# Technical Review of the New Fortress Energy (NFE) Louisiana FLNG LLC request to use the AERCOARE meteorological data preprocessor program in conjunction with AERMOD in support of their Prevention of Significant Deterioration (PSD) Permit Application

Ashley Mohr
EPA Region 6, Air Permits Section (ARPE)
Air Permit Modeling Contact
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## 1. Background and Project Overview

New Fortress Energy (NFE) Louisiana FLNG LLC, a limited liability company organized under the laws of Delaware, is proposing to construct, own, and operate the New Fortress Energy Louisiana FLNG Project, a deepwater port (DWP) export terminal approximately 16 nautical miles off the southeast coast of Grand Isle, Louisiana. The Project will involve the installation of two nominal 1.4 million metric tonnes per annum liquefaction systems (FLNG1 and FLNG2) installed in the West Delta Lease Block 38 in approximately 30 meters (98 feet) of water. Each system will contain three platforms consisting of natural gas processing, natural gas liquefaction, and utilities and accommodations. The proposed facility will provide natural gas supplies to global markets in the form of liquified natural gas and requires a PSD construction permit. NFE Louisiana FLNG submitted their PSD permit application, including the required air quality analysis, to EPA Region 6 on November 18, 2022. The applicant has requested the use of an alternative model to conduct their PSD air quality modeling analysis. Specifically, NFE has requested the use of 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 in order to assess ambient impacts in a marine environment. NFE Louisiana FLNG submitted their initial pre-application alternative model request on July 26, 2022 (Appendix A).

In their July 26, 2022, request, NFE Louisiana LNG indicated their preference to utilize the AERCOARE/AERMOD alternative modeling approach over the EPA's preferred model, the Offshore and Coastal Dispersion (OCD) model. NFE's alternative model request presented the following technical reasons, options, and/or features available in the alternative model to support their request:

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 ($NO_X$) 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.
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. 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.
10. 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). The modeling will conservatively treat the exhaust emissions from any angled stacks by using the horizontal stack option. 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.

11. 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 are emitted from stacks located far offshore (the Project site is located approximately 29 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.

As discussed in this technical document, EPA Region 6 has reviewed the applicant's alternative model request and determined that the use of the proposed alternative model is acceptable for the NFE Project. As such, EPA Region 6 currently intends to approve the use of AERCOARE in conjunction with AERMOD for the proposed NFE DWP facility.

## 2. Modeling Approach

The PSD application, dated November 18, 2022, submitted by NFE Louisiana FLNG contains detailed descriptions of the modeling approach using AERCOARE/AERMOD. This document is available upon request. A summary of the modeling approach is provided in this section.

NFE Louisiana LNG used AERMOD Version 22122 to conduct the dispersion modeling analyses necessary to demonstrate compliance with the applicable NAAQS and PSD increments. Modeled receptors were placed in all areas considered as ambient air out to 20 km from the "property line." The property line was defined based on the Coast Guard safety exclusion zone, which serves as the ambient air boundary. Meteorological data collected at nearby buoy stations in the Gulf of Mexico was processed with AERCOARE to create the meteorological data files for a 5-year modeling period for input to AERMOD.

For the NAAQS and PSD increment modeling analyses, NFE Louisiana LNG initially conducted a significant impact analysis (SIA) to determine if modeled impacts exceeded the significance levels (SILs). For those pollutants and averaging periods that exceeded the SILs, a cumulative impact analysis was conducted to demonstrate compliance with the associated NAAQS and/or PSD increments.

NFE used EPA's Modeled Emission Rate for Precursors (MERP) methodology based on low-level stack modeling results for nearby representative hypothetical sources to determine secondary formation of $PM_{2.5}$ and ozone.

## 3. Alternative Model Approval Approach

## 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 Appendix W of Part 51 (Guideline on Air Quality Models). However, 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 approval of an alternative model is outlined in 40 CFR Part 51 Appendix W, Section 3.2. Section 3.2.2(a) specifies that the determination of acceptability of an alternative model is a Regional Office responsibility in consultation with the Model Clearinghouse (MCH) and that an alternative model may be used subject to Regional Office approval based on the Section 3.2.2 requirements. 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 NFE Louisiana FLNG has requested the use of the AERCOARE/AERMOD.

Appendix W 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 NFE Louisiana LNG in their request to use an alternative model for their air quality modeling analyses. The following limitations are of particular importance to the NFE DWP project:

(1) OCD does not provide for the multi-tiered screening approach for $NO_2$ 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 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 NFE DWP project, or AERCOARE/AERMOD provides a more appropriate and conservative approach. The NFE DWP project emissions are emitted from stacks located far offshore (approximately 29 km or more offshore). Due to this, the controlling concentrations will occur at overwater receptors and not near the shoreline. Furthermore, exhaust plumes are expected to be substantially dispersed before encountering the thermal internal boundary layer and potential fumigation. Therefore, OCD's feature regarding shoreline fumigation further away onshore is not of concern for the NFE DWP project, which is located sufficiently offshore (approximately 29 km), and is not evaluated in the project's air quality impact analysis. Regarding downwash features, while OCD accounts for platform downwash, NFE Louisiana FLNG's 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, NFE Louisiana FLNG 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 conditions 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] In 2022, EPA Region 1 approved the use of AERCOARE/AERMOD in four separate instances for projects off the coast of Massachusetts.[3,4,5,6] EPA Region 2 approved the use of AERCOARE/AERMOD in two

[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
[5] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the December 2022 Region 1 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-I-03
[6] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the December 2022 Region 1 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-I-04

instances for projects off the coast of New York and New Jersey in 2022.[7,8] EPA Region 3 approved the use of AERCOARE/AERMOD for a project off the coast of Virginia in 2022.[9]

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

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

In their alternative model request, NFE Louisiana FLNG referenced the April 2011 EPA Region 10 approval and EPA MCH concurrence with the use of AERMOD-COARE for an Artic marine ice-free environment on the basis that the alternative model satisfied the five criteria contained in Section 3.2.2(e) of Appendix W. The April 2011 EPA MCH concurrence memorandum clearly states that the Region 10 approval did not constitute a generic approval of AERMOD-COARE 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 AERMOD-COARE for other applications, subject to Regional Office approval based on an assessment of the appropriateness of the performance evaluations (element 4) and the availability of the necessary data bases (element 3) on a case-by-case basis". In addition, the NFE alternative model request references the previous EPA Region 1 and Region 6 AERCOARE/AERMOD approvals, which 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 NFE Louisiana FLNG 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.*

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 AERMOD-COARE to be appropriate for use in the Artic marine ice-free environment. In

[7] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the July 2022 Region 2 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-II-01

[8] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the July 2022 Region 2 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-II-02

[9] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the November 2022 Region 3 approval of AERCOARE/AERMOD is available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=22-III-01

the 2019 Region 6 alternative model of AERCOARE/AERMOD, EPA determined the model was also appropriate for use in the subtropical marine environment off the coast of Louisiana. In the 2022 AERCOARE/AERMOD approvals, EPA Regions 1, 2, and 3 deemed it was appropriate on a theoretical basis for use in the marine environment off the coasts of Massachusetts, New York and New Jersey, and Virginia, respectively. In addition, the user manual for AERCOARE[10] developed by Region 10 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.

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 studies from the 1980s have been used in the performance evaluations of OCD, CALPUFF, and AERCOARE-AERMOD:

- Cameron, Louisiana: July 1981 and February 1982 (Dabberdt, Brodzinsky, Cantrell, & Ruff, 1982[11])
- Carpinteria, California: September 1985 (Johnson & Spangler, 1986[12])
- Pismo Beach, California: December 1981 and June 1982 (Schacher, et al., 1982[13])
- Ventura, California: September 1980 and January 1981 (Schacher, et al., 1982)

In the 2019 Region 6 approval for the SPOT DWP, EPA determined that the databases associated with these three experiments are representative of the atmospheric conditions in the Gulf of Mexico. In fact, EPA stated that the availability of the Cameron, Louisiana tracer experiment dataset, in particular, is even more representative of the atmospheric conditions occuring in the Gulf of Mexico. The proposed NFE DWP will be located off the Louisiana coast in the Gulf of Mexico in a very similar environment to that of the Cameron, Louisiana database site.

The tracer gas experiment in Cameron, Louisiana included tracer releases from both a boat and a low profile platform. The study's receptors were located in flat terrain near the

[10] *U.S. EPA (2012): User's Manual AERCOARE Version 1.0, EPA 910-R-12-008, October 2012.*
[11] 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.
[12] 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.
[13] 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.

shoreline. The dataset contains both very stable and fairly unstable conditions. The terrain and offshore conditions are expected to mimic those found at the proposed DWP location since both are located off the Louisiana coast in the Gulf of Mexico.

Region 6 finds that the datasets and four tracer studies used in the evaluation are sufficiently available and adequate for determining the effectiveness of the 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.*

In their request, NFE referenced previous Region 10, Region 6, and Region 1 alternative model approvals of AERCOARE/AERMOD. The April 2011 Region 10 approval included a performance evaluation of AERMOD-COARE using data from the four previously mentioned tracer gas experiments. The results of that evaluation demonstrated that the model is not biased toward underestimates. The 2019 Region 6 approval relied on the Region 10 evaluation with special emphasis on the results using the Cameron, Louisiana dataset because of the proximity of the proposed facility seeking approval relative to where this tracer study was conducted. The January 2022 EPA Region 1 approval considered quantile-quantile plots for the Cameron and Pismo Beach tracer studies, comparing combinations of simulated and observed concentrations that showed the modeled tends to overestimate concentrations at the upper-end of the distribution for both studies.

In all three approvals referenced by NFE in their request, the associated performance evaluations demonstrate that the model is not biased toward underestimates and support our intended approval of AERCOARE/AERMOD for the NFE Louisiana FLNG project.

Similar to our 2019 alternative model approval, Region 6 believes that the databases relied upon in the referenced model performance evaluation, in particular the Cameron, Louisiana dataset, are appropriate and representative of the atmospheric conditions for the proposed NFE Louisiana FLNG project to be located in the Gulf of Mexico.

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

NFE Louisiana FLNG submitted a modeling protocol to EPA on May 23, 2022. The modeling protocol outlined the modeling techniques employed in the air modeling analyses conducted in support of the NFE Louisiana FLNG project. This modeling protocol referenced the future submittal of an alternative model approval request to EPA. EPA received NFE Louisiana FLNG's alternative model request on July 26, 2022, to initiate the alternative model approval process. The July 26, 2022 request included the applicant's demonstration of AERCOARE/AERMOD as an alternative model.

## 4. Conclusions and Conditions for Use

EPA Region 6 has reviewed the alternative model request submittal provided by NFE Louisiana FLNG 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 their PSD permit application. Based on our review, we find that the proposed approach addresses the five elements contained in Section 3.2.2(e) of Appendix W. As such, pursuant to Sections 3.0(b) and 3.2.2(a), Region 6 currently intends to approve the use of AERCOARE/AERMOD as an acceptable alternative model for the NFE Louisiana FLNG project.

As with the other alternative model approvals of AERMOD-COARE, approval to use this alternative model is made on a case-by-case basis. Should a project 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 Appendix W.

**Appendix A – New Fortress Energy (NFE) Louisiana FLNG LLC's Alternative Model Request dated July 26, 2022**

July 26, 2022

Ms. Ashley N.Q. Mohr
Air Permits Section
EPA Region 6
1201 Elm Street,
Suite500
Dallas, TX 75270-7289

Subject: Request for Approval for Use of the Alternative Model AERMOD/AERCOARE for Offshore Modeling of the New Fortress Energy Louisiana FLNG Project

Dear Ms. Mohr,

New Fortress Energy Louisiana FLNG LLC ("Applicant"), a limited liability company organized under the laws of Delaware, is proposing to construct, own, and operate the New Fortress Energy ("NFE") Louisiana FLNG Project ("Project"), a deepwater port ("DWP") export terminal approximately 16 nautical miles ("nm") off the southeast coast of Grand Isle, Louisiana. The Project will provide a safe and reliable source of much needed natural gas supplies to global markets in the form of liquified natural gas ("LNG"). The Project is consistent with the Applicant's commitment to make clean, affordable energy available to markets around the world. The Applicant is filing an application for a license to construct, own, and operate the DWP export terminal pursuant to the Deepwater Port Act of 1974, as amended ("DWPA"), and in accordance with the U.S. Coast Guard's ("USCG") and the Maritime Administration's ("MARAD") implementing regulations.

The Project will involve the installation of two nominal 1.4 million metric tonnes per annum liquefaction systems (FLNG1 and FLNG2) installed in the West Delta Lease Block 38 ("WD-38") in approximately 30 meters (98 feet) of water. Each system will contain three platforms consisting of natural gas processing, natural gas liquefaction, and utilities and accommodations. FLNG1 will incorporate self-elevating platforms (aka jack-up platforms or rigs), and FLNG2, which will be located adjacent to the first, will utilize fixed platform structures. The feed gas supply to the Project will be transported to the WD-38 site via the existing Kinetica Energy Express, LLC ("Kinetica") offshore natural gas pipeline system and two, newly constructed, 24-inch pipeline laterals connecting the Kinetica pipeline system to the Project. Both FLNG1 and FLNG2 will be connected to a single Floating LNG Storage Unit ("FSU") via a flexible, partially submerged, 220-meter cryogenic hose transfer system. The FSU will be positioned approximately 107 meters (350 feet) from the FLNGs. LNG carriers ("LNGCs") will call on the Project approximately 40 times per year. Other than temporary construction staging areas, there are no onshore facilities associated with the Project. Staging for construction, if needed, will utilize existing staging, laydown, and warehouse space near Port Fourchon, Port Sulphur, or Venice. The general Project location is shown on Figure 1.

The United States Environmental Protection Agency ("EPA") is authorized by the Clean Air Act ("CAA"; 42 United States Code ["U.S.C."] section ["§"] 7401 et seq., as amended in 1977 and 1990), to promulgate regulations governing air pollution in the United States, which are codified in Title 40 of the CFR, Parts 50

through 99. Per 33 U.S.C. § 1518(b),the DWPA requires that the laws and regulations of the nearest adjacent coastal state apply to a DWP. Louisiana is the nearest adjacent coastal state to the Project. Accordingly, Louisiana's State Implementation Plan ("SIP") and implementing regulations under Louisiana Administrative Code ("LAC") 33.III will apply to the Project. LAC 33.III will govern the air permitting requirements as well as other applicable air pollutant emission standards for construction and operation of the Project. The DWPA stipulates that air permits required for a DWP project will be administered and issued by the EPA. Accordingly, the air permits for the Project will be issued by EPA Region 6.

The Project will include equipment regulated as stationary emission sources subject to the air permit to construct and operate requirements under LAC 33.III. The Project's major air emission sources will include natural gas–fired compressor turbines, natural gas–fired power generating turbines, thermal oxidizers to control acid gas from the gas treatment system, and flares used largely to safely handle gas streams during upset conditions, such as the effluent from pressure relief valves, and plant startup. Minor emission sources will include emergency generator engines, small package boilers, fuel oil storage tanks, and fugitive emissions from the gas handling equipment.

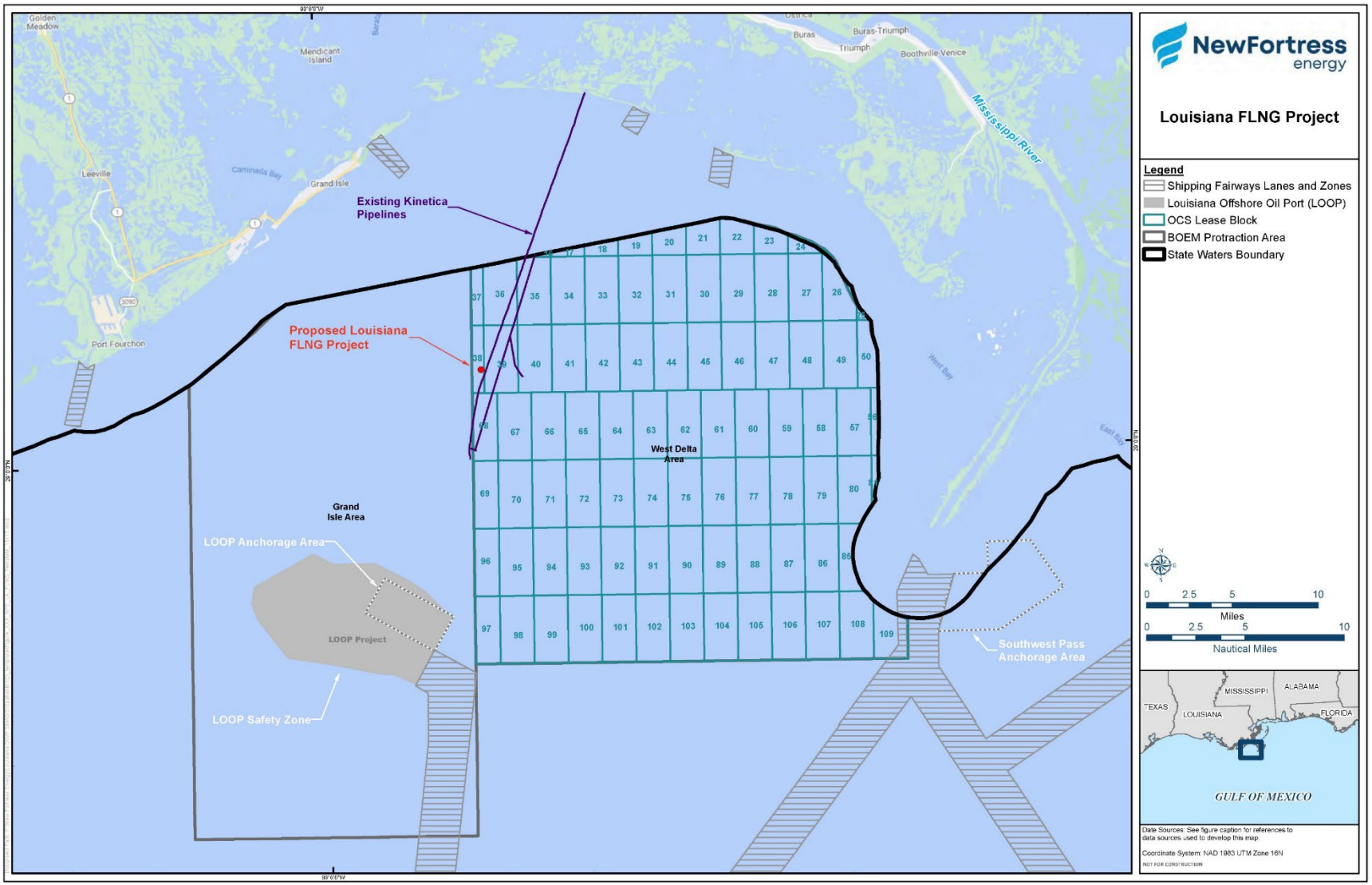


Figure 1. Project Area Overview

On May 23, 2022, the Applicant 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. NFE 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 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 ($NO_X$) to nitrogen dioxide ($NO_2$). Multiple tier $NO_X$ to $NO_2$ conversion techniques are available to the modeler

[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.

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.

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. 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.

10. 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). The modeling will conservatively treat the exhaust emissions from any angled stacks by using the horizontal stack option. 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.

11. 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 29 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.

**Proposed Modeling Approach**

The Applicant has not yet submitted its PSD application for the Project, which will include an air quality impact analysis (AQIA) report, as required to fulfill requirements under 40 CFR Part 52.21. On May 23, 2022, NFE 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. 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, NFE 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 multiple nearby buoy stations will be used to create a complete data set that 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.

NFE 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 Breton National Wilderness Area (located approximately 100.6 kilometers to the northeast of the Project). 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.

**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

[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.

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 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 a 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 the Applicant'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 Applicant's 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.

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[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.

[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

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.

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.

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[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.*

[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.*

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

***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. The Cameron, LA database site is located on the Louisiana coast and in a very similar environment as the Project. Therefore, the Cameron database is representative of the project site area.

The Applicant believes the meteorological dataset from the nearby buoys 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

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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.

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[15] 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)[16] 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].

Based on the study information described above, the Applicant 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.***

The Applicant submitted a modeling protocol to EPA on May 23, 2022 for the proposed 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 NFE FLNG project. The Applicant intends to run AERCOARE using the following settings recommended in EPA's AERCOARE User's Guide[17], as specified below:

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[15] *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.*

[16] *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.*

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

- 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**

The Applicant believes that AERCOARE/AERMOD meets the requirements for approval for use as an alternative model for offshore dispersion modeling for the NFE FLNG project located in the Gulf of Mexico off the Louisiana 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 (281) 704-5391 or khassan@newfortressenergy.com

Sincerely,

Komi Hassan

Komi Hassan
Vice President, Permitting
New Fortress Energy