of AERMOD/AERCOARE relied on the results of demonstrations showing no bias toward underestimates, using the campaign datasets listed above. EPA Region 6's approval of AERMOD/AERCOARE also relied on the results found in the original Region 10 approval. EPA Region 1's approval considered quantile-quantile (Q-Q) plots for the Cameron and Pismo Beach studies, comparing the combinations of AERCOARE/AERMOD simulations to measurements from each study. The Q-Q plots demonstrate the model tends to overestimate concentrations at the upper-end of the distribution for both studies.

A key element to both the original Region 10 approval study and a U.S. EPA (2015)[7]

[5] *U.S. EPA (2012): User's Manual AERCOARE Version 1.0, EPA 910-R-12-008, October 2012.*
[6] Fairall, C.W.; Bradley, E.F.; Hare, J.E.; Grachev, A.A.; Edson, J.B. (2003): Bulk Parameterization of Air-Sea Fluxes: Updates and Verification for the COARE Algorithm. Journal of Climate, Vol. 16, pp. 571-591. https://doi.org/10.1175/1520-0442(2003)016%3C0571:BPOASF%3E2.0.CO;2.
[7] U.S. EPA (2015): Combined WRF/MMIF/AERCOARE/AERMOD Overwater Modeling Approach for Offshore Emission Sources, Vol. 2. EPA 910-R-15-001b, October 2015.

WRF/MMIF study was an evaluation of the sensitivity of the modeling results to a minimum mixing height. The Region 10 approval found AERCOARE/AERMOD results were highly overpredicted when using AERMOD's default minimum mixing height of 1 meter. Region 10's sensitivity study, summarized in ENVIRON (2012) found a minimum mixing height of 25 meters for overwater applications was more physically realistic and resulted in better model performance. The Region 10 approval allowed for the use of a minimum mixing height of 25 meters for the application of AERCOARE/AERMOD and a minimum limit on the absolute value of Monin-Obukhov Length of 5 meters. These limits are recommended in the EPA's AERCOARE User's Guide.

Based on the above information, Region 2 concludes it is evident the AERCOARE/AERMOD approach does not result in systematic underprediction of concentrations. Instead, the evidence more likely leads to the conclusion the approach is conservative.

V. A protocol on methods and procedures to be followed has been established.

Empire submitted a modeling protocol to EPA on April 27, 2022. The modeling protocol outlined the modeling techniques employed in the air modeling analyses conducted in support of the Empire Wind project. This modeling protocol supplemented the applicant's demonstration of AERCOARE/AERMOD as an alternative model contained in their initial May 5, 2022 request to initiate the alternative model approval process.

4. Conclusions and Conditions for Use

EPA Region 2 has reviewed the alternative model request submittal provided by Empire Wind and has determined that the proposed AERCOARE/AERMOD modeling approach is acceptable as an alternative model for the air quality modeling analysis submitted in support of its OCS air permit application. Based on our review, we find that the proposed approach addresses the five elements contained in Section 3.2.2(e) of the Guideline. As such, pursuant to Sections 3.0(b) and 3.2.2(a), Region 2 currently intends to approve the use of AERCOARE/AERMOD as an acceptable alternative model for the Empire Wind project. We seek the concurrence from the Model Clearinghouse.

As with the April 2011 Region 10 alternative model approval of AERMOD-COARE, approval to use this alternative model is made on a case-by-case basis. Should an air permit applicant or state desire to use AERCOARE/AERMOD in an overwater modeling analysis for a different facility and/or location, a request for alternative approval must be made to the appropriate EPA Regional Office containing the appropriate technical justifications/demonstrations consistent with the *Guideline*.

Attachment 1 – Empire Wind's Alternative Model Request dated June 29, 2022

June 29, 2022

Ms. Neha Sareen
EPA Region 2
290 Broadway
25th Floor
New York, NY 10007-1866

Subject: Updated Request for Approval for Use of the Alternative Model AERMOD/AERCOARE for Offshore Modeling of the Empire Wind Offshore Wind Project

Dear Ms. Sareen,

Empire Offshore Wind LLC (Empire) proposes to construct and operate an offshore wind farm in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). The Lease Area covers approximately 79,350 acres (32,112 hectares) and is located approximately 14 statute miles (mi), (12 nautical miles [nm], 22 kilometers [km]) south of Long Island, New York and 19.5 mi (16.9 nm, 31.4 km) east of Long Branch, New Jersey (**Error! Reference source not found.**).

Empire proposes to develop the Lease Area in two wind farms, known as Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2) (collectively referred to hereafter as the Project). Both EW 1 and EW 2 will be covered in a single air permit application. EW 1 (816-megawatt (MW)) and EW 2 (1,260 MW) will be electrically isolated and independent from each other. Each wind farm will connect via offshore substations to separate Points of Interconnection (POIs) at onshore locations by way of export cable routes and onshore substations. In this respect, the Project includes two onshore locations in New York where the renewable electricity generated will be transmitted to the electric grid.

The Project will require a need for a total of up to 149 foundations to be installed in up to 176 locations. This number of foundations will allow for:

- 2 offshore substations;
- 138 Vestas 15-MW wind turbine generators for the 2,076 MW total capacity under contract (54 for EW 1 and 84 for EW 2); and
- Additional 9 Vestas 15-MW wind turbine generators to allow for overplanting (3 for EW 1 and 6 for EW 2).

Overplanting allows improvement in wind turbine generator availability (i.e., availability during maintenance outages) and potentially increased production at lower wind speeds. Overplanting is currently under review for both EW 1 and EW 2. The air quality modeling will consider the extra foundations for overplanting.

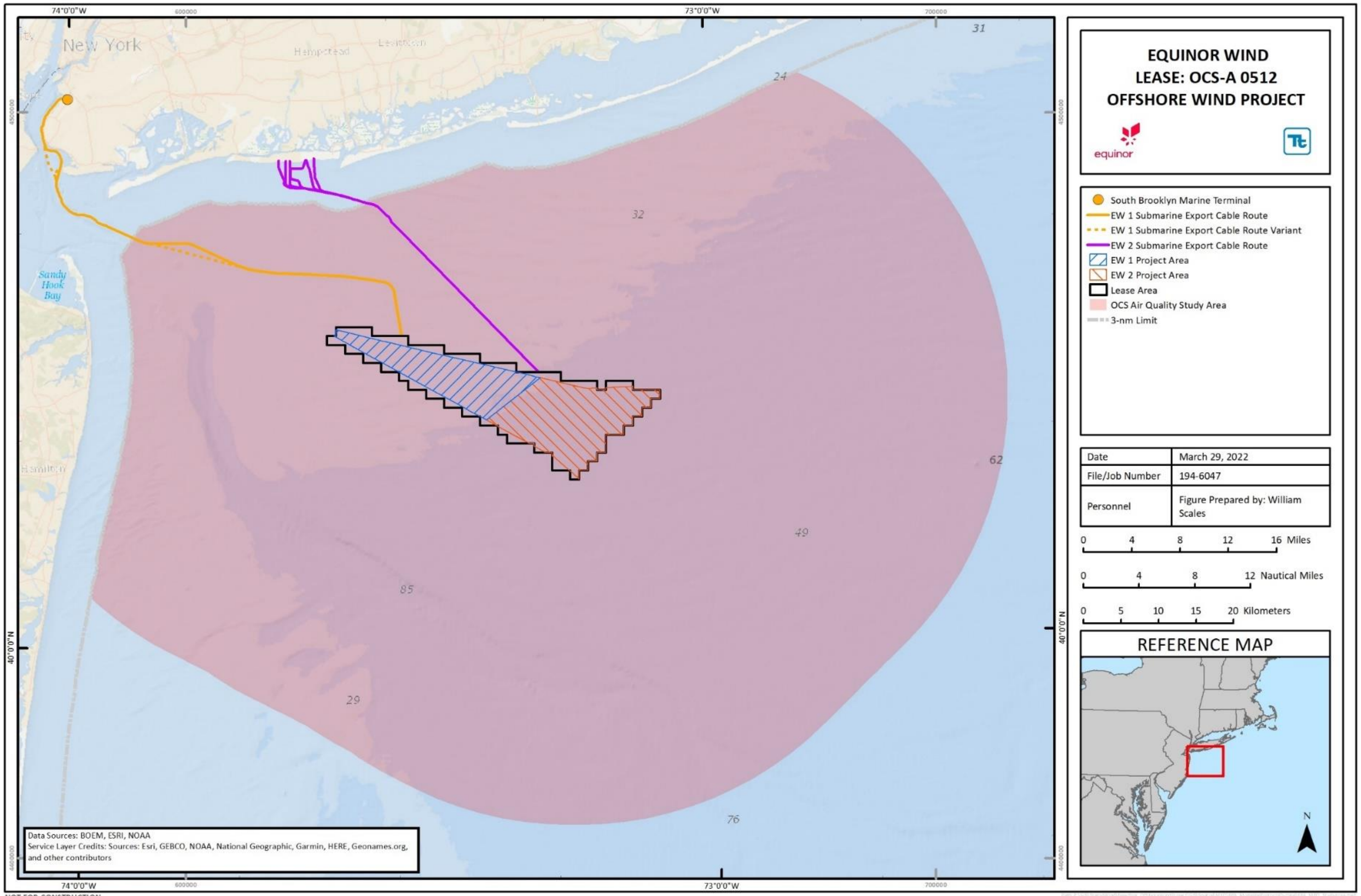

Figure 1. Project Area Overview

The Project will use offshore wind energy as a renewable resource to generate electricity. The Project addresses the need identified by New York for renewable energy and will help the State of New York Public Service Commission achieve their renewable energy goals. The Project consists of offshore wind turbine generators, each placed on a foundation support structure; offshore substations; onshore substations; offshore and onshore transmission cables and interarray cables; and an onshore Operations and Maintenance (O&M) Base. This alternative model request has been prepared in support of the OCS Air Permit Application for Empire's Project to fulfill the regulatory requirements of the United States Environmental Protection Agency's (EPA's) OCS Air Regulations, codified under Title 40 Code of Federal Regulations, Part 55 (40 CFR Part 55).

Air emissions from the proposed Project primarily consist of products of combustion from the vessels associated with the construction and operation of the Project. The Project is subject to Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NNSR) major source preconstruction permitting requirements. Pollutants that are regulated under federal and New York State programs, such as PSD, include: carbon monoxide (CO); nitrogen dioxide (NO_2); sulfur dioxide (SO_2); particulate matter (PM) including PM with a diameter equal to or less than 10 microns (PM_{10}) and PM with a diameter equal to or less than 2.5 microns ($PM_{2.5}$); ozone precursors, specifically volatile organic compounds (VOCs) and nitrogen oxides (NO_X); greenhouse gases (GHGs); lead (Pb); sulfuric acid mist (H_2SO_4); and potentially air toxics. The Project will trigger PSD review for NO_2, SO_2, CO, PM, PM_{10}, $PM_{2.5}$, and GHGs. The Project will trigger NNSR review for the ozone precursors, NO_X and VOC. There are no compliance modeling requirements for GHGs.

On April 28, 2022, Empire provided EPA with a proposed modeling protocol (Protocol) for the Project in which AERCOARE/AERMOD was proposed as an alternative modeling platform for near-field impact assessment. On May 5, 2022, Empire provided EPA a Request for Approval for Use of the Alternative Model AERMOD/AERCOARE for Offshore Modeling of the Empire Wind Offshore Wind Project. On June 16, 2022, EPA provided Empire with comments on Empire's Protocol and Alternative Model Request. This Updated Alternative Model Request has been revised to provide additional information in response to the EPA comments, including a more quantitative assessment of shoreline fumigation and a description of how downwash will be evaluated for platform structures. In addition, a description of how emission sources with angled stacks will be treated in the modeling analysis has been added to this Updated Alternative Model Request.

Empire is seeking approval for the Project to use the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm, as implemented in the meteorological data processor program (AERCOARE), to prepare meteorological data for use with the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD). AERCOARE is requested as an alternative to replace the regulatory AERMET preprocessor program that is specifically designed for applications over land. The AERCOARE processor will read and process overwater meteorological data using the COARE methodology designed for marine applications. The output from AERCOARE can then be input to AERMOD for modeling applications in a marine environment. AERMOD in conjunction with

AERCOARE prepared meteorological data (AERCOARE/AERMOD) is proposed as an alternative refined model for assessing compliance with air quality standards for the Project emission sources located over water. The Offshore and Coastal Dispersion (OCD) model is currently listed as the preferred model for over-water dispersion in USEPA's Guideline on Air Quality Models[1] (*Guideline*) as described in Section 4.2.2.3 of 40 CFR Part 51, Appendix W. AERCOARE/AERMOD is preferred by the Project over OCD for the following technical reasons:

1. The OCD modeling system was developed in the 1980-90s and as such the dispersion algorithms are outdated and have not been updated to account for advancements in dispersion modeling since that time. In contrast, AERMOD is frequently updated (the latest version was issued in 2021) and is considered the state-of-the-art for nearfield dispersion modeling.

2. The AERMOD model utilizes the Plume Rise Model Enhancements (PRIME) downwash algorithms to assess impacts in the cavity and wake regions of structures. For offshore wind projects, the vessels themselves may affect the wind flow in the area and cause aerodynamic downwash. This effect can be treated in AERMOD using the vessels as structures in the PRIME algorithms. In contrast, the OCD model only provides downwash for platform structures and is based on more simplistic algorithms.

3. Unlike OCD, AERMOD does not specifically evaluate downwash conditions for platform structures. Therefore, the Project's OSS platform structures will be conservatively evaluated with BPIPPRM by assuming the platform structures extend all the way down to the sea. This is a very conservative assumption since in reality air will flow under these structures.

4. AERMOD has the capability to treat missing or calm wind hours by implementing the calm wind processing procedures recommended in the *Guideline*. In contrast, OCD does not have the ability to process either missing or calm hours and to address this in accordance with the recommended Guideline procedures, a postprocessor would need to be developed.

5. AERMOD incorporates options for the treatment of the conversion from oxides of nitrogen (NO_X) to nitrogen dioxide (NO_2). Multiple tier NO_X to NO_2 conversion techniques are available to the modeler in AERMOD. The OCD model does not employ any NO_2 conversion techniques and only assumes full conversion of NO_X to NO_2. Some of the NO_2 conversion methods available in AERMOD could be applied to the OCD predicted concentrations in a postprocessing step, but to account for the Tier 2 ARM2 technique or Ozone Limiting Method (OLM), a custom postprocessor for OCD must be developed. The Plume Volume Molar Ratio Method (PVMRM) could not be implemented in a postprocessing step, as the adjustments to the predicted concentrations are internal to the AERMOD model calculations that are dependent on the plume characteristics.

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[1] EPA. 2017. *Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches To Address Ozone and Fine Particulate Matter.* Codified in Appendix W of 40 CFR Part 51. Federal Register Vol. 82, No. 10. Office of Air Quality Planning and Standards, Research Triangle Park, NC. January 17, 2017.

6. AERMOD incorporates options for the inclusion of varying ambient background concentrations during the model run. In contrast, OCD does not have an option to incorporate ambient background concentrations within the model. Ambient background concentrations could be applied to the OCD predicted concentrations in a postprocessing step. A custom postprocessor for OCD must be developed.

7. AERMOD can generate the output concentrations in the form required for comparison to the newer multi-year averaged statistically based NAAQS, namely the 1-hour NO_2, 1-hour SO_2, and 24-hour and annual $PM_{2.5}$ NAAQS. OCD cannot output any statistical or multi-year average results, so for a proper comparison to the NAAQS, a custom postprocessor for OCD must be developed.

8. The AERCOARE meteorological processor utilizes the COARE algorithm that uses air-sea temperature difference, overwater humidity and wind speed to estimate the heat fluxes in the atmosphere over water. AERCOARE is expected to be appropriate for use in marine conditions at all ice-free latitudes. For this application of modeling offshore sources, the use of AERCOARE to prepare the meteorological data for use in AERMOD is more appropriate than using AERMET, the regulatory meteorological processor that is part of the AERMOD modeling system.

9. Modeling of the temporally and spatially varying construction emission sources will be done with an hourly emissions input scheme that will necessitate many unique emission points. OCD limits the number of stationary sources to 8,500. AERMOD does not limit the number of sources.

10. The very large project area footprint will necessitate a substantial number of receptors be defined to ensure maximum impact concentrations are determined. OCD limits the number of receptors (3,000 discrete, 720 polar, and 1,600 cartesian). AERMOD does not place a limit on the number of receptors.

11. Unlike OCD, AERMOD does not specifically treat angled stack exhaust emissions. AERMOD is configured to treat vertical or horizontal venting stacks, but not angled stacks (between vertical and horizontal). Since many of the vessels that make up the Project emissions source inventory will include angled stacks, the modeling will conservatively treat the exhaust emissions from these stacks by using the horizontal stack options. This is a conservative approach which effectively takes credit for the plume rise due to buoyancy but does not take any credit for the momentum plume rise.

12. Unlike OCD, AERMOD does not include algorithms to evaluate shoreline fumigation conditions. However, shoreline fumigation is not expected to be an important impact consideration for the Project emission sources. Shoreline fumigation can occur when plumes traveling in relatively stable air near the shoreline encounter the thermal internal boundary layer (TIBL) and fumigate downward, potentially resulting in elevated pollutant concentrations at the ground. The TIBL is the boundary layer that can form between the more stable over-water air mass and the less stable over-land air mass and typically forms during sea breeze conditions. EPA modeling guidance indicates that shoreline fumigation can be an important phenomenon on and near the shoreline of bodies of water for sources with tall stacks located on or just inland of a shoreline. However, the Project emissions (primarily vessels) are emitted from stacks with low release heights that will generally be located far offshore (the Project site is located approximately 22 km or more offshore). Exhaust

plumes are expected to be substantially dispersed before encountering the TIBL and potential fumigation conditions. Therefore, shoreline fumigation is not expected to be an important impact condition for Project emissions and is not proposed to be specifically evaluated for the air quality analysis.

To confirm this understanding, test modeling has been conducted with the OCD model (which includes algorithms to assess shoreline fumigation conditions). The OCD test modeling was based on a representative Project vessel emission source and a year of meteorological data (2019 hourly meteorological data from the New York Harbor Entrance Buoy (#44065) in OCD overwater format and overland format data from JFK airport meteorological station with upper air observations from Brookhaven) for which the wind direction for every hour have been artificially adjusted to blow due north toward the nearest coast (Long Island). Receptors were placed to the north from the coastline at 100-meter intervals out to approximately 5 kilometers to predict inland concentrations in the area where fumigation conditions could potentially increase predicted concentrations. This modeling shows that maximum 1-hour predicted concentrations decrease in magnitude along the string of receptors that extend from the coastline inland and does not show any indication of concentrations increasing. A set of four OCD test runs were made, first for a full year (2019) of meteorological conditions, then with the case study option turned on for the individual hours (three of them) that produced the maximum impacts at the 50 receptors in the full year run. The case study output lists the plume rise and dispersion parameters at each receptor. The case study output showed that a TIBL did form during these stable hours and the plume did intersect the TIBL, however the predicted concentrations decreased due to the TIBL intersection. This is likely because the plume is substantially dispersed before encountering the TIBL and is further diluted when it is fumigated to the ground and uniformly mixed. This demonstrates that shoreline fumigation is not a concern with emission sources having an emissions configuration consistent with the marine vessels to be used for project construction and located far offshore the coast. The electronic modeling files for the OCD test runs will be provided to EPA for review upon request.

Proposed Modeling Approach

Empire has not yet submitted its OCS application for the Empire Wind Project, which will include an air quality impact analysis (AQIA) report, as required to fulfill requirements under 40 CFR Part 52.21 and 40 CFR Part 55. On April 28, 2022, Empire provided EPA with a proposed modeling protocol (Protocol) for the Empire Wind Project in which AERCOARE/AERMOD was proposed as an alternative modeling platform for near-field impact assessment. A brief summary of the protocol's proposed modeling approach is provided in this section. AERCOARE/AERMOD will be used to conduct the analyses necessary to demonstrate compliance with the NAAQS, PSD Increments, and other applicable near-field impact assessments. The near-field NAAQS and PSD increment AERCOARE/AERMOD modeling will first determine if modeled Project potential-to-emit (PTE) impacts exceed the EPA-prescribed pollutant significant impact levels (SILs) and if so, then determine the associated significant impact area (SIA) for each pollutant and averaging period. For project impacts that exceed the SILs, a cumulative impact analysis will be conducted to demonstrate compliance with the associated NAAQS and/or PSD Increments. If necessary, Empire will work with EPA to develop the background source inventory for cumulative modeling.

The AERMOD model requires hourly meteorological data to simulate plume transport and dispersion. The AERCOARE meteorological data preprocessor program was specifically designed to process overwater hourly meteorological data for use in AERMOD dispersion model simulations in a marine environment. AERCOARE applies the COARE air-sea flux procedure to estimate surface energy fluxes from either overwater meteorological measurements or prognostic predicted meteorological parameters extracted at a particular location using the EPA's Mesoscale Model Interface (MMIF) program. Meteorological data collected at Buoy Station #44065 (New York Harbor Entrance /Ambrose Light - 15 nautical miles southeast of Breezy Point, NY) will be processed with AERCOARE to create the overwater meteorological data files for each of the years (2015-2019) for input to AERMOD. This period is the most recent 5-year period with suitable data capture for use in dispersion modeling.

Secondary formation of $PM_{2.5}$ and ozone will be determined using EPA's Modeled Emission Rate for Precursors (MERP) methodology based on low-level stack modeling results for nearby representative hypothetical sources.

Empire proposes to perform an initial assessment of Class I area impacts at a nominal 50-km distance using the AERCOARE/AERMOD modeling system, in accordance with the screening technique outlined in §4.2 of the *Guideline*. As directed in §4.2, if the analysis finds Class I area significant impacts at the screening distance, a long-range transport analysis will be conducted using the CALPUFF model. CALPUFF will be used in a screening mode to assess if the Project has significant impacts at the nearest Class I areas, specifically the E.B Forsythe (Brigantine) Wilderness (located approximately 108 kilometers to the south-southwest of the lease area) and the Lye Brook Wilderness (located approximately 299 kilometers to the north). If CALPUFF screening finds Project impacts are significant at Class I areas, refined three-dimensional meteorological data will be developed. If the CALPUFF refined mode finds Project impacts are significant at Class I areas, a full-scale cumulative analysis may be necessary, under the direction specified in §4.2(d) of the *Guideline*.

Prognostic meteorological model data will be used if refined long-range transport modeling for Class I area impact analysis is required. Gridded Weather Research and Forecasting (WRF) model-derived multi-level meteorological data will be used for CALPUFF Class I area modeling, if necessary. Note that refined CALPUFF modeling will be conducted for the Class I Area (E.B. Forsythe (Brigantine) Wilderness) Air Quality Related Values (AQRVs) assessment per the direction of the US Fish and Wildlife Service (USFWS, Tim Allen). USFWS has provided the meteorological data for this analysis.

Regulatory Summary for Alternative Modeling Request

The PSD preconstruction air permit requirements of 40 CFR Part 52.21 apply to new OCS sources under 40 CFR Part 55.13(d). Part 52.21(k) requires a source impact analysis be conducted as part of the permitting process to confirm the new source will not cause or contribute to the violation of an air quality standard.

The PSD regulations (40 CFR Part 52.21(l)) state that all applications of air quality modeling shall be based on the preferred models specified in the *Guideline* but also provides on a case-by-case basis that an alternative air quality dispersion model may be used if written approval from the EPA Regional Administrator is obtained. The alternative model approval process and conditions are outlined in Section

3.2 of the *Guideline*. Section 3.2.2(a) specifies that the determination of acceptability of an alternative model is an EPA Regional Office responsibility in consultation with EPA's Model Clearinghouse (MCH). An alternative model may be used subject to Regional Office approval if found to satisfy the requirements listed in Section 3.2.2. Section 3.2.2(e) sets forth the five elements that must be satisfied for alternative model approval:

I. *The model or technique has received a scientific peer review;*

II. *The model or technique can be demonstrated to be applicable to the problem on a theoretical basis;*

III. *The databases which are necessary to perform the analysis are available and adequate;*

IV. *Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application; and,*

V. *A protocol on methods and procedures to be followed has been established.*

The EPA has approved the use of AERCOARE/AERMOD as an alternative model for overwater modeling on three previous occasions. The first such approval was by USEPA Region 10 on April 1, 2011, when approval was granted for the use of output from the COARE algorithm coupled with AERMOD to estimate ambient air pollutant concentrations in an ice-free marine environment.[2,3] The COARE algorithm output was assembled with other meteorological variables in a spreadsheet to form the AERMOD overwater meteorological input files. After USEPA's 2011 approval of the use of the COARE algorithm in spreadsheet form the COARE air-sea flux procedure was coded into the AERCOARE program.

On November 19th, 2019, EPA Region 6 approved the use of AERCOARE/AERMOD for the proposed Sea Port Oil Terminal (SPOT) offshore oil export facility located in EPA Region 6 off the Louisiana coast. The SPOT request documented several limitations of OCD, as well as the key dispersion features of OCD that are not available within AERCOARE/AERMOD (i.e., platform downwash and shoreline fumigation). The SPOT request documented that the applicant would model the platform sources as solid structures and that the project's operation was sufficiently offshore that shoreline fumigation would not be a concern. On November 19th, 2019, USEPA approved the use of AERCOARE/AERMOD for SPOT.[4]

On January 28, 2022, EPA Region 1 approved the use of AERCOARE/AERMOD for the proposed Park City Wind (PCW) offshore wind power project located off Martha's Vineyard, Massachusetts.[5] The PCW alternative model request referenced the aforementioned 2011 EPA Region 10 and 2019 EPA Region 6

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[2] 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, 2011

[3] 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.

[4] Model Clearinghouse review of an alternative model application of AERCOARE in conjunction with AERMOD for the proposed Sea Port Oil Terminal (SPOT) Terminal Services LLC's Deepwater Port Project, George Bridgers, USEPA to Ashley Mohr, USEPA. November 19th, 2019.

[5] Model Clearinghouse review of an alternative model application of AERCOARE in conjunction with AERMOD in Support of Outer Continental Shelf PSD air permitting of the Park City Wind offshore wind power project, George Bridgers, USEPA to Jay McAlpine, USEPA. January 28th, 2022.

alternative model requests and listed several limitations of OCD that AERCOARE/AERMOD can accomplish.

As documented in the EPA Region 1 and the USEPA Region 6 approvals, the AERCOARE/AERMOD model was approved for use in an arctic marine ice-free environment because it satisfied the five criteria contained in Section 3.2.2.e of the *Guideline*. In the previous MCH concurrence memorandums, it stated that its concurrences with the approvals does not constitute a generic approval of the alternative AERCOARE/AERMOD modeling system for other applications, however it does provide a good basis for such considerations provided technical justifications are provided.

The following section of this request for alternative model approval provides Empire's justification for the approval of AERCOARE/AERMOD for its overwater source with respect to each of the five elements contained in Section 3.2.2(e).

Evaluation of Approach under Section 3.2.2(e)

The justification for the use of AERCOARE/AERMOD for the Empire Wind Project modeling analysis addresses each of the five elements in Section 3.2.2(e), as discussed below.

I. The model or technique has received a scientific peer review.

As described in the 2011 EPA Region 10 approval[6] (and referenced in the 2019 EPA Region 6 approval[7] and 2022 EPA Region 1 approval[8]), the science behind the COARE algorithm, which is incorporated into AERCOARE, has been published in scientific peer review journals. In its approval, Region 10 confirmed the scientific legitimacy and applicability of the COARE algorithm to various over-water conditions through a sufficient body of peer-reviewed literature. The Region 10 approval also documented that the algorithms in COARE are configured to handle a wide range of temperature gradient conditions including the extremes that could be found in the Arctic or the tropics.

A key peer reviewed article that demonstrated the effectiveness of the COARE 3.0 algorithm when compared to datasets from multiple air-sea flux and bulk meteorological data collection campaigns was presented by Fairall et al.[9] in 2003.

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[6] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the April 2011 Region 10 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=11-X-01

[7] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the November 2019 Region 6 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=19-VI-01

[8] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the January 28, 2022 Region 1 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-I-01

[9] *Fairall, C.W.; Bradley, E.F.; Hare, J.E.; Grachev, A.A.; Edson, J.B. (2003): Bulk Parameterization of Air-Sea Fluxes: Updates and Verification for the COARE Algorithm. Journal of Climate, Vol. 16, pp. 571-591. https://doi.org/10.1175/1520-0442(2003)016%3C0571:BPOASF%3E2.0.CO;2*

Wong et al.[10] also described the concepts and configuration of the AERCOARE model and its association with AERMOD in the 2016 peer-reviewed article by Region 10 and partner scientists.

II. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis.

The EPA has previously found the AERCOARE/AERMOD approach to be applicable, on a theoretical basis, for the simulation of pollutant dispersion in the marine atmospheric boundary layer. In the April 2011 Region 10 alternative model approval, EPA deemed AERCOARE/AERMOD to be appropriate for use in the Arctic marine ice-free environment. In the 2019 Region 6 approval of AERCOARE/AERMOD, EPA determined the model was also appropriate on a theoretical basis for use in the subtropical marine environment off the coast of Louisiana. In the 2022 AERCOARE/AERMOD approval for the PCW project, EPA Region 1 deemed it was appropriate on a theoretical basis for use in the marine environment off the coast of Massachusetts. In addition, as shown below, EPA's current user manual for AERCOARE[11] indicates that AERCOARE is expected to be appropriate for marine conditions at all latitudes:

"AERCOARE uses Version 3.0 of the COARE algorithm that has been updated several times since the initial international TOGA-COARE field program in the western Pacific Ocean from November 1992 to February 1993. The basic algorithm uses air-sea temperature difference, overwater humidity, and wind speed measurements to estimate the sensible heat, latent heat, and momentum fluxes. The original algorithm was based on measurements in the tropics with winds generally less than 10 m/s but has since been modified and extensively evaluated against measurements in high latitudes with winds up to 20 m/s. Based on these studies, AERCOARE is expected to be appropriate for marine conditions found at all latitudes including the Arctic."

As described in the AERCOARE user's manual, AERCOARE calculates the meteorological input parameters needed for AERMOD by accounting for heat flux to and from the atmosphere due to the difference in temperature between the water surface and the air. AERMOD alone does not depend on parameterizations specific to overland conditions. The meteorological inputs provided by AERCOARE (for input to AERMOD) provide the information necessary to parameterize the structure of the marine atmospheric boundary layer using Monin-Obukhov Similarity Theory. This parameterization scheme is universally applicable to over-land and over-water domains. The COARE 3.0 algorithms use standard meteorological variables such as wind speed, air temperature, relative humidity, and water temperature to determine bulk transfer coefficients used in Monin-Obukhov Similarity Theory to describe the structure of the atmospheric surface layer.

Based on the information summarized above, Empire believes that the coupled AERCOARE/AERMOD modeling approach is applicable to the Project on a theoretical basis.

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[10] *Wong, H.; Elleman, R.; Wolvovsky, E.; Richmond, K.; Paumier, J. (2016): AERCOARE: An overwater meteorological preprocessor for AERMOD, Journal of the Air & Waste Management Association, 66:11, 1121-1140, DOI: 10.1080/10962247.2016.1202156*

[11] *U.S. EPA (2012): User's Manual AERCOARE Version 1.0, EPA 910-R-12-008, October 2012.*

III. The databases which are necessary to perform the analysis are available and adequate.

The *Guideline* refers to the databases collected to develop and verify the proposed modeling methodologies. The meteorological databases that were used to develop the COARE algorithms for marine conditions are publicly available in the scientific literature. Datasets from previous dispersion experiment studies have been used to verify the accuracy of the AERCOARE/AERMOD modeling approach. There are four comprehensive historical overwater dispersion datasets available in the record that involve study of air pollutant dispersion in the marine atmospheric boundary layer. The following four tracer gas studies from the 1980s have been used in performance evaluations of OCD, CALPUFF, and AERCOARE/AERMOD:

- Cameron, Louisiana: July 1981 and February 1982 (Dabberdt, Brodzinsky, Cantrell, & Ruff, 1982[12])
- Carpinteria, California: September 1985 (Johnson & Spangler, 1986[13])
- Pismo Beach, California: December 1981 and June 1982 (Schacher, et al., 1982[14])
- Ventura, California: September 1980 and January 1981 (Schacher, et al., 1982)

The Region 10 alternative model approval of AERCOARE/AERMOD utilized tracer gas experiments from the four studies listed above. In all of the previous approvals, EPA determined that these datasets were adequate for verification of the AERCOARE/AERMOD system.

Additional information was provided by PCW to Region 1 to demonstrate the referenced tracer studies were sufficiently representative of the marine environment off the coast of Massachusetts.[15] Likewise, Empire provides statistics for key meteorological parameters for the New York Harbor Entrance buoy station (#44065) located near the Project area. The buoy is located 5.5 miles west of the northwest corner of the Project Area and is the nearest offshore meteorological station between the Project Area and land with the necessary meteorological parameters. Table 1 summarizes key meteorological data and compares them to data from the tracer studies. The data demonstrates that the range of atmospheric conditions that typically occur in the New York Long Island offshore region fit the range of conditions used to develop and verify the COARE 3.0 algorithm.

The New York Harbor Entrance buoy air-sea temperature gradient data and wind data from the years 2015 to 2019 were obtained for comparison to the range of conditions used to develop the COARE 3.0 algorithm and the conditions during the four tracer experiments. Data statistics are provided on the distribution of

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[12] Dabberdt, W., Brodzinsky, R., Cantrell, B., & Ruff, R. (1982). Atmospheric Dispersion Over Water and in the Shoreline Transition Zone, Final Report Volume II: Data. Menlo Park, CA: Prepared for American Petroleum Institute by SRI International.

[13] Johnson, V., & Spangler, T. (1986). Tracer Study Conducted to Acquire Data for Evaluation of Air Quality Dispersion Models. San Diego, CA: WESTEC Services, Inc. for the American Petroleum Institute

[14] Schacher, G., Spiel, D., Fairall, C., Davidson, K., Leonard, C., & Reheis, C. (1982). California Coastal Offshore Transport and Diffusion Experiments: Meteorological Conditions and Data. Monterey, CA: Report NPS-61-82-007, Naval Postgraduate School.

[15] Supplemental Information for the Request for Approval for Use of COARE Bulk Flux Algorithm to Generate Hourly Meteorological Data for use with AERMOD, Joseph Sabato, Epsilon Associates, Inc. to Jerrold McAlpine, USEPA Region 1, November 24, 2021.

wind speed and air-sea temperature differences from the four tracer studies, consisting of a total of 101 hourly observations. The maximum hourly average wind speed measured at the buoy was 21.2 m/s and the 99th percentile of wind speed was 15.2 m/s. The COARE algorithm was developed and verified with conditions up to 20 m/s. Therefore, more than 99 percent of the New York offshore winds are within the COARE evaluation wind speed range. The highest wind speeds that exceed the values in the COARE evaluation range will be associated with highly dispersive conditions such that maximal predicted concentrations will not be a consideration at the wind speeds in excess of the range.

The maximum wind speed from any of the four tracer studies was 12.7 m/s, during the Pismo Beach study. Average wind speeds during each study ranged from 2.5 to 6.1 m/s. Average wind speed at the New York Harbor Entrance buoy was 6.4 m/s, with a median wind speed of 6.0 m/s. Highest concentrations from the project are likely to occur during lower wind speeds. The range of wind speed conditions observed during the tracer experiments covers the range of conditions when the maximum project concentrations are expected.

Because the air-sea temperature difference is an important parameter in characterizing the marine boundary layer, a comparison of the air-sea temperature difference at the New York Harbor Entrance buoy was made with the air-sea temperature differences observed in the evaluation tracer studies. The average air-sea temperature difference at the New York Harbor Entrance buoy (1.4 degrees K) is just above the range of averages at the tracer study sites (-0.2 to 1.3 degrees K). The air-sea temperature difference ranges were -4.5 to 5.0, -1.1 to 2.8, -0.8 to 3.7, and -2.1 to 1.8 degrees Kelvin (K) from the Cameron, Carpinteria, Pismo Beach, and Ventura tracer studies, respectively. The range of air-sea temperature differences at the New York Harbor Entrance buoy is -8.8 to 21.2 degrees K. It should be noted that the data period analyzed at the New York Harbor Entrance offshore buoy was much longer (5 years of hourly data) and included many more hours than the tracer studies and covered all seasons of the year. The New York Harbor Entrance buoy 10th and 90th percentile air-sea temperature differences were -1.8 and 6.2 degrees K, indicating most of the conditions fall within or are near the most extreme range of conditions tested in the AERMOD simulations of the tracer experiments as represented by the range of the Cameron study.

Box and whisker plots were used to further examine and compare the New York Harbor Entrance and tracer study data sets. Figure 2 presents the box and whisker plots for wind speed, which show that wind speeds at New York Harbor Entrance are generally within the range of those observed during the tracer studies, with the 25th percentile and 75th percentile range in line with the Pismo Beach wind speed data. Figure 3 presents the box and whisker plots for air-sea temperature difference, which show that air-sea temperature difference at New York Harbor Entrance are generally within the range of those observed during the tracer studies. The four tracer studies evaluated do cover a range of wind and temperature gradient conditions and represent the majority of the range of conditions that occur at the Project site, as inferred through the New York Harbor Entrance dataset. Most importantly, the low wind speed conditions that are most likely to result in highest predicted concentrations are well addressed in the tracer studies.

Empire believes the meteorological dataset from the New York Harbor Entrance buoy proposed for use in AERCOARE and the four tracer studies data sets used in the evaluation of the COARE 3.0 algorithms in

AERCOARE are sufficiently available and adequate for determining the effectiveness of the proposed modeling approach.

IV. Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application.

Previous performance evaluations have demonstrated that AERCOARE/AERMOD predicted concentrations are not biased toward underestimates. EPA Region 10's approval of AERCOARE/ AERMOD relied on the results of demonstrations showing no bias toward underestimates, using the overwater study datasets listed above. EPA Region 6's approval of AERCOARE/AERMOD also relied on the results presented in the EPA Region 10 approval. The Region 10 evaluation described the AERCOARE/AERMOD predictions from three of the four tracer study datasets (the Ventura dataset was not included because it was considered not representative due the receptors being located well inland and not representative of marine conditions) using various combinations of meteorological data (including different approach to mixing height calculation, use or no use of wind direction variance, and other settings). A statistical analysis was conducted to evaluate whether the AERCOARE/AERMOD alternative modeling approach was biased towards underpredictions.

EPA Region 1's approval considered quantile-quantile (Q-Q) plots for the Cameron and Pismo Beach studies, comparing the combinations of AERCOARE/AERMOD simulations to measurements from each study. The Q-Q plots demonstrate the model tends to overestimate concentrations at the upper-end of the distribution for both studies. The plot for the Cameron case shows that the highest predicted concentrations match well to observations. The plot for the Pismo Beach case shows that the highest predicted concentrations are much greater than the observations, exceeding by more than the factor-of-two threshold. The Region 10 approval included a Q-Q plot of the results from the Carpinteria study. The Carpinteria data showed the AERCOARE/AERMOD results at the upper tail of the distribution exceeded the observations. The data also showed that the five combinations of AERCOARE configurations tested result in predicted concentrations that are all generally of the same magnitude.

Both the original Region 10 approval study and a 2015 EPA[16] study included evaluations of the sensitivity of the modeling results to a minimum mixing height. As described in the Region 10 approval, the AERCOARE/AERMOD results were shown to be highly overpredicted when using AERMOD's default minimum mixing height of 1 meter. Region 10's sensitivity study, summarized in ENVIRON (2012)[17] found a minimum mixing height of 25 meters for overwater applications was more physically realistic and resulted in better model performance. The Region 10 approval allowed for the use of a minimum mixing height of 25 meters for the application of AERCOARE/AERMOD and a minimum limit on the absolute value of Monin-Obukhov Length of 5 meters. These limits are recommended in the EPA's AERCOARE User's Guide[9].

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[16] *U.S. EPA (2015): Combined WRF/MMIF/AERCOARE/AERMOD Overwater Modeling Approach for Offshore Emission Sources, Vol. 2. EPA 910-R-15-001b, October 2015.*

[17] *ENVIRON 2012. Evaluation of the Combined AERCOARE/AERMOD Modeling Approach for Offshore Sources. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA. EPA Contract EP-D-08-102, Work Assignment 5-17, EPA 910-R-12-007, October 2012.*

Based on the study information described above, Empire believes it is evident the AERCOARE/AERMOD approach is not likely to result in underprediction of concentrations, but rather more likely the approach is conservative.

V. A protocol on methods and procedures to be followed has been established.

Empire submitted a modeling protocol to EPA on April 28, 2022 for the proposed EW 1 and EW 2 modeling analysis. The modeling protocol outlines the modeling procedures to be employed in the air modeling analyses including the use of AERCOARE/AERMOD for the offshore Empire Wind Project. Empire intends to run AERCOARE using the following settings recommended in EPA's AERCOARE User's Guide[18], as specified below:

- The default threshold wind speed will be used to identify calm hours (i.e., WSCALM = 0.5 m/s). Wind speeds below this value will be considered calms;
- Mechanical mixing heights will be calculated by AERCOARE from the friction velocity using the Venkatram method. During convective hours, the convective mixing height will be set to the mechanical mixing height. The default minimum mixing height of 25 meters will be assigned.
- Warm layer and cool-skin effects will not be considered.
- Friction velocity will be determined from wind speed only; wave-height will not be considered.

Conclusion

Empire believes that AERCOARE/AERMOD meets the requirements for approval for use as an alternative model for offshore dispersion modeling for the Empire Wind Project located in the Atlantic Ocean off the Long Island, New York coast. As shown above, the proposed approach satisfies each of the five elements contained in Section 3.2.2(e) of the *Guideline* required for alternative model approvals.

If you have any questions or require additional information, please contact me at (617) 866-1318 or evlan@equinor.com.

Sincerely,

Eva Land

Eva Land
Federal Permitting Manager

[18] https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aercoare/AERCOAREv1_0_Users_Manual.pdf

Table 1: Comparison of Meteorological Data Summary Statistics

Location	Observations	Range	10th Percentile	25th Percentile	Median	Average	75th Percentile	90th Percentile
	Wind Speed (m/s)							
Cameron, LA	26	2.1 to 6.2	3.4	3.7	4.6	4.5	5.0	5.8
Carpinteria, CA	27	1 to 5.4	1.0	1.3	2.4	2.5	3.2	4.3
Pismo Beach, CA	31	1.6 to 12.7	2.3	3.8	5.6	6.1	8.6	10.1
Ventura, CA	17	3.1 to 6.9	3.3	4.2	4.9	5.0	6.0	6.4
New York Harbor Entrance, NY	43,586	0 to 21.2	2.4	3.9	6.0	6.4	8.5	11.0
	Air/Sea Temperature Difference (K)							
Cameron, LA	26	-4.5 to 5	-3	-1.8	0.5	0.3	2.2	4.6
Carpinteria, CA	27	-1.1 to 2.8	-1	-0.7	-0.4	0.2	1.0	2.4
Pismo Beach, CA	31	-0.8 to 3.7	0	0.4	1.3	1.3	2.2	3.4
Ventura, CA	17	-2.1 to 1.8	-2	-1.5	0.0	-0.2	0.9	1.7
New York Harbor Entrance, NY	43,469	-8.8 to 21.2	-1.8	-0.7	0.4	1.4	2.8	6.2

Figure 2: Box and Whisker Plots for New York Harbor Entrance Buoy and 4 Tracer Study Data Sets – Wind Speed (m/s)

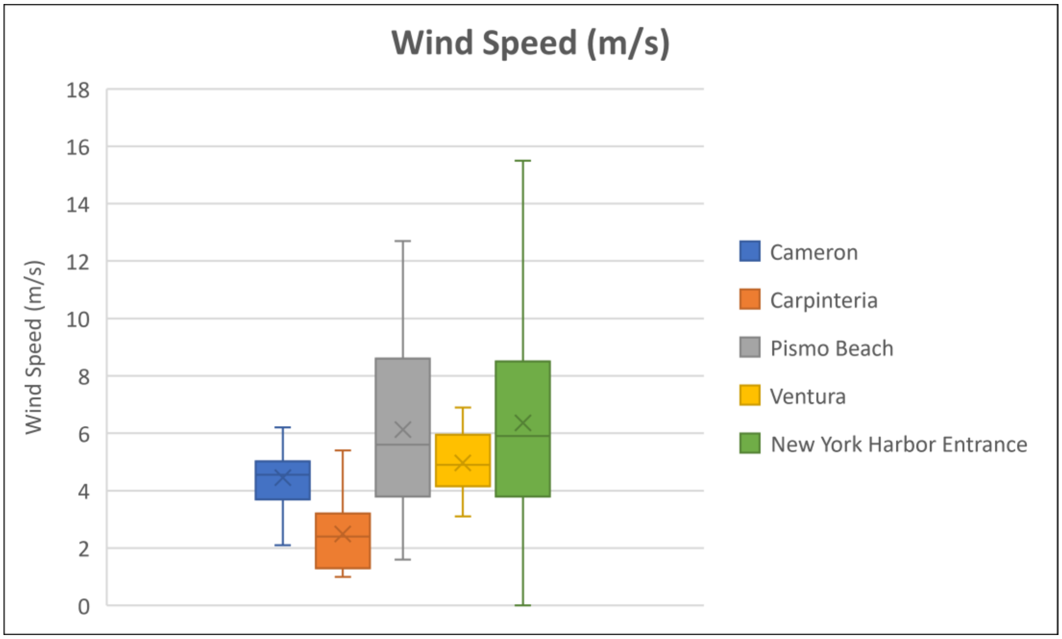

Figure 3: Box and Whisker Plots for New York Harbor Entrance Buoy and 4 Tracer Study Data Sets – Air-Sea Temperature Difference (K)