BROADWATER

# RESOURCE REPORT NO. 9

## AIR AND NOISE QUALITY

FOR A

PROJECT TO CONSTRUCT AND OPERATE A

LIQUEFIED NATURAL GAS RECEIVING TERMINAL

IN

LONG ISLAND SOUND

LONG ISLAND, NEW YORK

*UNITED STATES OF AMERICA*

**JANUARY 2006**

Critical Energy Infrastructure Information has been removed from the Public Volume and is contained in the Critical Energy Infrastructure Information Volume.

**RESOURCE REPORT 9 - AIR AND NOISE QUALITY**

| Minimum Filing Requirement | Location in Environmental Report |
|---|---|
| • • Describe existing air quality in the vicinity of the project. (§ 380.12 (k) (1)) | Section 9.2.2 |
| • • Quantify the existing noise levels (day-night sound level ($L_{dn}$) and other applicable noise parameters) at noise-sensitive areas and at other areas covered by relevant state and local noise ordinances. (§ 380.12 (k) (2)) | Section 9.5.2 |
| • • Quantify existing and proposed emissions of compressor equipment, plus construction emissions, including nitrogen oxides ($NO_X$) and carbon monoxide (CO), and the basis for these calculations. Summarize anticipated air quality impacts for the project. (§ 380.12 (k) (3)) | Section 9.3.1 and 9.3.2 (FSRU emissions); Appendix B (FSRU emissions); Section 9.4.1 (Construction Emissions); Appendix A (Construction Emissions); Section 9.4.2 (Air Quality Impacts) |
| • • Describe the existing and proposed compressor units at each station where new, additional, or modified compression units are proposed, including the manufacturer, model number, and horsepower of the compressor units. (§ 380.12 (k) (4)) | Section 9.3.1 under 'NSR/PSD'; Detailed information in Appendix B, Table B-1. |
| • • Identify any nearby noise-sensitive area by distance and direction from the proposed compressor unit building/enclosure. (§ 380.12 (k) (4)) | Section 9.5.3 |
| • • Identify any applicable state or local noise regulations. (§ 380.12 (k) (4)) | Section 9.5.1 |
| • • Calculate the noise impact at noise-sensitive areas of the proposed compressor unit modifications or additions, specifying how the impact was calculated, including manufacturer's data and proposed noise control equipment. (§ 380.12 (k) (4)) | Section 9.5.4 |

| | Request | Location in Environmental Report |
|---|---|---|
| 30. | Identify EPA requirements and applicable State Implementation Plans for quantifying emissions from the LNG carriers either while docked or unloading at the FSRU. | Sections 9.3.1 and 9.3.2 |
| 31. | Applicability of New Source Performance Standards for the proposed equipment, including determinations of whether or not the LNG tanks would vent to the atmosphere. | Section 9.3.1 under 'NSPS' |
| 32. | New Source Review/Prevention of Significant Deterioration as it relates to "boilers," named sources, and regulated emissions from LNG carriers. | Sections 9.3.1 and 9.3.2 |
| 33. | Compliance Assurance Monitoring (CAM) protocol to evaluate whether or not emission standards would be met. | Will be included in air permit application. |
| 34. | Conformity analysis for service vessel and construction emissions. | Sections 9.3.1 and 9.4.1 |
| 35. | The magnitude, duration, and frequency of emissions during construction and operation including, but not limited to, dredging equipment, pile-driving equipment, pipelay vessels, tugs, supply boats, crew boats, FSRU operation, and LNG carriers. Specify fuels used for each vessel and the FSRU, and quantify emission as pounds per hour and tons per year under maximum operating conditions. | Section 9.4.1 (Construction Emissions); Sections 9.3.1 and 9.4.1 (Operational Emissions); Appendix A (Construction Emissions); Appendix B (Operational Emissions) |
| 36. | Mitigation measures, including emission control systems, filters, mufflers, and location and orientation of equipment. | Sections 9.4.4 and 9.5.7 |
| 37. | Potential nuisance emissions for either onshore or marine receptors. | No nuisance emissions anticipated. |

**Environmental Information Request**
**August 8, 2005**

| Request | | Location in Environmental Report |
|---|---|---|
| 38. | Permit requirements and a copy of the application for the prevention of significant deterioration permit, and demonstration of compliance with associated regulations. | Permit requirements are discussed in Sections 9.3.1 and 9.3.2.<br>EPA has not made a PSD applicability determination.<br>Permit Application under development. |

**Broadwater Supplemental Air and Noise Questions/Issues to be Addressed**

| Request | | Location in Environmental Report |
|---|---|---|
| S-1. | Provide a tabular summary of the ambient air monitoring data for the ambient air monitoring stations depicted in Figure 7-1. | Figure 7-1 has become Figure 9-2.<br>*See* tabular summary in Section 9.2.2 |
| S-2. | Identify EPA requirements and applicable State Implementation Plans for quantifying emissions from the LNG carriers either while docked or unloading at the FSRU. | Sections 9.3.1 and 9.3.2 |
| S-3. | Permit requirements and a schedule for submission of the PSD permit. | Sections 9.3.1 and 9.3.2<br>EPA has not made a determination regarding PSD applicability; therefore, submission schedule is not known. |
| S-4. | The discussion of potential impacts to air quality and appropriate measures to avoid and minimize impacts in pending Resource Reports should address: | Section 9.4.2 (Air Quality Impacts);<br>Section 9.4.4 (Mitigation) |
| | a. Applicability of NSPS for the proposed equipment including determination of whether or not LNG carriers either while docked or unloading at the FSRU; | Section 9.3.1 under 'NSPS' |
| | b. NSR/PSD as it relates to boilers, named sources and regulated emissions from LNG carriers; and | Section 9.3.1 and 9.3.2 |

| | Request | Location in Environmental Report |
|---|---|---|
| | c. Compliance Assurance Monitoring protocol to evaluate whether or not emission standards would be met. | The CAM protocol will be provided in the permit application. |
| S-5. | Provide quantified construction emission estimates by type of emission source (e.g. dredging equipment, pile-driving equipment, pipelay vessels, tugs, supply boats, crew boats, etc.), their duration and the emissions associated with each activity. Provide data on $NO_X$, CO, $SO_2$, VOC, $PM_{10}$, $PM_{2.5}$, ammonia, and HAPS in lbs/hr and tons/year under maximum operating conditions. Describe which pollutants have significant impacts and the primary sources and activities contributing to emissions. Describe which pollutants have significant impacts and the primary sources and activities contributing to emissions. Describe how these emissions may affect the air quality. | Section 9.4.1 (Construction emissions); Section 9.3.1 and 9.4.1 (Operational Emissions); Appendix A (Construction Emissions); Appendix B (Operational Emissions) |
| S-6. | Please provide description and efficacy of all air and noise mitigation measures, including emission control systems, filters, lagging, mufflers and location and orientation of equipment. | Sections 9.4.4 and 9.5.6 |
| S-7. | Address potential nuisance emissions for either onshore or marine receptors. | Nuisance emissions not anticipated. |
| S-8. | Provide detailed modeling data and results for any models designated as required by state agencies. | Section 9.4.2 and Appendix C |
| S-9. | Provide the following for LNG vessels while unloading. | Incomplete request. |
| S-10. | Please confirm whether the LNG vessels generate their own electrical power or use FSRU power. | LNG vessels will generate their own power. *See* Section 9.3.1 |

**Broadwater Supplemental Air and Noise Questions/Issues to be Addressed**

| Request | Location in Environmental Report |
|---|---|
| S-11. If the LNG vessels will generate their own electrical power, will the LNG vessels burn natural gas or bunker fuel? | LNG vessels will burn bunker fuel (heavy fuel oil) while at the FSRU. *See* Section 9.3.1. |
| S-12. If natural gas will be used, provide the source (ship boil off, vapor return from FSRU, on-ship vaporization, etc.). | LNG vessels will burn bunker fuel (heavy fuel oil) while at the FSRU. *See* Section 9.3.1. |
| S-13. If natural gas will be used, how will the company ensure that there is a sufficient supply for the LNG vessel's resident time at berth? | LNG vessels will burn bunker fuel (heavy fuel oil) while at the FSRU. *See* Section 9.3.1. |
| S-14. Will LNG vessels use boil-off gas prior to, and after unloading? If alternative fuels will be used, update the emission data to reflect this. | LNG carriers will use boil-off gas inbound through the Sound to the FSRU. Heavy fuel oil will be used during and after unloading. Carrier emission estimates in Section 9.4.1 reflect this scenario. |
| S-15. Identify the point at which the LNG vessel will enter any US state waters, and provide and estimate of the length and time the vessel will be traveling through each state waters. Additionally, provide information detailing the type of fuel used during each leg of the transit of the LNG tanker and the estimated emissions of $NO_X$, CO, $SO_2$, VOC, $PM_{10}$, $PM_{2.5}$, ammonia, and HAPS from the LNG tanker and any supporting vessels for each state. | LNG carrier route is under discussion with the USCG. Carrier emissions from the Race to the FSRU and back to the Race have been included. *See* Section 9.4.1 |
| S-16. Provide detailed information on how the portion of the project generating emissions in the State of New York and the State of Connecticut would comply with General Conformity in accordance with the requirements codified in 40 CFR Part § 51.858 through § 51.860. | Sections 9.3.1 and 9.4.1 |

**Broadwater Supplemental Air and Noise Questions/Issues to be Addressed**

| Request | Location in Environmental Report |
|---|---|
| S-17. Provide a complete description and emission estimates for marine operations (supporting vessels, tug boats, escort boats, etc.), as well as emissions that might be expected to occur from LNG tankers (both natural gas and alternate fuels) on a routine basis during transit and while off-loading LNG at the FSRU. Provide data on $NO_X$, CO, $SO_2$, VOC, $PM_{10}$, $PM_{2.5}$, ammonia, and HAPS emissions for each state transited. | Section 9.4.1; Appendix B Table B-15 (Basis of Emissions for Support Vessels) |
| S-18. Quantify marine-related emission impacts to air quality in the region; discuss the feasibility of emission controls; and demonstrate compliance with associated regulations. Please detail the sources of the emission estimates, whether from manufacturer derived estimates, EPA AP-42 tables or other models. | Section 9.4.1; Appendix B |
| S-19. Primary noise impacts of concern are sound pressure waves generated within the water due to both construction activities at the YMS and dredging operations, as well as noise due to operation of the FSRU, tugs, and LNG vessels. Please evaluate and quantify sound pressure levels in the aquatic environments (in dB re: 1μPa) to a distance of 1 mile and discuss impacts on species of concern. | *See* Resource Report 3, Sections 3.3.1.2, 3.3.4.2, and 3.3.4.6 |
| S-20. Provide an assessment of noise impacts to avians and marine animals due to operation of the FSRU, tugs, and LNG ships. | *See* Resource Report 3, Sections 3.3.1.2, 3.3.4.2, and 3.3.4.6 |

| Request | Location in Environmental Report |
|---|---|
| 1. Section 9.4.2 indicates that the air modeling protocol has been approved. Provide documentation of acceptance by the applicable federal and state agencies for the air modeling protocol as well as for the technical justification and resolution of the specific issues identified in the November 7, 2005 letter from the NYSDEC. This documentation address issues such as: | The model protocol has been reviewed by agencies; however. Final approval will occur only after EPA makes a determination regarding PSD applicability and the modeling protocol is revised to reflect EPA's determination. The text in Section 9.4.2 has been reworded accordingly. |
| a. Implementation of the fine particle review for the National Ambient Air Quality Standards (NAAQS), and applicability of the New Source Review provisions; | Section 9.3.2 |
| b. Cumulative impact analysis for NAAQS compliance; | Section 9.4.2 and Table 9-15 |
| c. Use of the AERMOD model to address cavity and wake effects; | Section 9.4.2; *see* also Appendix C, Section 2, and Appendix C, Attachment A, Section 2.4.2. |
| d. Clarification of differences in the hourly emissions for PM2.5 and PM10 in Table 3-1 of the modeling appendix (Appendix C) and those presented in Appendix B. | Differences were due to rounding and decimal places shown. The tables have been brought into conformance. |
| e. Identification and analysis of all potential combinations of load, fuel, and ambient conditions used in the model; | Section 9.4.1 and Appendix C, Section 3.3 |
| f. Use of proper intervals for receptors at the edge of the safety zone and terrain features at the land boundaries; and | Section 9.4.2 under 'Building Downwash Wake Effects and Cavity Analysis – AERMOD PRIME'; *see* also Appendix C, Section 3.6. |
| g. Compliance with requirements of the U.S. Environmental Protection Agency and NYSDEC for acceptable meteorological data, including station locations, use of specific over-water and onshore monitoring sites, data completeness, and data substitution. | Section 9.4.2 under 'Meteorological Data'; *see* also Appendix C, Section 3.5. |

| Request | Location in Environmental Report |
|---|---|
| 2. Specify whether or not emissions from LNG carriers are incorporated into the Prevention of Significant Deterioration (PSD) determination and Title V Operating permitting process, and whether the PSD applicability limit for the Project should be 100 tons per year or 250 tons per year. | Section 9.3.1 under 'NSR/PSD'; see also Appendix C, Attachment A, Section 2.3. |
| 3. Provide the calculations used to support the general construction emissions presented in Table 9-11. | Table 9-11 has been renumbered as Table 9-12 in this document. Appendix A provides the calculations. |
| 4. In Table 9-12 and the supporting text, the emissions identified for LNG carriers appear to only include steam turbine carriers. Confirm that the Broadwater Project would only use LNG carriers powered by steam turbines, or provide emissions for all types of LNG carriers that could use the FSRU, including piston-driven diesel carriers. | Table 9-12 has been renumbered to Table 9-13 in this document. Appendix B, Table B-13, presents emissions for all types of carriers. Steam turbine carriers are the current vessel type in use. Various LNG carrier designs have been ordered by the LNG transport industry and are identified in Table B-13. Table B-13 also contains estimates for LNG carriers that have yet to reach the order/design stage. |
| 5. Provide the emissions data from each source that was used to calculate the total emissions summarized in Table 9-13. | The emissions data are shown in Appendix B, Table B-13. Footnotes to Table B-13 indicate the reference used for emission data. Full reference titles are shown in Appendix B, Table B-14. |

**Environmental Information Request**
**November 23, 2005**

| Request | Location in Environmental Report |
|---|---|
| 6. Provide estimated emissions for onshore facilities associated with the Project that may experience an increase in emissions due to construction or operation of the Project. In addition, provide evidence that any such emissions would be in compliance with federal and state regulations. If specific emissions are not currently known, identify the worst-case scenarios based on the potential range of emissions increases at onshore facilities that may be part of the Project, or provide evidence that onshore activities associated with the Project would not result in increases in point-source emissions during either construction or operation. | Onshore facilities are discussed in the Onshore Facilities Resource Reports. Reference to the document is in Section 1 and Section 9.4.1 under 'Construction'. |
| 7. Provide technical justification for the statement that ambient airborne noise levels of 50 to 55 decibels typically occur in the vicinity of the proposed site for the FSRU (Section 9.5.4). In addition, explain how a Project-related noise level of 59 decibels would be in compliance with New York State guidance that increases in noise levels be less than 6 decibels above baseline. | Section 9.5.2 provides a reference for typical at sea background sound levels.<br>Section 9.5.6 describes conformance with NYSDEC Program Policy DEP-00-1. |

**Environmental Information Request**
**January 18, 2006**

| Request | Location in Environmental Report |
|---|---|
| 1. Precisely define the New Source Review (NSR) and Prevention of Significant Deterioration (PSD) applicability status and conduct the appropriate assessment, analysis and permitting activities based on the determinations. | Section 9.3.1 under 'NSR/PSD'. Upon final determination by EPA on PSD applicability, the appropriate activities as defined in the comment will be performed. |
| 2. Provide a tabular summary of ambient ozone conditions. | Section 9.2.2, Table 9-7 |

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## Acronyms and Abbreviations

| | |
|---|---|
| AQCR | air quality control region |
| bcf | billion cubic feet |
| bcfd | billion cubic feet per day |
| CAA | Clean Air Act |
| CFR | Code of Federal Regulations |
| CO | carbon monoxide |
| dBA | A-weighted decibels |
| °C | degrees Celsius |
| °F | degrees Fahrenheit |
| ECL | Environmental Conservation Law |
| EIS | Environmental Impact Statement |
| EPA | (United States) Environmental Protection Agency |
| FERC | Federal Energy Regulatory Commission |
| FSRU | Floating Storage and Regasification Unit |
| HAPs | hazardous air pollutants |
| IGTS | Iroquois Gas Transmission System |
| km | kilometer |
| LAER | lowest achievable emission rate |
| LNG | liquefied natural gas |
| m | meter |
| $m^2$ | square meter |
| $\mu g/m^3$ | micrograms per cubic meter |
| MMBtu/hr | million British thermal units per hour |
| MW | megawatt |
| NAAQS | National Ambient Air Quality Standards |
| NA NSR | Nonattainment New Source Review |
| NESHAPs | National Emission Standards for Hazardous Air Pollutants |
| $NO_2$ | nitrogen dioxide |
| $NO_x$ | nitrogen oxides |
| NSPS | New Source Performance Standards |
| NSR | New Source Review |

| | |
|---|---|
| NYCRR | New York Codes, Rules, and Regulations |
| NYSDEC | New York State Department of Environmental Conservation |
| OCD | Offshore Coastal Dispersion |
| $PM_{2.5}$ | particulate matter with aerodynamic diameters of 2.5 microns or less |
| $PM_{10}$ | particulate matter with aerodynamic diameters of 10 microns or less |
| ppm | parts per million |
| PSD | Prevention of Significant Deterioration |
| PTE | potential to emit |
| RACT | reasonably available control technology |
| SCR | selective catalytic reduction |
| SIL | Significant Impact Level |
| SIP | State Implementation Plan |
| $SO_2$ | sulfur dioxide |
| SPL | sound pressure level |
| STV | shell and tube vaporizer |
| tpy | tons per year |
| TSP | total suspended particulates |
| VOCs | volatile organic compounds |
| YMS | yoke mooring system |

# 9. AIR AND NOISE QUALITY

## 9.1 INTRODUCTION

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and subsea pipeline for the importation, storage, regasification, and transportation of natural gas. The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS). The FERC application for the Project requires the submittal of 13 Resource Reports, with each report evaluating Project effects on a particular aspect of the environment.

Resource Report 9 is required for all new LNG facilities. The report describes existing air and noise quality conditions and the regulations potentially affecting the Project. The report also addresses the effects of construction and operation of the Project on the existing air and noise environment and describes any proposed measures to mitigate those effects.

The proposed Broadwater LNG terminal will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters, as shown on Figure 9-1. The LNG terminal facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcfd) and will be capable of delivering a peak throughput of 1.25 bcfd. The Project will deliver the regasified LNG to the existing interstate natural gas pipeline system via an interconnection to the IGTS pipeline. Onshore facilities are discussed in the Onshore Facilities Resource Reports.

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [$m^3$] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas) with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 $m^3$ up to a potential future size of 250,000 $m^3$ at the frequency of two to three carriers per week.

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the

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Source: ESRI StreetMap, 2002.

Figure 9-1
Proposed Broadwater Project
Location in Long Island Sound

BW002234

stationary tower also serves the purpose of securing the FSRU in such a manner to allow it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS), allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [$m^2$]).

A 30-inch-diameter natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be installed beneath the seafloor from the stationary tower structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. To stabilize and protect the operating components, sections of the pipeline will be covered with engineered back-fill material or spoil removed during the lowering operation. Figure 9-1 presents the proposed pipeline route.

## 9.2 EXISTING ENVIRONMENT

### 9.2.1 Climate

Long Island Sound is considered to have a mixed maritime-continental type climate. Air masses of continental origin frequently affect weather conditions over Long Island Sound, although the ocean also has a strong influence on the area's climatic conditions. This influence includes moderating winter temperatures such that minimum temperatures below zero °F (-18 °C) are uncommon.

Strong coastal storms, including tropical weather systems moving along the Atlantic Ocean coastline, can produce heavy rains and windy conditions in late summer and fall. In winter, coastal storms called "nor'easters" disrupt activities on land with snow and/or heavy rain.

Fair weather conditions can occur during summer when the region is dominated by a stagnant high-pressure system called a "Bermuda high." Under such conditions, extended periods of light winds result in poor movement of air, which can allow the buildup of air pollutants. Episodes of ozone buildup commonly occur during these weather conditions.

### 9.2.2 Existing Air Quality

Air emissions from the Project will be regulated under the federal Clean Air Act (CAA) and state law administered by NYSDEC. NYSDEC and the United States Environmental Protection Agency (EPA) have promulgated air quality standards to protect the public health and welfare. The EPA has established National Ambient Air Quality Standards (NAAQS) for seven criteria pollutants: carbon monoxide (CO), lead, nitrogen dioxide ($NO_2$), ozone, particulate matter with aerodynamic diameters less than or equal to 10 microns ($PM_{10}$), particulate matter with aerodynamic diameters less than or equal to 2.5 microns ($PM_{2.5}$), and sulfur dioxide ($SO_2$). A summary of NAAQS is presented in Table 9-1. The NAAQS are set at levels the EPA believe necessary to protect human health (primary standards) and human welfare (secondary standards). NYSDEC has adopted the EPA's NAAQS for each of the pollutants identified in Table 9-1.

**Table 9-1 National Ambient Air Quality Standards (40 CFR Part 50)**

| Pollutant | Averaging Time | Primary Standard | Secondary Standard |
|---|---|---|---|
| Ozone | 1-Hour(1) | 235 μg/m$^3$ (0.125 ppm) | 235 μg/m$^3$ (0.125 ppm) |
| | 8-Hour(2) | 156 μg/m$^3$ (0.084 ppm) | 156 μg/m$^3$ (0.084 ppm) |
| CO | 1-Hour(3) | 40,000 μg/m$^3$ | – |
| | 8-Hour(3) | 10,000 μg/m$^3$ | – |
| $NO_2$ | Annual(4) | 100 μg/m$^3$ | 100 μg/m$^3$ |
| $PM_{2.5}$ | 24-Hour(5) | 65 μg/m$^3$ | 65 μg/m$^3$ |
| | Annual(6) | 15 μg/m$^3$ | 15 μg/m$^3$ |
| Lead | Quarter(4) | 1.5 μg/m$^3$ | – |
| $PM_{10}$ | 24-Hour(1) | 150 μg/m$^3$ | 150 μg/m$^3$ |
| | Annual(7) | 50 μg/m$^3$ | 50 μg/m$^3$ |
| $SO_2$ | 3-Hour(3) | – | 1,300 μg/m$^3$ |
| | 24-Hour(3) | 365 μg/m$^3$ | – |
| | Annual(4) | 80 μg/m$^3$ | – |

Notes:

(1) Standard is attained when expected number of exceedances is less than or equal to one per year.

(2) Standard is compared to the average of the annual 4th highest 8-hour concentrations over a 3-year period.

(3) Standard not to be exceeded more than once per year.

(4) Standard never to be exceeded.

(5) Standard is compared to the average of the annual 98th percentile 24-hour concentrations over a 3-year period.

(6) Standard is compared to the average of the annual concentrations over a 3-year period.

(7) Standard (as expected annual arithmetic mean of 24-hour concentrations) never to be exceeded.

Key:

μg/m$^3$ = micrograms per cubic meter.

ppm = parts per million.

The United States is divided into "air quality control regions," and ambient air monitoring of criteria air pollutants within these regions is used to determine compliance with NAAQS. Regions (or portions of regions) with criteria air pollutant concentrations less than or equal to NAAQS are categorized as attainment areas. Regions (or portions of regions) with criteria air pollutant concentrations greater than NAAQS are categorized as nonattainment areas. Nonattainment areas are further categorized by the degree of nonattainment relative to the NAAQS.

The Project would be located entirely within Suffolk County, New York, which is part of the New Jersey-New York-Connecticut Interstate Air Quality Control Region (AQCR). This AQCR is currently designated as an attainment area for CO, lead, $NO_2$, $PM_{10}$, and $SO_2$. It is designated as a severe nonattainment area for the 1-hour ozone standard and as a moderate nonattainment area for the 8-hour ozone standard. Certain counties within the AQCR, including Suffolk County, also are designated as nonattainment areas for the annual standard for $PM_{2.5}$. Ambient air quality monitoring stations are located throughout the AQCR. The ambient air quality monitoring stations within the AQCR that are closest to the proposed Project are located onshore in New York and Connecticut. Figure 9-2 indicates the locations of these monitoring stations. A summary of ambient air monitoring data for these stations is provided in Tables 9-2 through 9-7.

**Table 9-2 Ambient Air Measurements of CO (in ppm)**

| Averaging Time | State | Station Name/Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| 1-hr (1st highest) | NY | Holtsville | n/a | 3.7 | 3.9 | 3.7 | 3.1 | 2.9 |
| | CT | New Haven Courthouse | 4.4 | 4.4 | 3.9 | 3.7 | 3.0 | 3.1 |
| 1-hr (2nd highest) | NY | Holtsville | n/a | 3.4 | 3.4 | 3.7 | 2.8 | 2.9 |
| | CT | New Haven Courthouse | 4.2 | 4.3 | 3.5 | 3.4 | 2.7 | 2.8 |
| 8-hr (1st highest) | NY | Holtsville | n/a | 2.8 | 2.3 | 2.2 | 2.0 | 2.2 |
| | CT | New Haven Courthouse | 3.3 | 3.3 | 2.7 | 2.6 | 2.1 | 2.0 |
| 8-hr (2nd highest) | NY | Holtsville | n/a | 2.8 | 2.2 | 1.9 | 1.6 | 1.6 |
| | CT | New Haven Courthouse | 3.1 | 2.6 | 2.5 | 2.3 | 1.9 | 2.0 |

Source: NYSDEC 2000 thru 2003; EPA 2005.

Note:

n/a indicates station did not operate or data recovery did not meet minimum requirements.

**Table 9-3 Ambient Air Measurements of $NO_2$ (in ppm)**

| Averaging Time | State | Station Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| Annual | NY | Holtsville | n/a | 0.017 | 0.017 | 0.017 | 0.014 | 0.012 |
| | CT | Sherwood Island SP | 0.017 | 0.018 | 0.021 | 0.019 | 0.016 | 0.014 |

Source: NYSDEC 2000 thru 2003; EPA 2005.

Note:

n/a indicates station did not operate or data recovery did not meet minimum requirements.

**Table 9-4 Ambient Air Measurements of $PM_{2.5}$ (in • g/m³)**

| Averaging Time | State | Station Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| 24-hr (1st highest) | NY | Babylon (FRM) | n/a | 42.1 | 45.3 | 40.0 | 47.1 | 37 |
| | CT | Sherwood Island SP (FRM) | n/a | 43.6 | 38.7 | 81.5 | 44.8 | 41 |
| 24-hr (98th %) | NY | Babylon (FRM) | 31.9 | 31.8 | 34.1 | 30.9 | 38.8 | 34 |
| | CT | Sherwood Island SP (FRM) | n/a | 33.4 | 34.5 | 34.3 | 44.8 | 41 |
| Annual | NY | Babylon (FRM) | 13.0 | 12.6 | 13.0 | 11.4 | 11.9 | 11.2 |
| | CT | Sherwood Island SP (FRM) | n/a | 13.5 | 12.1 | 12.1 | 11.7 | 12 |

Source: NYSDEC 2000 thru 2003; EPA 2005.

Notes:

n/a indicates station did not operate or data recovery did not meet minimum requirements.

1. 2000 24-hr 98% data for CT sites based on reported 2nd highest 24-hour reading.
2. The following annual data did not satisfy summary criteria:
   1999: all NY and CT sites
   2000: Sherwood Island SP

**Table 9-5 Ambient Air Measurements of $PM_{10}$ (in • $g/m^3$)**

| Averaging Time | State | Station Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| 24-hr (1st highest) | NY | Eisenhower Park (Wedding) | n/a | 45 | 61 | 85 | 58 | 46 |
| | CT | Sherwood Island SP (FRM) | n/a | 46 | 42 | 75 | 54 | 27 |
| 24-hr (2nd highest) | NY | Eisenhower Park (Wedding) | n/a | 38 | 41 | 47 | 37 | 30 |
| | CT | Sherwood Island SP (FRM) | n/a | 39 | 40 | 31 | 33 | 26 |
| Annual | NY | Eisenhower Park (Wedding) | 16 | 17 | 17 | 18 | 18 | 15 |
| | CT | Sherwood Island SP (FRM) | n/a | 16 | 15 | 14 | 21 | 13 |

Source: NYSDEC 2000 thru 2003; EPA 2005.

Note:

n/a indicates station did not operate or data recovery did not meet minimum requirements.

1. The following annual data did not satisfy summary criteria:
   2000: all CT sites.

**Table 9-6 Ambient Air Measurement of $SO_2$ (in ppm)**

| Averaging Time | State | Station Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| 3-hr (1st highest) | NY | Holtsville | n/a | 0.040 | 0.035 | 0.039 | 0.045 | 0.065 |
| | CT | Sherwood Island SP | n/a | 0.041 | 0.034 | 0.035 | 0.042 | 0.034 |
| 3-hr (2nd highest) | NY | Holtsville | n/a | 0.040 | 0.033 | 0.037 | 0.045 | 0.065 |
| | CT | Sherwood Island SP | n/a | 0.039 | 0.034 | 0.032 | 0.036 | 0.031 |
| 24-hr (1st highest) | NY | Holtsville | n/a | 0.023 | 0.024 | 0.030 | 0.030 | 0.034 |
| | CT | Sherwood Island SP | n/a | 0.023 | 0.025 | 0.028 | 0.030 | 0.021 |

**Table 9-6 Ambient Air Measurement of $SO_2$ (in ppm)**

| Averaging Time | State | Station Location | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|
| 24-hr (2nd highest) | NY | Holtsville | n/a | 0.022 | 0.023 | 0.021 | 0.030 | 0.033 |
| | CT | Sherwood Island SP | n/a | 0.022 | 0.024 | 0.026 | 0.028 | 0.021 |
| Annual | NY | Holtsville | n/a | 0.007 | 0.006 | 0.006 | 0.006 | 0.007 |
| | CT | Sherwood Island SP | n/a | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |

Source: NYSDEC 2000 thru 2003; EPA 2005.

n/a indicates station did not operate or data recovery did not meet minimum requirements.

**Table 9-7 Ambient Air Measurements of Ozone (in ppm)**

| Averaging Time | State | Station Name/Location | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|
| 1-hr (1st highest) | NY | Babylon | 0.134 | 0.128 | 0.143 | 0.151 | 0.103 | 0.130 |
| | | Riverhead (seasonal)[1] | 0.145 | 0.122 | 0.129 | 0.118 | 0.104 | 0.126 |
| | CT | Stratford USCG Lighthouse | 0.140 | 0.148 | 0.145 | 0.155 | 0.135 | 0.136 |
| 1-hr (2nd highest) | NY | Babylon | 0.112 | 0.126 | 0.141 | 0.130 | 0.101 | 0.124 |
| | | Riverhead (seasonal)[1] | 0.116 | 0.111 | 0.127 | 0.114 | 0.085 | 0.113 |
| | CT | Stratford USCG Lighthouse | 0.122 | 0.144 | 0.135 | 0.144 | 0.105 | 0.111 |
| 8-hr (4th highest) | NY | Babylon | 0.086 | 0.084 | 0.108 | 0.094 | 0.081 | 0.098 |
| | | Riverhead (seasonal)[1] | 0.085 | 0.082 | 0.090 | 0.082 | 0.069 | 0.086 |
| | CT | Stratford USCG Lighthouse | 0.090 | 0.102 | 0.103 | 0.101 | 0.081 | 0.090 |

Source: NYSDEC 2000 thru 2004; CTDEP 2000 to 2004.

Note: The Riverhead station operates seasonally, generally March/April through October. Site has EPA waiver from % annual availability based on operational year of less than 12 months.

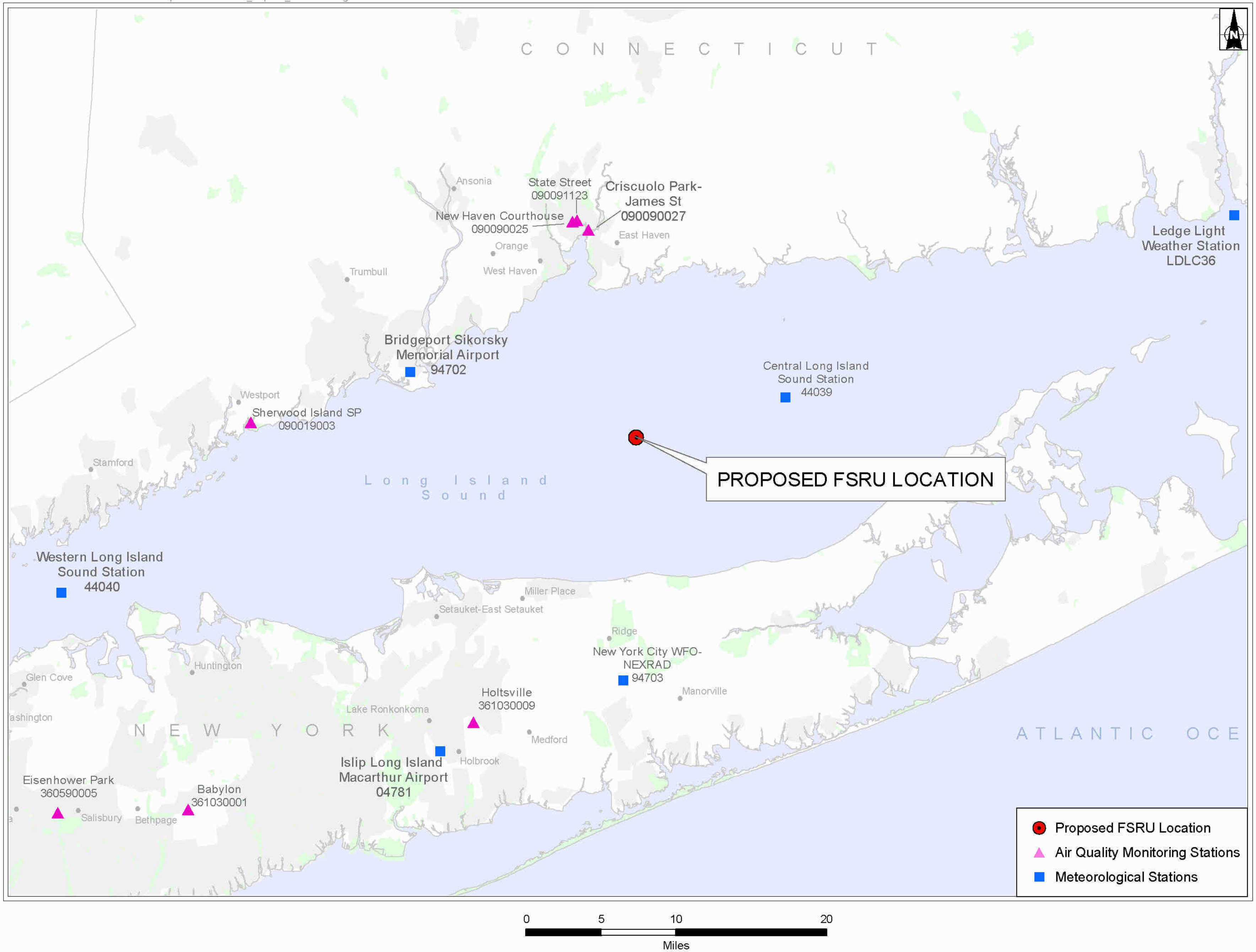


Figure 9-2 Air Monitoring Stations and Meteorological Stations in the Broadwater Project Area

Ozone is a regional problem, with much of the Northeast considered to be a "non-attainment" area. Ozone is rarely emitted directly into the air. The majority of ground-level ozone is formed through reactions in the atmosphere between oxides of nitrogen ($NO_x$) and volatile organic compounds (VOCs). The major sources of $NO_X$ and VOC emissions include motor vehicles, industrial facilities, electric utilities, gasoline storage facilities, chemical solvents, and biogenic sources. Control programs for ozone regulate $NO_X$ and VOC emissions from these sources.

$PM_{2.5}$ also is a regional problem in the Northeast; however, the $PM_{2.5}$ nonattainment area covers a smaller area within the AQCR than the ozone nonattainment area. $PM_{2.5}$ is a pollutant that is emitted directly by a variety of emission source types in the region, including mobile and stationary combustion sources, and it also results from particle formation in the atmosphere from the reaction of gaseous air pollutants.

### 9.2.3 Class I Prevention of Significant Deterioration (PSD) Areas

The 1977 amendments to the CAA established the PSD program. This program was designed to protect air quality in areas where existing air quality was better than NAAQS. The program established a set of increments of new air pollution that would be allowed over an established emissions baseline. Increments were set for Class I, Class II, and Class III areas. The Class I increment allows only a small increase over baseline, Class II a moderate increase, and Class III a greater increase. In addition to restrictive Class I increments for $SO_2$, particulate matter, and $NO_2$, visibility protection requirements were adopted for select Class I areas to ensure the preservation of visibility in those areas.

Class I areas are defined as locations of special air quality concern due to national or regional natural, scenic, recreational, or historical value. PSD regulations provide special protection for these areas, the aim of which is to maintain the pristine nature of air quality. Class I areas include international parks, national wilderness areas, and national parks. In general, a source within 62 miles (100 km) of a Class I area is required to evaluate air quality impacts in the Class I area. Very large sources beyond 62 miles (100 km) also may be required to evaluate Class I impacts.

The Project is located more than 62 miles (100 km) from all Class I areas in the Northeast and Mid-Atlantic regions of the United States. Based on an evaluation of the Project's potential to emit (including the effect of using emission controls and permit restrictions), it is not considered a major source of emissions under PSD. Accordingly, it will not need to be evaluated against ambient air concentration thresholds for Class I areas. The thresholds applicable to a Class II area are applicable in the Project area. These thresholds describe an ambient air quality impact level below which no further air quality analysis is required; conversely, if impacts are above these thresholds, then further study is required to evaluate the predicted impacts by taking into account existing air quality measurements followed by a comparison to NAAQS. The Class II thresholds are called "Significance Levels for Air Quality Impacts in Class II Areas" and are shown in Table 9-8.

**Table 9-8 Significance Levels for Air Quality Impacts in Class II Areas ($\mu g/m^3$)**

| Pollutant | Annual | 24-hour | 8-hour | 3-hour | 1-hour |
|---|---|---|---|---|---|
| $SO_2$ | 1 | 5 | (a) | 25 | (a) |
| $PM_{10}$ | 1 | 5 | (a) | (a) | (a) |
| $PM_{2.5}$ | (a) | (a) | (a) | (a) | (a) |
| $NO_x$ | 1 | (a) | (a) | (a) | (a) |
| CO | (a) | (a) | 500 | (a) | 2,000 |
| $O_3$ | (a) | (a) | (b) | (a) | (a) |

(a) No significant ambient impact concentration has been established.

(b) No significant ambient impact concentration has been established. Instead, an ambient impact analysis must be performed for any net emissions increase of 100 tons per year of VOCs subject to PSD.

## 9.3 AIR REGULATORY REQUIREMENTS

Air emission sources in New York State are regulated at the federal level by the CAA, as amended, and at the state level by Environmental Conservation Law (ECL) Article 19 and the New York Codes, Rules, and Regulations (NYCRR).

### 9.3.1 Federal Regulations

The federal regulations established as a result of the CAA that are applicable to operational air emission sources at the proposed FSRU include the following:

- New Source Performance Standards (NSPS);
- New Source Review (NSR)/Prevention of Significant Deterioration (PSD) review;
- Title V Operating Permits;
- National Emission Standards for Hazardous Air Pollutants (NESHAP);
- Chemical Accident Prevention Provisions; and
- General Conformity.

**NSPS**

NSPS regulations, as codified in Title 40 Part 60 of the Code of Federal Regulations (40 CFR 60) establish pollutant emission limits and monitoring, reporting, and record-keeping requirements for various emission sources based on source type and size. The requirements of NSPS apply to new, modified, or reconstructed sources. The following NSPS subparts are potentially applicable to the Project. The potential applicability of these subparts is based on a review of the Project's specifications.

Subpart Db of 40 CFR 60 applies to industrial, commercial, and institutional steam generating units with maximum heat input rates greater than or equal to 100 million British thermal units per hour (MMBtu/hr) that were modified, constructed, or reconstructed after June 19, 1984. Based on the definitions and heat input rates in Subpart Db, the FSRU process heaters are classified as a steam generating unit and the heat input rating of the process heaters (247 MMBtu/hr each) causes them to be subject to Subpart Db.

Subpart Kb of 40 CFR 60 applies to any volatile organic liquid storage unit with a capacity of 40 $m^3$ or greater modified, constructed, or reconstructed after July 23, 1984. LNG is composed primarily of methane and ethane (~94 mole %), with the remainder being propane and butanes. EPA lists methane and ethane as non-VOCs due to their negligible photochemical reactivity. Propane has a low, but not negligible, photochemical reactivity, and butane is not on the exemption list. However, the Project will not emit LNG to the atmosphere; LNG would only be directly released to the atmosphere during emergency situations. Therefore, the LNG storage tanks, as proposed, will not be subject to the requirements of Subpart Kb.

Subpart GG of 40 CFR 60 applies to all stationary gas turbines with a heat input at peak load equal to or greater than 10.7 gigajoules per hour that were modified, constructed, or reconstructed after October 3, 1977. In terms of electrical power production, turbines applicable to this standard are capable of powering generators producing greater than 1 megawatt (MW) of electricity. The natural gas turbine(s) proposed for this facility will be required to supply 22 MW each; therefore, it is anticipated that the selected turbines will be subject to the requirements of Subpart GG.

Proposed Subpart KKKK of 40 CFR 60, if promulgated, will apply to each stationary combustion turbine with a power output at peak load greater than or equal to 1 MW that commences construction, modification, or reconstruction after February 18, 2005. It is anticipated that the selected turbines will be subject to the requirements of Subpart KKKK.

### NSR/PSD

Title I of the CAA established guidelines for the preconstruction review of major stationary air emission sources. If construction of a major stationary source in an attainment area results in emissions above major source thresholds, then the Project must be reviewed in accordance with PSD regulations. If construction of a major stationary source in a nonattainment area results in emissions above major source thresholds, then the Project must be reviewed in accordance with nonattainment NSR regulations. Nonattainment NSR review in New York State is currently delegated to NYSDEC. PSD review in New York State is currently conducted by EPA Region II.

Since the proposed FSRU is located in an area designated attainment for NAAQS for some criteria pollutants, the PSD regulations are potentially applicable to the Project. In order for PSD to be applicable, a new facility needs to be classified as a major stationary source. For the 28 listed source categories in 40 CFR 52.21(b)(1)(i)(a), the major source threshold is a potential to emit (PTE) of greater than or equal to 100 tons per year (tpy) for any criteria pollutant. For all other source types, the major source threshold is a PTE greater than or equal to 250 tpy for any criteria pollutant. For the latter source type, if a grouping of emission units is used in operations at the source that by themselves would be considered one of the 28 source categories with the 100-tpy threshold, the 100-tpy threshold applies to those emission units only.

To date, EPA has not made an agency-wide determination as to whether an FSRU would be subject to a PSD threshold of 250 tpy or 100 tpy. Based on a review of available prior applications for other proposed LNG regasification facilities under Section 3 of the Natural Gas Act and the Deep Water Port Act, both 100-tpy and 250-tpy thresholds have been used in the PSD review process. The Gulf Landing project, proposed for a site located 38 miles offshore of Louisiana, recently was approved by EPA Region 6 based on a 250-tpy PSD threshold. The EPA NSR guidance document provides an example case on this issue, demonstrating that a 250-tpy PSD threshold should be applied to the collective emissions from all emission sources at a facility (the FSRU) and a 100-tpy PSD threshold should be applied to the gas turbines as a separate group and the process heaters as a separate group (EPA 1990). The analysis set forth below is consistent with EPA guidance.

The FSRU process is not one of the 28 listed source categories. The FSRU process requires certain supports to properly function. The FSRU will operate two gas turbines (with one additional turbine as a backup unit) with waste heat recovery, which will have a combined heat input capacity greater than 250 MMBtu/hr. These turbines will be used to generate electricity solely for use onboard the FSRU. The FSRU also will operate four process heaters (with one additional unit as a backup unit), each with a combined heat input capacity less than 250 MMBtu/hr but with a combined heat input capacity greater than 250 MMBtu/hr. The process heaters will be used to heat a heat-transfer fluid in a closed-loop system that will be used by the vaporizers to regasify the LNG. The gas turbines and heating units, taken individually, would be included, respectively, in the source categories "Fossil Fuel Fired Steam Electric Plants" and "Fossil Fuel Boilers," both of which are one of the 28 listed source categories. Therefore, the 100-tpy threshold applies to the gas turbines and process heaters as separate groups; however, since the primary purpose of the FSRU, the storage and regasification of natural gas, does not fall within the 28 recognized source categories, the 250-tpy threshold applies to the FSRU process.

Emissions from all sources on the FSRU, including the gas turbines and process heaters, are counted in determining the PTE for the FSRU and in subsequent comparison to the 250-tpy threshold, whereas only emissions from the gas turbines are counted in determining the PTE for comparison to the 100-tpy threshold for "Fossil Fuel Fired Steam Electric Plants". Similarly, only emissions from the process heaters are counted in determining the PTE for comparison to the 100-tpy threshold for "Fossil Fuel Boilers."

The air pollutants examined under PSD applicability include CO, $NO_2$, $SO_2$, and $PM_{10}$. An estimate of annual emissions is presented in Table 9-9. The emissions shown in

Table 9-9 represent the contribution from combustion sources on the FSRU. As LNG is delivered to the FSRU, vapor displaced by the incoming LNG will be routed to the LNG carrier tanks such that no emissions to the atmosphere will occur. Broadwater has requested a determination from EPA on whether emissions from LNG carrier docked at the FSRU need to be included in the PSD applicability determination. EPA has not provided a determination at this time; therefore, emissions from docked LNG carriers are not included in this total.

The LNG carrier is a delivery vehicle to the FSRU and thus is considered a mobile source. The Broadwater Project will not use a fleet of dedicated, company-owned LNG carriers to deliver LNG to the FSRU. LNG carrier operations, and hence emissions, will not be under the control of Broadwater. Broadwater has no mechanism by which to accept and implement permit conditions on vessels that are not under its control. The lack of control over these emissions precludes them from being considered in the PSD applicability determination for the FSRU.

Notwithstanding the fact that PSD does not apply to the LNG carriers, anticipated emissions from the LNG carriers were considered in the General Conformity analysis conducted for the Project.

Emission thresholds under PSD regulations are presented in Tables 9-9 and 9-10. Based on the estimated annual potential emissions (with emission controls applied) shown in Tables 9-9 and 9-10, the proposed FSRU would not be classified as a major stationary source under PSD. In addition, the gas turbines ("Fossil Fuel Fired Steam Electric Plants") and process heaters ("Fossil Fuel Boilers"), when compared against the PSD 28 source category list, would not be classified as major stationary sources under PSD. Therefore, because the facility as a whole is not a major source under PSD, and the gas turbines and process heaters are individually not major sources under PSD, review under PSD is not required.

**Table 9-9 Annual Potential to Emit for the Proposed FSRU Stationary Sources Compared to PSD Major Source Size Thresholds**

| Air Pollutant | Estimated Annual Potential Emissions[1] (tpy) | PSD Major Source Size (tpy) |
|---|---|---|
| $NO_x$ | 71 | 250 |
| CO | 88 | 250 |
| $PM_{10}$ | 48 | 250 |
| $SO_2$ | 4 | 250 |

(1) Accounts for use of SCR and oxidation catalyst for $NO_x$ and CO/VOC control, respectively.

**Table 9-10 Annual Potential to Emit for Emission Units in the PSD 28 Source Category List Compared to PSD Major Source Size Thresholds**

| Air Pollutant | Gas Turbines - Annual Potential Emissions(1) (tpy) | Process Heaters - Annual Potential Emissions(1) (tpy) | PSD 28 Category List Major Source Size (tpy) |
|---|---|---|---|
| $NO_x$ | 34 | 21 | 100 |
| CO | 30 | 49 | 100 |
| $PM_{10}$ | 16 | 31 | 100 |
| $SO_2$ | 1.6 | 2.5 | 100 |

(1) Accounts for use of SCR and oxidation catalyst for $NO_x$ and CO/VOC control, respectively.

### Title V Operating Permit Program

Compliance with the requirements of the Title V permit program in New York State lies with NYSDEC (*see* discussion under Section 9.3.2).

### National Emission Standards for Hazardous Air Pollutants (NESHAP)

Emissions of hazardous air pollutants (HAPs) from specific processes and from major sources that generate significant quantities of HAPs are regulated by 40 CFR 61 and 40 CFR 63. These regulations are also known as NESHAP. The major source threshold is 10 tpy for any single HAP or 25 tpy for all combined HAP emissions. Since the proposed FSRU is not a major source of HAPs and does not fall under any of the specifically identified processes, NESHAP regulations are not applicable.

### Chemical Accident Prevention Provisions

40 CFR 68 sets forth the list of regulated substances and thresholds, the petition process for adding or deleting substances to the list of regulated substances, the requirements for owners or operators of stationary sources concerning the prevention of accidental releases, and the state accidental release prevention programs approved under Section 112(r) of the CAA. Since the proposed FSRU is expected to store more than 10,000 pounds of methane, the accident provisions of 40 CFR 68 are applicable.

### General Conformity

General Conformity applies only in nonattainment areas. Therefore, the ozone nonattainment designation triggers the review of $NO_X$ and VOC emissions under the General Conformity regulation. The proposed rule for implementation of the 8-hour ozone NAAQS prescribes *de minimis* levels for these compounds (Federal Register 2003). The recent designation of Suffolk County as a nonattainment area for the annual $PM_{2.5}$ NAAQS triggers a General Conformity review for $PM_{2.5}$ emissions and potentially $PM_{2.5}$ precursor compounds. In its proposed rule for implementation of the $PM_{2.5}$ NAAQS, EPA proposed candidate compounds as $PM_{2.5}$ precursors but did not indicate which candidate precursors would be regulated, deferring the decision until promulgation of the $PM_{2.5}$ NAAQS implementation rule. Project emissions such as vessel, motor vehicle, and construction emissions that are not covered by stationary source permits are considered under the General Conformity Rule. Evaluation of the Project's requirements under General Conformity consists of an applicability analysis via comparison of potential emissions to *de minimis* (threshold) levels, followed by a conformity determination if the emissions are found to be above *de minimis* levels. The *de minimis* levels applicable to Broadwater are:

- For the 1-hour ozone nonattainment designation, $NO_X$ and VOCs, 25 tpy each;
- For the 8-hour ozone nonattainment designation, $NO_X$ 100 tpy and VOCs 50 tpy; and
- For the $PM_{2.5}$ nonattainment designation, 100 tpy (based on EPA's April 2005 $PM_{2.5}$ interim guidance on applying $PM_{10}$ thresholds and *de minimis* levels to $PM_{2.5}$ nonattainment areas).

General Conformity is intended to require federal agencies, in this case FERC, to ensure proposed projects conform to the applicable State Implementation Plan (SIP). General Conformity applies to project-wide emissions of nonattainment pollutants such as $PM_{2.5}$ or, in the case of ozone, its precursors $NO_X$ and VOC that exceed significance thresholds. Under EPA's proposed rule to implement the $PM_{2.5}$ NAAQS, direct $PM_{2.5}$ emissions as well as precursor compounds must be evaluated, although EPA has not made a final determination on which compounds will be regulated as precursors to $PM_{2.5}$. Candidate $PM_{2.5}$ precursor compounds are $SO_2$, $NO_X$, VOCs, and ammonia. EPA's April 2005 interim guidance applying $PM_{10}$ thresholds to $PM_{2.5}$ nonattainment areas does not provide guidance on potential *de minimis* levels for $PM_{2.5}$ precursors since current $PM_{10}$ regulations do not address $PM_{10}$ precursor compounds. A federal agency can make a positive conformity determination for a proposed project by meeting any of several criteria in the General Conformity Rule, such as:

- Emissions from the project are specifically identified and accounted for in the SIP attainment or maintenance demonstration; or
- Emissions from the action are fully offset within the same area through a revision to the SIP or a similarly enforceable measure that creates emissions reductions so that there is no net increase in emissions of that pollutant.

### 9.3.2 New York State Regulations

The applicable federal regulations that were delegated to NYSDEC include nonattainment NSR and Title V operating permits. The NYCRR includes many of the same requirements as the federal regulations but may include more stringent emission standards and toxic air pollutant regulations.

#### Nonattainment NSR

It is unclear which threshold will apply for $NO_X$ and VOCs due to the transition from the 1-hour to the 8-hour ozone standard and new nonattainment designation. Under the 1-hour ozone nonattainment designation, the nonattainment NSR threshold is 25 tpy each



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for $NO_X$ and VOCs. Under the 8-hour ozone nonattainment designation, the nonattainment NSR threshold is 100 tpy for $NO_X$ and 50 tpy for VOCs. NYSDEC is in the process of revising the SIP for ozone to address these changes. It is likely that the SIP will be revised by 2008 and that moderate ozone nonattainment thresholds will apply. Broadwater is in discussion with the regulatory agencies to determine which major source thresholds apply, and in the case of $PM_{2.5}$ precursors, which pollutants apply to Broadwater. The final rule implementing the 8-hour ozone NAAQS was published November 29, 2005 (Federal Register 2005).

Nonattainment NSR includes many stringent requirements, including the application of lowest achievable emission rate (LAER) to source emissions. The emission rates incorporated into the design of the FSRU are consistent with LAER in the current 1-hour ozone nonattainment area. Based on the estimated annual potential emissions presented in Table 9-11, and assuming the New York State SIP has been revised for the 8-hour moderate ozone nonattainment designation, potential $NO_X$ and VOC emissions from the facility will be below 100 tpy and 50 tpy, respectively. As a minor stationary source in an ozone nonattainment area, the Project will not be subject to ozone nonattainment requirements in the NSR regulations. If the New York State SIP provisions for the 1-hour severe ozone nonattainment designation remain in effect, the Project will be subject to nonattainment NSR requirements. In accordance with the New York SIP, federal NSR regulations are administered by NYSDEC under NYCRR Title 6, Part 231 (6 NYCRR 231).

**Table 9-11 Annual Potential to Emit for the Proposed FSRU Stationary Sources and Nonattainment NSR/Title V Major Source Size Thresholds**

| Air Pollutant[1] | Estimated Annual Emissions[2] (tpy) | Title V Major Source Size (tpy) |
|---|---|---|
| $NO_x$[3] | 71 | 100/25 |
| CO | 88 | 100 |
| VOCs[3] | 18 | 50/25 |
| $PM_{10}$ | 48 | 100[4] |
| $PM_{2.5}$ | 48 | 100 |
| $SO_2$ | 4 | 100 |
| Ammonia | 66 | — |
| Total HAPs | 9.4 | 25 |

(1) $NO_X$, VOCs, $SO_2$, and ammonia are also candidate $PM_{2.5}$ precursors as defined in the EPA proposed $PM_{2.5}$ implementation rule.

(2) Emission estimates do not include any mobile source emissions or LNG carrier emissions occurring during LNG unloading.

(3) First value is threshold for 8-hour moderate ozone nonattainment designation, second value is threshold for 1-hour severe ozone nonattainment designation.

(4) DEC Policy CP-33 for fine particulate matter prescribes a significant source size threshold of 15 tpy for $PM_{10}$ as a surrogate measure to determine whether secondary $PM_{2.5}$ effects must be considered (NYSDEC 2003a).

The Project will be able to achieve annual emission levels for $NO_X$ and VOCs that are below the major source threshold for the 8-hour moderate ozone nonattainment area by applying control equipment to source emissions that reduces emission levels to the current LAER. Under the 1-hour ozone nonattainment designation and with application of LAER, the Project will be above the major source threshold for $NO_X$ and offsets for the $NO_X$ emissions will be required. Use of the control equipment (i.e., selective catalytic reduction [SCR] and oxidation catalyst) will be required by the air permit. Low $NO_X$ burners will be used, and both the process heaters and the turbines will be equipped with SCR and oxidation catalyst units.

The EPA published a proposed rule on November 1, 2005, in the Federal Register to implement the fine particle (i.e., $PM_{2.5}$) NAAQS and solicited comments on the proposed rule (Federal Register 2005a). The proposed rule prescribes the requirements that NYSDEC (and other states' agencies) must meet in their implementation plans in order to attain the $PM_{2.5}$ NAAQS. The proposed rule suggests states control stationary sources affecting regional $PM_{2.5}$ air quality and sources affecting local $PM_{2.5}$ air quality such as traffic, industrial sources, and other combustion-related activities. The implementation program will focus on direct $PM_{2.5}$ emissions as well as emissions of precursor compounds. The candidate list of precursor compounds includes $NO_X$, $SO_2$, VOCs, and ammonia; the proposed rule does not conclude which of these candidate precursor compounds will be regulated as $PM_{2.5}$ precursors, deferring until the final rule is issued. The proposed rule contains several options with regard to control of $PM_{2.5}$ precursors that states may consider during implementation plan development. The SIP revision and attainment demonstration are due to EPA by April 2008; this date corresponds to the approximate date that installation of Broadwater facilities will begin in the Sound. The attainment date for the $PM_{2.5}$ NAAQS is April 2010, although EPA may extend the attainment date to no later than April 2015, depending on the severity of the nonattainment situation and the availability and feasibility of control measures.

The proposed rule addresses emission thresholds for direct $PM_{2.5}$ and precursor compounds for determining whether a project is major or minor under NSR. For PSD, the current limits of 100 or 250 tpy apply. For nonattainment New Source Review (NA NSR), the current major source threshold of 100 tpy applies.

Offset ratios for direct $PM_{2.5}$ and $PM_{2.5}$ precursors are not defined in the proposed rule, although they must be at least 1:1 to meet the minimum offset ratio required under the CAA.

During the SIP development period, EPA allows the use of a $PM_{10}$ nonattainment major NSR program as a surrogate program to address $PM_{2.5}$ nonattainment NSR. NYSDEC Policy CP-33 (Assessing and Mitigating Impacts of Fine Particulate Matter Emissions) sets forth guidance on project-specific assessments (NYSDEC 2003a). NYSDEC policy CP-33 follows EPA guidance by using $PM_{10}$ emissions as a surrogate for $PM_{2.5}$. The policy prescribes a $PM_{10}$ emission rate of 15 tpy or greater as a significant emission rate (in this case, NYSDEC uses the term "significant emission rate" as a threshold for any project, including new construction); projects with an annual potential to emit greater than 15 tpy must evaluate secondary formation of $PM_{2.5}$ through an evaluation of precursor emissions. The evaluation includes quantifying potential $PM_{2.5}$ precursor emissions, discussing the potential for secondary $PM_{2.5}$ formation, and demonstrating that the precursor emissions will comply with all state and federal regulations and programs. NYSDEC policy CP-33 also requires a modeling analysis of $PM_{2.5}$ for projects whose $PM_{10}$ emissions are above 15 tpy.

### Operating Permit

Title V of the CAA requires states to establish an air operating permit program. The requirements of Title V are outlined in 40 CFR 70. The New York State Title V permitting program is codified in 6 NYCRR 201. This regulation contains provisions for operating permits for State Facility (minor source) permits (6 NYCRR 201-5) and Title V (major source) permits (6 NYCRR 201-6). In accordance with 6 NYCRR 201-6.1, a Title V permit must be obtained for the following:

- Any major stationary source (defined below);
- Any major stationary source subject to an NSPS; non-major stationary sources subject to an NSPS are currently exempt from Title V;
- Any stationary or area source subject to regulations for HAPs under Section 112 of the CAA, except sources solely subject to the control of accidental release provisions of Section 112;
- Any affected source (combustion sources subject to the federal acid rain program under Title IV of the CAA); and
- Any stationary source in a category designated by EPA and added by NYSDEC pursuant to rulemaking.

Major stationary sources defined for Title V applicability differ from major stationary sources defined for PSD applicability. For Suffolk County, New York, a Title V major stationary source is defined as a facility with the PTE that meets the criteria listed below. If a facility's emissions are lower than the criteria, the source is minor and a State Facility Permit is issued. The thresholds are:

- 100 tpy or more of any air pollutant;
- 100 tpy or more of $NO_X$ or 50 tpy or more of VOCs (8-hour moderate ozone nonattainment designation);
- 25 tpy or more of $NO_X$ or VOC (1-hour severe ozone nonattainment designation);
- 25 tpy or more of any combination of HAPs; or

- 10 tpy or more of any individual HAP.

Based on the emission estimates of $NO_X$, VOCs, and HAPs, the permit restrictions and control equipment accepted by Broadwater, and the Project's location in an 8-hour moderate ozone nonattainment area, the proposed Project will be below the major stationary source size under Title V (*see* Table 9-11). Therefore, the Project will need to obtain a State Facility (minor source) permit from New York State authorizing both construction and operation in accordance with all applicable state and federal air regulations. If the 1-hour severe ozone nonattainment designation applies, the proposed Project will be above the major stationary source size for $NO_X$ and will require a Title V permit.

### State-Only Regulations

Air emission sources in New York State must meet state air emission standards and requirements codified in 6 NYCRR Parts 201 to 257. Part 204 ($NO_X$ Budget Trading Program) is applicable to this facility because the heat input rating of each gas turbine is slightly over the applicability threshold of 250 MMBtu/hr as listed in Part 204-1.4. Conversely, the process heaters are not $NO_X$ budget units because their heat input is slightly below the unit applicability threshold of 250 MMBtu/hr as listed in Part 204-1.4. The emission standards and requirements that may potentially apply to the proposed FSRU are described below.

- Part 200: General Provisions;
- Part 201: Construction and Operating Permits;
- Part 202: Emissions Verification;
- Part 211: General Prohibitions;
- Part 212: General Process Emission Sources;
- Part 226: Solvent Metal Cleaning Processes;
- Part 227: Stationary Combustion Installations;
- Part 231: New Source Review; and
- Part 257: Ambient Air Quality Standards.

Part 200 contains several general provisions regarding the proper operation of all types of air emission sources.

Part 201 contains the permitting requirements for the construction and operation of air emission sources. State Facility and Title V (operating) permit requirements are included in Part 201. The application process for construction and operating permits is combined into a single application in New York. For the proposed FSRU, NYSDEC will generate a draft Part 201 (State Facility) permit from this application, which then undergoes public notice.

Part 202 contains guidelines for emissions testing and annual emission reporting. Emission statements for the proposed FSRU will be required to be submitted to NYSDEC on an annual basis.

Part 211 contains general prohibitions on injurious air pollution releases and excessive visible emissions.

Part 212 contains emission standards for process emission sources. The emission standards outlined in this part applies to all nonexempt emission sources at a proposed facility except combustion units (as well as other exceptions). The proposed LNG process heaters, gas turbines, and auxiliary equipment are defined as combustion installations, not process emission sources. Thus, Part 212 is not applicable to the Project.

Part 226 contains provisions for the operation of degreasers and other solvent-based metal cleaning devices.

Part 227 contains emission standards and testing/monitoring/reporting requirements for stationary combustion installations. Since the proposed FSRU will be a minor stationary source of $NO_X$, a compliance plan that outlines the methods and measures of compliance of combustion installations at the FSRU will not be required. However, it is anticipated that recordkeeping and reporting requirements to monitor adherence to the emission cap will be imposed on the Project. The Part 227 $NO_X$ emission limit for each process heater is 0.2 pound per MMBtu for a heat input range of 100 MMBtu/hour to less than 250 MMBtu/hour. If this emission rate cannot be achieved, or low $NO_X$ burners and SCR are impossible or impractical, a clear and convincing technical demonstration on such constraints and proposed alternate controls must be included as part of a compliance plan. For the gas turbine, a case-by-case determination will be made based on the reasonably available control technology (RACT) proposal submitted. Historically, the $NO_X$ RACT limit for gas turbines in the New York City metropolitan area (which Suffolk County is part of) has been 2.5 parts per million by volume on a dry basis at 15% oxygen. Small boilers and emergency equipment are not subject to specific emission limits.

Part 231 contains the Federal Nonattainment NSR rules.

Part 257 contains the ambient air quality standards for New York State. NYSDEC has adopted the federal NAAQS for criteria pollutants. NYSDEC also has adopted additional ambient air quality standards for the following pollutants: $SO_2$, settled particulates, total suspended particulates (TSP), non-methane hydrocarbons, fluorides, beryllium, and hydrogen sulfide.

## 9.4 CONSTRUCTION AND OPERATION AIR QUALITY IMPACTS AND MITIGATION

### 9.4.1 Emissions

#### Construction

Onshore facilities are addressed separately in Section 9 of the Onshore Facilities Resource Reports. No discussion of potential impacts from the onshore facilities are included in this report.

Offshore construction activities will consist of pipeline installation and installation and hook up of the mooring tower and FSRU. The FSRU will be constructed in a shipyard away from the Project site and towed to the site. Thus, the primary sources of emissions during construction activities will be the marine construction vessels used to install the pipeline and FSRU. Ships of various sizes, ranging from small day-use workboats to large supply vessels and pipeline construction vessels, will be used. Emission estimates from construction activities are based on the anticipated duration of use of each vessel type during the construction period, the vessels' engine characteristics and duty cycles, and emission factors.

Construction is anticipated to occur during winter months only over a two-year period. The emission estimate requires the use of a detailed construction schedule, inventory of vessel types, quantity and duration of use, and emission factors. The major construction activities consist of pipeline installation, tower installation, and FSRU towing. A spreadsheet emission estimate tool provided by the U.S. Department of the Interior, Minerals Management Service, was used to estimate construction-related emissions. Emission estimates for construction activity are presented in Table 9-12; the detailed construction emission estimate study is provided in Appendix A.

As discussed in Section 9.3.1, emissions of nonattainment pollutants not subject to a permit program are subject to review under the General Conformity rule. Construction-related emissions are not covered by an air permit program and are evaluated under the General Conformity rule. Construction-related emissions occur in calendar years prior to commencement of FSRU operations. No other Project-related emissions will occur simultaneously with construction-related emissions. Since the region is in nonattainment for ozone, emissions of $NO_X$ and VOCs are compared to General Conformity *de minimis* thresholds. Suffolk County also is designated nonattainment for $PM_{2.5}$; thus, in accordance with EPA guidance, direct emissions of $PM_{2.5}$ (using $PM_{10}$ emissions as a surrogate) and emissions of candidate $PM_{2.5}$ precursor compounds ($NO_X$, VOCs, $SO_2$, and ammonia) are compared to proposed General Conformity *de minimis* thresholds defined in the proposed rule to implement the $PM_{2.5}$ NAAQS (Federal Register 2005a). The $NO_X$ emissions shown in Table 9-12 are above the General Conformity *de minimis* threshold of 100 tpy for each year of construction, assuming applicability of the 8-hour moderate ozone nonattainment threshold. $NO_X$ emissions would also be above the General Conformity *de minimis* threshold of 25 tpy for each year of construction, assuming applicability of the 1-hour serious ozone nonattainment threshold. Thus, during the two-year construction period, the full amount of the $NO_X$ emissions is subject to mitigation under General Conformity. However, with construction scheduled to occur outside of the ozone season (May 15 through September 15), construction emissions will not contribute to the summertime ozone season, and Broadwater does not anticipate the need to mitigate short-term ozone precursor emissions that occur outside of the ozone season. If construction were to occur during the ozone season, Broadwater would acquire $NO_X$ emission offsets for the two years of construction emissions.

**Table 9-12 Estimated Emissions from Construction Activities**

| Year | PM (tpy) | $SO_2$ (tpy) | $NO_X$[1] (tpy) | VOCs[1] (tpy) | CO (tpy) | Ammonia (tpy) |
|---|---|---|---|---|---|---|
| 1 | 13 | 32 | 269 | 14 | 58 | 0 |
| 2 | 18 | 60 | 471 | 22 | 103 | 0 |
| Annual General Conformity *de minimis* | 100[2] | 100[3] | 100 | 50 | Not applicable | 100[3] |

(1) Assumes that *de minimis* thresholds proposed by EPA for a moderate ozone nonattainment area are applicable. The *de minimis* threshold for VOCs under the proposed $PM_{2.5}$ implementation rule is less stringent than the ozone nonattainment *de minimis* VOC threshold; the *de minimis* threshold for $NO_x$ under the proposed $PM_{2.5}$ implementation rule is equal to 100 tpy, which is the same as the *de minimis* threshold proposed by EPA for moderate ozone nonattainment. If the 1-hour ozone nonattainment *de minimis* thresholds are applied for $NO_x$ and VOC (25 tpy each), the outcome would be the same for each construction year; i.e., construction emissions of $NO_x$ would be above *de minimis*, while construction emissions of VOC would be below *de minimis*.

(2) EPA issued guidance in April 2005 describing an interim surrogate $PM_{2.5}$ program for nonattainment areas to be used while states develop $PM_{2.5}$ control programs. The threshold for $PM_{2.5}$ in this guidance is recommended to equal the 100-tpy threshold for $PM_{10}$ nonattainment areas.

(3) EPA's proposed $PM_{2.5}$ implementation rule (issued 11/01/05) does not set *de minimis* levels for $PM_{2.5}$ precursor compounds. However, the proposed rule suggests that the *de minimis* levels will be set equal to nonattainment area major source levels for the NSR program. Thus, using this approach, 100 tpy would be the *de minimis* level for all $PM_{2.5}$ precursor pollutants.

Direct emissions of $PM_{10}$ will be less than the *de minimis* threshold; therefore, $PM_{2.5}$ emissions would be less than the *de minimis* threshold (following EPA's April 2005 interim guidance on using $PM_{10}$ as a surrogate for $PM_{2.5}$). Of the $PM_{2.5}$ precursor compounds EPA is considering for regulation, only $NO_X$ would exceed a *de minimis* threshold. However, EPA has not yet determined whether it will regulate $NO_X$ as a $PM_{2.5}$ precursor compound; thus, offsetting these emissions may not be required. Offsets that Broadwater uses for construction-related $NO_X$ emissions during the ozone control period may also serve as a $PM_{2.5}$ precursor offset if EPA decides to regulate $NO_X$ as a $PM_{2.5}$ precursor at a future date.

### Facility Stationary-Source Operation

All emission sources identified on the FSRU are combustion sources that will generate air emissions throughout the long-term operation of the facility. The emissions from these sources will be subject to applicable state and federal air regulations such as emission standards and permit programs. The air pollutants associated with the combustion of natural gas and diesel fuel include CO, HAPs, $NO_x$ (e.g., nitrogen oxide (NO) and $NO_2$), $PM_{10}$, $PM_{2.5}$, $SO_2$, and VOCs. Ammonia will also be emitted due to the 'slip' of unreacted ammonia through the SCRs used on the gas turbines and process heaters.

Emission estimates for these sources were generated by:

- Examining the projected LNG peak throughput data for the proposed FSRU (1.25 bcfd);
- Examining the annual limit of LNG delivered to the FSRU on an annual basis (7.7 million metric tons of natural gas delivered to the pipeline);
- Identifying the emission factors from process heater and gas turbine manufacturers;
- Incorporating EPA emission factors; and
- Evaluating emission data for other similar LNG projects.

Emission estimates were generated for all criteria pollutants except lead and ozone, since these compounds are either not emitted from the facility in significant amounts (lead), or are not directly emitted (as is the case for ozone). Emission estimates also were developed for $NO_x$, VOCs, and HAPs.

Lead emissions from the proposed facility are expected to be insignificant. Emissions of $NO_x$ are typically measured and reported in lieu of $NO_2$ emissions. Ozone is not emitted directly from emission sources, but it is formed in the atmosphere through the reactions of precursors such as $NO_x$ and VOCs. While not classified as criteria pollutants, HAPs are regulated under various federal and state regulations. HAP emissions from the proposed FSRU are expected to be a subcategory of VOCs.

Operations-related emission estimates for the proposed facility are presented in Table 9-11. Appendix B provides detailed emission calculations for the estimates summarized in Table 9-11. The emission estimates reflect the use of SCR for $NO_x$ reduction and CO oxidation catalysts on the gas turbines and process heaters.

FSRU operations will result in annual emissions that are below ozone nonattainment NSR thresholds for the Project area (assuming applicability of moderate ozone nonattainment thresholds); therefore, emission offsets will not be required.

FSRU operations will result in annual $PM_{10}$ emissions that are greater than 15 tpy. Therefore, as required by NYSDEC policy CP-33, an analysis of the secondary formation of $PM_{2.5}$ must be conducted. A quantitative measure of potential $PM_{2.5}$ precursor emissions, as required by the policy, is shown in Table 9-11 for $SO_2$, $NO_x$, VOCs, and ammonia. The policy also requires a qualitative discussion of secondary $PM_{2.5}$

formation. The EPA proposed rule for implementation of the $PM_{2.5}$ NAAQS provides information about the potential mechanisms of secondary $PM_{2.5}$ formation. $NO_X$ and $SO_2$, through various atmospheric chemical reactions, can result in the formation of nitrate and sulfate $PM_{2.5}$ particles. VOCs can act as precursors for the formation of secondary organic aerosols. Ammonia can combine with nitrate, sulfate, and/or VOCs, also resulting in particles. The process and role of ammonia in particle formation in atmospheric conditions is very complex. In fact, the interaction of ammonia with sulfate aerosol, nitrate aerosol, and secondary organic aerosol is described as a complex and nonlinear process in the proposed rule. Ammonia may contribute to the formation of particles when it combines with sulfate and nitrate, thus reducing the acidity of atmospheric particles and precipitation. Reducing the ammonia concentration may reduce particle formation, but it also may result in an increase in particle and precipitation acidity. In turn, the acidification of particles may itself result in secondary particle formation. This brief discussion shows just how complex and intertwined the particle formation process is. The proposed $PM_{2.5}$ rule concludes by indicating that more research is needed before considering programs for ammonia emission reduction. Thus, at this time, it is inconclusive as to whether the ammonia emissions from the FSRU would contribute significantly to secondary particle formation. The proposed $PM_{2.5}$ rule states that reducing $SO_2$ and $NO_X$ will contribute substantially to controlling the secondary formation of $PM_{2.5}$. For the FSRU emissions shown in Table 9-11, $SO_2$ emissions are minor (4 tpy) and thus are not likely to result in substantial secondary $PM_{2.5}$ formation. $NO_X$ and VOC emissions are controlled to meet LAER, thus minimizing the potential for secondary $PM_{2.5}$ nitrate particle and secondary organic aerosol formation.

The NYSDEC policy CP-33 also requires a demonstration that Broadwater will comply with all state and federal regulations and programs applicable to emission of pollutants that are possible $PM_{2.5}$ precursors (NYSDEC 2003a). By controlling $NO_X$ and VOCs to meet LAER, the Project is complying with state and federal NA NSR requirements. $SO_2$ emissions are minimized by use of only natural gas in the FSRU gas turbines and process heaters. Ammonia emissions occur due to use of SCR in order to meet LAER for $NO_X$ under the NA NSR program; ammonia emissions will be minimized through proper operation of the SCR units and compliance with air permit limits.

The emission levels also will be below the applicable PSD major source thresholds and, therefore, a review of the Project under PSD requirements is not required. Finally, the annual emissions will be below Title V operating permit major source thresholds. Therefore, the facility will be operated under a State Facility Permit issued by NYSDEC.

#### Facility Mobile-Source Emissions during Operation

Emissions will be produced by LNG carriers during transit to and from the FSRU and by support vessel operation during routine operation of the FSRU. Vessels associated with routine operation of the FSRU include the LNG carriers; tug boats associated with escorting and assisting the LNG carriers while approaching, positioning, docking, and leaving the FSRU; and small supply vessels delivering supplies for use on the FSRU.

Emissions for the LNG carrier are calculated for the complete delivery cycle beginning at the location at which the vessel enters U.S. waters, as it travels inbound to the FSRU, unloads LNG at the FSRU, and as it travels outbound until it reaches the boundary of U.S. waters. The USCG is currently reviewing proposed LNG carrier routes.

Tug boats will be used to assist an LNG carrier during its operation in the vicinity of the FSRU. The tugs are used to aid in making turns and positioning the LNG carrier alongside the FSRU. In addition, tug boats will typically meet the inbound LNG carrier at the Race during transit into Long Island Sound, escort it to the FSRU, and escort the outbound LNG carrier out to the Race after it delivers its LNG cargo. The number of tug boats required for these operations will vary depending on the size of the LNG carrier and USCG requirements. Three tug boats assisting the LNG carrier while berthing to the FSRU and two escort tugs were used in the emission analysis. One supply vessel will typically visit the FSRU per each LNG delivery. Based on LNG deliveries from a conventional LNG carrier with a cargo capacity of 140,000 $m^3$, 118 supply vessel trips will be made to the FSRU annually.

The LNG carrier will operate its main power generator while docked alongside the FSRU. Approximately 10 MW of electrical power will be needed to operate pumps on the carrier during the transfer of LNG to the FSRU. For various reasons (e.g., contractual, U.S. Customs, etc.), the LNG carrier cannot use boil off gas to produce electricity while docked. During the LNG transfer period, which lasts approximately 14 hours for a LNG carrier with a cargo capacity of 140,000 $m^3$, residual oil will be used in the power generation equipment onboard the carrier. The mix of carrier types that will call on the Broadwater FSRU is unknown at this time and ultimately will be determined based on commercial and logistical considerations. The current fleet of LNG carriers that could call on the Broadwater FSRU are steam propulsion carriers using LNG as fuel. Future carriers may be larger, and their fuel mix for propulsion could use LNG alone or heavy fuel oil. Therefore, the impact of emissions on the atmosphere is an estimate of future conditions that have yet to materialize. Table B-13 of Appendix B provides a summary of emissions for LNG carriers of various cargo capacities, propulsion types, and in-use dates (i.e., current use, vessels expected to be available within the next 5 years, and vessel concepts beyond 5 years).

A summary of emissions from vessel activities during normal FSRU operation is presented in Table 9-13. These emissions are not covered by an air permit program; they are evaluated under the General Conformity rule by comparison to *de minimis* thresholds. Thresholds for an 8-hour moderate ozone nonattainment area are shown in Table 9-13; however, the same outcome would occur if thresholds for the 1-hour ozone nonattainment area were applied. *De minimis* thresholds described in EPA's proposed rule for the implementation of the $PM_{2.5}$ NAAQS are also shown.

**Table 9-13 Annual Emission Summary for Vessel Activity**

| | $NO_x$ (tpy) | CO (tpy) | VOCs (tpy) | $PM_{10}/PM_{2.5}$ (tpy) | $SO_2$ (tpy) | $CO_2$ (tpy) |
|---|---|---|---|---|---|---|
| LNG Carrier Unloading | 29 | 2 | <1 | 10 | 222 | 13,032 |
| Carrier Transit and Support Tugs | 427 | 54 | 18 | 25 | 341 | 37,437 |
| Total | 456 | 56 | 19 | 35 | 563 | 50,469 |
| Annual General Conformity *De minimis* | 100[1] | Not applicable | 50[(1)] | 100[(2)] | 100[(3)] | Not applicable |

(1) Assumes that *de minimis* thresholds proposed by EPA for a moderate ozone nonattainment area are applicable. The *de minimis* threshold for VOCs under the proposed $PM_{2.5}$ implementation rule is less stringent than the ozone nonattainment *de minimis* VOC threshold; the *de minimis* threshold for $NO_x$ under the proposed $PM_{2.5}$ implementation rule is equal to 100 tpy, which is the same as the *de minimis* threshold proposed by EPA for moderate ozone nonattainment. If the 1-hour ozone nonattainment *de minimis* thresholds are applied for $NO_x$ and VOC (25 tpy each), the outcome would be the same, i.e., emissions of $NO_x$ would be above *de minimis*, while emissions of VOC would be below *de minimis*.

(2) EPA issued guidance in April 2005 describing an interim surrogate $PM_{2.5}$ program for nonattainment areas to be used while states develop $PM_{2.5}$ control programs. The threshold for $PM_{2.5}$ in this guidance is recommended to be equal to the 100-tpy threshold for $PM_{10}$ nonattainment areas.

(3) EPA's proposed $PM_{2.5}$ implementation rule (issued 11/01/05) does not set *de minimis* levels for $PM_{2.5}$ precursor compounds. However, the proposed rule suggests that the *de minimis* levels will be set equal to nonattainment area major source levels for the NSR program. Thus, using this approach, 100 tpy would be the *de minimis* levels for all $PM_{2.5}$ precursor pollutants.

### 9.4.2 Air Quality Modeling and Analysis

#### Air Quality Modeling

Air quality impacts were determined using atmospheric dispersion models. Modeling studies were conducted following a modeling protocol that was developed by the Project and reviewed by NYSDEC and EPA. Approval of the protocol will be addressed by regulatory agencies after EPA determination of PSD applicability has been finalized. Dispersion modeling was performed using the Offshore Coastal Dispersion (OCD) model to estimate concentration levels beyond the assumed 500-yard safety and security zone boundary (i.e., over water and on land in shore areas of New York and Connecticut). For modeling purposes, the boundary of the safety and security zone is treated as the fenceline of the facility; public access to the area within the safety and security zone boundary will be restricted. The USCG has not made a final determination regarding the appropriate radial distance from the FSRU for establishing the boundary. The AERMOD-PRIME model was used to evaluate the emission point/ship structure relationship for formation of recirculation (cavity) effects and to determine whether the cavity extends to or beyond the assumed safety and security zone boundary.

The OCD model is suited to evaluating the transport and dispersion of emissions from an offshore source such as an FSRU over water to a shoreline (DOI 1997). While similar to overland Gaussian dispersion models such as ISCST3 and SCREEN3, OCD is optimized for estimating dispersion in an over-water environment. The OCD model also contains a calculation procedure to evaluate the impact on air quality over water areas in the immediate vicinity of the FSRU due to aerodynamic effects of air flow over the FSRU.

AERMOD is an EPA-approved model containing the most up-to-date methods for evaluating cavity effect and downwind dispersion. Only results from the cavity portion of the model were used for this study since the OCD model was used to evaluate over-water dispersion beyond the assumed 500-yard safety and security zone boundary.

As detailed in the modeling protocol (*see* Attachment A of Appendix C), meteorological data sets for offshore and onshore sites were used in OCD. Background (existing) air pollutant concentration levels also were obtained from New York State stations located on Long Island and onshore Connecticut stations near the north shore of the Sound (*see* Section 9.2.2). These data were used to compare estimated air quality impacts from FSRU operations to existing conditions and provide an indication of the relative effect on existing air quality. As discussed later in this section, OCD-modeled air quality concentrations due to the FSRU are below Significant Impact Levels (SILs); the downwash analysis using AERMOD-PRIME indicates that for some pollutants and averaging periods, the SIL would be exceeded at the boundary of the assumed 500-yard safety and security zone. For pollutant and averaging period combinations for which a SIL is exceeded, an additional step in evaluating the impact on ambient air quality was conducted. Background ambient air concentrations for the New York station were added to the maximum concentration and compared to the NAAQS. Based on this additional step, no NAAQS were exceeded.

The modeling protocol also defines how the operation of the FSRU was input into the models. Emissions and subsequent ambient air quality impacts are affected by the number of emission sources operating at any given time, the load being placed on each unit (e.g., operating at 50% or 100% of capacity), and the type of fuel being used. Operating scenarios were developed and evaluated in the modeling study to characterize long-term (i.e., annual) impacts on air quality and short-term (i.e., 1-, 3-, 8-, or 24-hour) impacts. These time periods correspond to those used for criteria pollutants in the NAAQS.

**Air Quality Analysis - OCD**

The objective of the modeling analysis was to assess the ambient air quality impacts using design parameters identified for the Project in Resource Report 13, Engineering and Design Material. These impacts were compared to appropriate regulatory levels to identify potential issues with predicted air pollutant emission rates. Air quality impacts were assessed only for emission sources associated with operation of the FSRU.

The FSRU air emission sources included in this preliminary analysis are summarized in Appendix B, Table B-1. This table outlines fuel type, rating, and potential operational hours per year for each air emission source.

### Stack Parameters

All emission sources on the FSRU are categorized as point sources (i.e., stacks). Model input parameters, including stack height, stack gas temperature, stack exit inside diameter, stack gas exit velocity, stack angle from vertical, and elevation of stack base above water surface, are summarized in Appendix B, Table B-2.

### Pollutant Emission Rates

For pollutants with short-term averaging periods (1-hour to 24-hour), model runs were conducted using the maximum hourly emission rate. The maximum emission rate used as model input was developed through an examination of the equipment emissions under normal operations at various ambient temperatures and based on a peak send-out rate of 1.25 bcfd. Startup/shutdown conditions were incorporated into these emission rates.

For pollutants with annual averaging periods, model runs were conducted using the highest hourly emission rate that would occur during delivery of natural gas up to an annual maximum limit of 7.7 million tons into the pipeline. In this case, the modeled hourly emission rate was calculated by dividing annual emissions by 8,760 hours per year. Startup/shutdown conditions were incorporated into these emission rates.

Pollutant emission rates are summarized in Appendix B, Table B-3.

$NO_X$ emissions from these sources will be in the form of NO and $NO_2$. Following release to the atmosphere, a significant portion of NO is oxidized to $NO_2$. Since NSR significance levels and NAAQS are expressed in terms of $NO_2$, the model result expressed in terms of $NO_X$ must be converted to an $NO_2$ value. For this modeling analysis, complete conversion of $NO_X$ to $NO_2$ was assumed.

### Building and Structure Parameters

Building and nearby structure data were included as OCD model input to account for potential building wake effects (downwash) on emission plumes. The lengths and widths of the FSRU and LNG carrier are listed in Appendix B, Figure B-1. The deck heights (not including the heights of structures on the deck) of the FSRU and LNG carrier were assumed to be 25 m and 15 m, respectively. A more detailed representation of the FSRU structure shape, taking into account the shape of the main hull and the accommodation block, was input to the building profile preprocessor program (BPIP-PRIME). The preprocessed structure data were subsequently read into AERMOD-PRIME to evaluate cavity effects.

### Meteorological Data

The OCD model requires surface meteorological data and upper air data from representative measurement sites over land and over water. AERMOD-PRIME requires overland surface meteorological and upper air data. The over land surface data station used in this study was Islip (MacArthur Airport), New York, and the upper air over land data were obtained from Brookhaven (Upton), New York. The over water surface data were obtained from the central Long Island Sound data buoy (Buoy 44039) operated by the University of Connecticut, which is the data buoy located closest to the proposed FSRU location. There are no stations that collect over water upper air data along the immediate coastline of Long Island Sound or within the Sound itself. The closest site collecting upper air data is Brookhaven (Upton), New York, approximately 15 miles south of the proposed FSRU location. The upper air data site is located approximately midway between the north and south coast of Long Island, approximately 7.5 miles from each coast. At this location, Long Island is approximately 15 miles wide. Although the land surface will influence the very near surface conditions differently than over water, the long fetch over the ocean to the south of Brookhaven, and the approximately 20 mile fetch over Long Island Sound to the north of Brookhaven is expected to impart a strong maritime signature in the low-altitude atmospheric conditions. Thus, these data were deemed an appropriate representation for over water, upper air observations.

The data period used in the modeling study extended from December 9, 2004, through December 8, 2005. Data missing from the central Long Island Sound buoy data set were filled in following EPA procedures for short duration missing periods and procedures described in the OCD model User's Guide (DOI 1997). Data missing for longer periods were filled in using data from the Western Sound data buoy (Buoy 44040) and Bridgeport, Sikorsky Memorial Airport, located on the north coast of Long Island Sound, following EPA and OCD model guidance. The modeling report provided in Appendix C provides more detail on the procedures used to prepare the meteorological data for modeling.

#### Receptors

Ambient air quality impacts were analyzed at specific receptor locations input into the OCD model. Three receptor grids were used: the highest-density receptor grid pattern (a Cartesian grid) was nested inside of two less-dense Polar receptor grids as follows:

- A 2-km by 2-km Cartesian grid system was centered on the YMS with 100-m spacing in the x and y direction between the grid points. Locations within an assumed 500-yard safety and security zone around the FSRU were excluded. To date, the USCG has not defined a specific safety and security zone for the Project. However, for the purposes of air quality modeling and to assess potential impacts, a representative safety and security zone was included, based on previous such zones established both within Long Island Sound and for other LNG facilities. Following establishment of a defined safety and security zone by the USCG, modeling will be updated, as necessary, to represent anticipated conditions.

- Extending out from the boundary of the Cartesian receptor grid described above, a radial (i.e., polar) grid system was established with receptors located on radial arms at 10-degree compass direction intervals centered on the YMS. On each radial, receptors were placed at 100-m intervals between 1.5 km and 2.5 km; from 2.5 km to 5 km, receptors were placed at 500-m intervals.

- A large-scale receptor grid covering an area measuring 20 km by 20 km centered on the YMS was used to evaluate transport to shore, with receptors located 3.4 km and 4.1 km apart in the east-west and north-south directions, respectively.

### Land Use

The surface roughness length for the overland meteorological data in OCD was chosen to be 0.024 m, which is representative of land surfaces near Islip, New York.

### Miscellaneous Model Options

The following options were used during OCD model runs: stack-tip downwash, buoyancy-induced dispersion, and terrain adjustments. The gradual plume rise option was not used during the OCD model runs. In accordance with recommendations in the OCD User's Guide, the minimum "miss distance" was set equal to 10 m.

### Results

The receptor grids used in the OCD model were designed to thoroughly cover the study area in order to find the maximum ambient concentration (highest annual and highest first high for short-term averaging periods) for each regulated pollutant for each pollutant's applicable averaging time. Thus, the OCD model output for all receptors was analyzed to find these specific concentrations. All other receptor locations would have predicted concentrations less than these maximum values, which are shown in Table 9-14.

For pollutants with short-term averaging periods (i.e., 1-hour to 24-hour averaging times), the modeled air quality concentrations are based on maximum operation of FSRU turbines, process heaters, and auxiliary equipment. Annual impacts are based on continuous operation of FSRU turbines and process heaters at full load required to deliver natural gas up to an annual natural gas delivery limit into the pipeline of 7.7 million tons and operation of emergency fire pumps and emergency generators for 100 hours per year.

Ambient impacts were compared with significant impact concentration values defined in NSR regulations. The OCD results and the comparison are presented in Table 9-14.

**Table 9-14 OCD Model Results**

| Pollutant | Averaging Period | Significant Impact Level ($\mu g/m^3$) | OCD Maximum Predicted ($\mu g/m^3$) | Exceeds Significant Concentration Level? |
|---|---|---|---|---|
| Carbon monoxide (CO) | 8-Hour | 500 | 111 | No |
| | 1-Hour | 2,000 | 258 | No |
| Nitrogen dioxide ($NO_2$) | Annual | 1 | 0.26 | No |
| $PM_{10}$ | Annual | 1 | 0.05 | No |
| | 24-Hour | 5 | 2.82 | No |

**Table 9-14 OCD Model Results**

| Pollutant | Averaging Period | Significant Impact Level (μg/m³) | OCD Maximum Predicted (μg/m³) | Exceeds Significant Concentration Level? |
|---|---|---|---|---|
| $PM_{2.5}$ | Annual | 1 | 0.05 | No |
| | 24-Hour | 5 | 2.75 | No |
| Sulfur dioxide ($SO_2$) | Annual | 1 | 0.00 | No |
| | 24-Hour | 25 | 0.15 | No |
| | 3-Hour | 5 | 0.65 | No |
| Ammonia ($NH_3$) | Annual | 100[(1)] | 0.06 | Below AGC |
| | 1-hour | 2,400[(1)] | 9.50 | Below SGC |

Note:
(1) Significant concentrations for ammonia taken from NYSDEC DAR-1 guidance, SGC/AGC table. The 1-hour maximum impact was compared to SGC, and the annual maximum impact was compared to AGC.

As shown in Table 9-14, all predicted OCD maximum concentrations (i.e., the highest concentration found throughout the entire receptor grid) are less than the NSR significance levels applicable to Class II areas. Therefore, the Project is expected to have minimal air quality impacts over most water areas and onshore and does not require further modeling analysis.

**Building Downwash Wake Effects and Cavity Analysis – AERMOD PRIME**

AERMOD-PRIME was used to evaluate building downwash effects. The purpose was to determine concentrations near the FSRU due to downwash of stack emissions caused by aerodynamic effects of the ship's structure. The locations of maximum concentrations were examined in relationship to an assumed safety and security zone distance of 500 yards. Concentration estimates produced by AERMOD-PRIME, if greater than the maximum concentration estimated from OCD, would be compared to SILevels for criteria pollutants or against the NYSDEC DAR-1 short-term guideline concentration (SGC) and annual guideline concentration (AGC) for ammonia (ammonia is emitted due to use of the SCR for $NO_X$ control). The modeling protocol (*see* Attachment A to the modeling report in Appendix C) discusses the implementation of AERMOD-PRIME for this project.

Important dimensions in this analysis are the length, width, and height of the structures being evaluated for building downwash. The downwash algorithm evaluates downwash for wind directions from 10 to 360 degrees. Building information for each 10-degree sector is calculated by the model's preprocessor program (BPIP-PRIME) and subsequently used in the AERMOD-PRIME evaluation. The width dimension used in the model was based on the combined width of the FSRU with an LNG carrier alongside. The FSRU was modeled as a structure with two tier heights; the second tier in the model described the accommodation area at the aft end of the FSRU. The input data used for the building downwash analysis is described in detail in the modeling report in Appendix C.

Meteorological data for AERMOD-PRIME were prepared using the model's meteorological preprocessor program AERMET. Surface data for Islip, New York, and upper air data from Brookhaven (Upton), New York, were used. The period of record for the meteorological data is December 9, 2004, through December 8, 2005.

Receptors were placed at 25-m spacing along the boundary of the assumed safety and security zone. In addition, a square grid (2.7 km by 2.7km) with receptor locations spaced a maximum of 50 m apart (35 m separation in the north/south and east/west directions, 50 m on the diagonal) extended out from the assumed safety and security zone boundary.

The AERMOD-PRIME results presented in Table 9-15 show higher maximums than when modeled using OCD. Some maximums are shown to be above the applicable SIL. These maxima are located on the assumed safety and security zone boundary. For pollutant and averaging period combinations for which a SIL is exceeded, an additional step in evaluating the impact on ambient air quality is required. Background ambient air concentrations for the New York station listed in Tables 9-2 through 9-6 are added to the maximum concentration and compared to the NAAQS. The results of this comparison are also shown in Table 9-15. No NAAQS are exceeded.

**Table 9-15 AERMOD-PRIME Downwash Results**

| Pollutant | Averaging Period | Significant Impact Level/NAAQS (μg/m$^3$) | AERMOD-PRIME Maximum (μg/ m$^3$) | AERMOD-PRIME Maximum including Background (μg/ m$^3$) (1) | Exceeds SIL/NAAQS? |
|---|---|---|---|---|---|
| Carbon monoxide (CO) | 8-Hour | 500/10,000 | 531 | 3,845 | Y/N |
| | 1-Hour | 2,000/40,000 | 971 | - | N/N |
| Nitrogen dioxide ($NO_2$) | Annual | 1/100 | 2.02 | 24.7 | Y/N |
| $PM_{10}$ | Annual | 1/50 | 1.32 (1$^{st}$ high)<br>1.26 (4$^{th}$ high) | 16.3 | Y/N |
| | 24-Hour | 5/150 | 17.8 | 63.5 | Y/N |
| $PM_{2.5}$ | Annual | 1/15 | 1.32 | 12.5 | Y/N |
| | 24-Hour | 5/65 | 24 | 61 | Y/N |
| Sulfur dioxide ($SO_2$) | Annual | 1/80 | 0.1 | - | N |
| | 24-Hour | 25/365 | 1.5 | - | N |
| | 3-Hour | 5/1,300 | 2.2 | - | N |

**Table 9-15 AERMOD-PRIME Downwash Results**

| Pollutant | Averaging Period | Significant Impact Level/NAAQS (µg/m³) | AERMOD-PRIME Maximum (µg/ m³) | AERMOD-PRIME Maximum including Background (µg/ m³) (1) | Exceeds SIL/NAAQS? |
|---|---|---|---|---|---|
| Ammonia ($NH_3$) | Annual | 100(2) | 1.5 | - | Below AGC |
| | 1-hour | 2,400(2) | 32.6 | - | Below SGC |

Notes:

(1) Background concentrations are shown in Tables 9-2 through 9-6. 2004 data were applied.

(2) Significant concentrations for ammonia taken from NYSDEC DAR-1 guidance, short-term guideline concentration/annual guideline concentration (SGC/AGC) table. The 1-hour maximum impact was compared to SGC, and the annual maximum impact was compared to AGC.

### 9.4.3 Greenhouse Gas Emissions

Combustion of fuels during construction and operation of the Project will result in the emission of $CO_2$, a greenhouse gas. Emissions of $CO_2$ are currently not subject to regulation in the United States. Although there is an initiative in the northeastern United States to develop a regional greenhouse gas regulation (the Regional Greenhouse Gas Initiative), it is currently envisioned to apply only to major electric generating facilities that supply electricity for sale to the electric grid; thus, it would not be applicable to Broadwater.

In order to provide insight into the amount of $CO_2$ that would be generated by the Project, the amount of $CO_2$ emitted on an on-going annual basis was calculated (*see* Table 9-16). Construction activities also will produce temporary $CO_2$ emissions from the operation of various vessels and equipment used during construction. These emissions are shown in Table 9-12.

**Table 9-16 Annual Carbon Dioxide Emissions from Project Sources**

| Source | Tons per Year |
|---|---|
| FSRU | 824,788 |
| Vessel activity(1) | 50,469 |

(1) Vessel activity includes support vessels, LNG carrier transit in and out of the sound, and LNG unloading at the FSRU.

### 9.4.4 Mitigation

As discussed in Section 9.3.1, certain emission sources of the ozone-forming pollutants $NO_X$ and VOCs are evaluated under the General Conformity rule because the Project area is in nonattainment for ozone. Similarly, direct emission of $PM_{2.5}$ and $PM_{2.5}$ precursors are also subject to evaluation under General Conformity because the Project area is nonattainment for $PM_{2.5}$. Projected emissions from direct and indirect sources not subject to air permitting are considered in this analysis. As shown in Section 9.4.1, construction activities during each year of the two-year construction period are estimated to result in $NO_x$ emissions that will exceed the *de minimis* threshold for applicability of the General Conformity rule. Construction emissions will occur during the winter construction period. Thus, construction activities will not contribute to ozone precursor emissions during the May 15 through September 15 ozone control period as long as construction occurs as planned.

Vessel activity during operation of the facility is shown to result in annual $NO_x$ and $SO_2$ emissions above the *de minimis* thresholds for these pollutants (assuming $SO_2$ is regulated as a precursor compound for $PM_{2.5}$ formation). Direct emissions of $PM_{2.5}$ (using $PM_{10}$ as a surrogate) are below *de minimis* thresholds. As required by the General Conformity rule, emissions above the *de minimis* threshold will require an evaluation of mitigation options as part of a full General Conformity analysis. As lead federal agency for the Project, FERC conducts the full General Conformity determination parallel to the Environmental Impact Statement (EIS) process. FERC will utilize emission estimates prepared for this Resource Report in its General Conformity analysis. The magnitude and potential impact of the emissions will be evaluated, and a determination will be made regarding whether mitigation is necessary. Mitigation for construction $NO_x$ emissions should not be necessary if the two-year construction period emissions occur during the winter months (i.e., outside of the summer ozone control period) or can be accommodated in the air quality region's emission budget. However, if EPA decides to also regulate $NO_x$ as a precursor emission compound for $PM_{2.5}$ formation, mitigation may be required to meet General Conformity requirements for $PM_{2.5}$ nonattainment areas. If mitigation is required, the acquisition of offsets during the two-year construction period or the use of other mitigation measures may be prescribed. Annual vessel activity emissions will also be evaluated in the General Conformity determination by FERC. These emissions will be subject to mitigation if they cannot be accommodated in the AQCR emission budget.

Ambient air quality impacts from operation of the FSRU are not above air quality impact thresholds and, therefore, do not require mitigation beyond the emission controls already applied to the FSRU. The FSRU will be operated under an air quality stationary source permit issued by NYSDEC. The permit will prescribe recordkeeping and reporting requirements that will be used to demonstrate compliance with permit conditions.

## 9.5 NOISE IMPACT EVALUATION

### 9.5.1 New York State Regulations

No promulgated noise regulations are applicable state-wide in New York. However, NYSDEC has issued a noise guidance document that is used as part of the SEQRA process to evaluate a project's potential noise impact (Program Policy DEP-00-1 Revised: June 3, 2003, Assessing and Mitigating Noise Impacts). This guidance serves to identify when noise levels may cause a significant environmental impact and gives methods for noise impact assessment, avoidance, and reduction measures. Under this policy, sound pressure increases of more than 6 decibels over the baseline conditions may require a closer analysis of impact potential, depending on existing sound pressure levels

(SPLs) and the character of surrounding land use and receptors. Appropriate receptor locations may be either at the property line of the parcel on which the facility is located (or in this case the edge of the assumed safety and security zone) or at the location of use or inhabitance on adjacent property (i.e., the shoreline).

### 9.5.2 Existing Noise Levels

The proposed facility location is approximately 9 miles from the New York shore and 10 miles from the Connecticut shore. The ambient sound level of a region is defined by the total noise generated, including sounds from both natural and artificial sources. The magnitude and frequency of environmental noise may vary considerably over the course of the day and throughout the week, due in part to changing weather conditions affecting wind and wave activity. Typically, ambient airborne noise levels over ocean areas are in the range of 50 to 55 A-weighted decibels (dBA) (NAWCWD 2002). Other contributors to short-term noise levels include airplanes, helicopters, and commercial shipping traffic.

### 9.5.3 Identification of Noise-Sensitive Areas

Due to the distance from the FSRU to onshore communities, the most sensitive onshore receptors (e.g., schools, churches, and hospitals) will not be affected.

### 9.5.4 Projected Facility Noise Levels

#### FSRU

The FSRU will utilize power-generating equipment, pumps, compressors, and other rotating equipment that create noise. Sound pressure levels at a distance of 3.3 feet (1 m) are listed in Table 9-17 for the major noise-producing equipment to be installed on the FSRU. The sources were combined using the following formula:

$$Leq_{total} = 10\log\left(10^{\frac{Leq_1}{10}} + 10^{\frac{Leq_2}{10}} + 10^{\frac{Leq_3}{10}} ...etc.\right)$$

**Table 9-17 FSRU Equipment Noise Summary**

| FSRU Equipment Description | Location | Initial SPL(1) (dBA) | TL (dB) | Reduced SPL (dBA) | All Units Combined (dBA) |
|---|---|---|---|---|---|
| Process heaters (3) | Below deck | 85 | 10 | 75 | 80 |
| Boil-off gas compressors (3), housed | Above deck | 95 | 20 | 75 | 80 |
| High-pressure LNG pumps (8) | Above deck | 94 | 10 | 84 | 93 |
| Ballast water pumps (4) | Below deck | 87 | 30 | 57 | 62 |
| Cooling water circulation pumps (4) | Below deck | 78 | 30 | 48 | 54 |
| Nitrogen system air compressors (2) | Above deck | 110 | --- | 110 | 113 |

**Table 9-17 FSRU Equipment Noise Summary**

| FSRU Equipment Description | Location | Initial SPL[1] (dBA) | TL (dB) | Reduced SPL (dBA) | All Units Combined (dBA) |
|---|---|---|---|---|---|
| 20-MW gas turbines (2) air intake/exhaust | Above deck | 95 | --- | 95 | 98 |
| LNG transport vessel (1) | --- | 90 | --- | 90 | 90 |
| | | Combined SPL for Sources | | | 113 |

(1) At a distance of 1 meter.

Source: USCG 2004.

Key:
dBA = Decibels, A scale.
SPL = Sound pressure level.
TL = Transmission loss through deck or enclosure.

Although a helicopter deck will be located on the stern of the FSRU, helicopters will be used only during emergencies (e.g., an evacuation for emergency medical treatment). Therefore, a noise impact analysis for helicopter use has not been included in this evaluation.

Atmospheric noise modeling was conducted to reflect the reduction of sound levels over distance due to hemispherical spreading. The modeling was conducted in spreadsheet format using the following equation for noise reduction over distance:

$$L_2 \bullet L_1 \bullet 20\log \left( \frac{d_2}{d_1} \right)$$

where $d_1$ is starting distance, $d_2$ is ending distance, $L_1$ is noise level at distance $d_1$ and $L_2$ is noise level at distance $d_2$.

Table 9-18 presents the projected noise levels at various distances from the FSRU.

As discussed previously, ambient noise levels would typically be 50 to 55 dBA in the vicinity of the proposed FSRU. Given this background level and the predicted noise from the operation of the FSRU of 50 dBA at 0.9 mile (1,500 m), the operating noise will not normally be noticeable 1 mile (1.9 km) or more from the FSRU. However, based on the equipment noise levels presented in Table 9-17, at distances of less than 0.9 mile (1,500 m), the operating noise may become noticeable (i.e., it may produce a 3 dBA increase above background noise levels), and at less than 820 feet (250 m), it may be at or above ~65 dBA and begin to interfere with normal conversation volume (i.e., cause speech to be conducted at slightly higher volume than during normal conversation). At the boundary of the assumed 500-yard safety and security zone around the FSRU, the level would be 60 dBA.



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Table 9-18 Projected Sound Levels

| FSRU Equipment Description | Sound Pressure Level (dBA) 1 Meter | 250 Meters | 500 Meters (Yards)(1) | 1,000 Meters | 1,500 Meters |
|---|---|---|---|---|---|
| Process heaters | 80 | 32 | 26 (27) | 20 | 16 |
| Boil-off gas compressors, housed | 80 | 32 | 26 (27) | 20 | 16 |
| Submerged LNG high-pressure pumps | 93 | 45 | 39(40) | 33 | 30 |
| Ballast water pumps | 60 | 12 | 6 (7) | 0 | 0 |
| Cooling water circulation pumps | 54 | 6 | 0 (1) | 0 | 0 |
| Nitrogen system air compressors | 113 | 65 | 59 (60 | 53 | 49 |
| 20 MW Gas Turbines (Air Intake/Exhaust) | 98 | 50 | 44 (45) | 38 | 34 |
| LNG carrier | 90 | 42 | 36 (37) | 30 | 26 |
| Combined Sound Pressure Level | 113 | 65 | 60 (60) | 53 | 50 |

(1) Values shown in parentheses are sound pressure levels at the assumed safety zone boundary.

Foghorns installed on each end of the FSRU will generate warning signals at 146 dBA (100 hertz) at 3.3 feet (1 m), as required by USCG regulation 33 CFR 67.10. This level is required in order for the foghorn to be audible at 2 miles (3.2 km). In addition, the device must sound a 2-second blast every 20 seconds during low-visibility conditions (i.e., visibility less than 2 miles [3.2 km]). The foghorn sound level onshore will be barely audible over background onshore noise levels (barely audible is approximately 3 dBA above background levels); therefore, it will not have a significant impact on onshore noise receptors. An additional standby foghorn will be installed on each end of the FSRU that will be audible at 0.5 mile from the FSRU. The foghorn would not be audible onshore.

#### LNG Carriers

The contribution of LNG carriers to existing shipping noise will be insignificant. Transiting LNG carriers are designed to operate at decibel levels specified to be 90 dBA or less at 1 meter above the deck. LNG carriers moored at the proposed FSRU will emit similar noise levels during offloading operations and will not affect human receptors onshore.

### 9.5.5 Construction Noise Assessment

The construction equipment used to install the offshore FSRU and pipeline will consist of typical offshore vessels such as crane barges, tug boats, supply vessels, remotely operated vehicles, and surveying equipment. Commercial, fishing, and recreational vessels transit the area regularly. The crews of these vessels could encounter the construction vessels or be passed by a supply vessel. These boaters would not be particularly susceptible to additional noise because engine noise from their own vessels will dominate. However, recreational boaters in sailboats or other non-powered vessels could be impacted by the increased noise associated with construction. Because there are so many commercial vessels in the area, most of these boaters would be accustomed to encountering the noise associated with commercial vessels. Recreational boaters could easily avoid the construction area, and all boaters would be transient; therefore, this impact will not likely be significant.

Construction equipment used to install the proposed Project will be operated on an as-needed basis and maintained to the manufacturers' specifications in order to minimize noise impacts. The construction noise will have a direct, short-term, minor adverse impact on sound levels in the vicinity of the construction activities; however, it will not affect human receptors onshore, since the Project area will be located far offshore. Increased noise levels and vessel traffic will result from construction of the proposed facilities.

During installation of the tower structure, conventional pile driving will be used above the water surface to install the system's four legs. One leg will be driven at a time, and each leg will take approximately one week to install. Pile driving will be limited to 12 hours per day and will not occur during the night. A typical unquieted impact-type pile driver produces a peak impact level of about 101 dBA at 50 feet (EPA 1971). Due to the distances to the nearest residential noise sensitive areas, there will be no noise contribution from the pile-driving activities (i.e., pile driving would not be perceptible).

However, recreation boaters in sailboats or other non-powered vessels could be impacted by the pile driving. Due to the impulsive characteristics of pile driver noise, there is heightened potential for annoyance during the pile-driving period. Recreational boaters can easily avoid the construction area, and all boaters will be transient; therefore, this impact will likely not be significant.

### 9.5.6 Conformance with NYSDEC Program Policy DEP-00-1

The NYSDEC Policy on Assessing and Mitigating Noise Impacts (Program Policy DEP-00-1) was developed to assess the noise impacts of proposed sources to receptors of a more permanent nature, as would be found on land in the form of residences, schools, parks, or, as stated in the policy, "When lands adjoining an existing or proposed facility contain residential, commercial, institutional or recreational uses that are proximal to the facility, noise is likely to be a matter of concern to residents or users of adjacent lands." As indicated in the policy, "appropriate receptor locations may be either at the property line of the parcel on which the facility is located or at the location of use or inhabitance on adjacent property."

There will be no contribution or noise impact at any of these type of receptors located on land due to the distance between the FSRU and the shoreline. Although there are no permanent residents offshore, commercial fishing and recreational vessels transit the area. Occupants of these vessels would not be particularly susceptible to additional noise because engine noise from their own vessels would dominate. However, recreational boaters in sailboats or other non-powered vessels could be impacted by the increased noise associated with construction or operation of the Project. Occupants of sailboats or other non-motorized vessels transiting the area will potentially notice operational noise levels only if they operated along the assumed safety zone boundary or within a few hundred meters of the boundary. Table 9-18 shows that sound pressure levels at 1,500 meters are within the range of background sound levels referenced in Section 9.5.2. The impact will be transitory because non-motorized boaters likely will not remain in the area for extended time periods.

### 9.5.7 Noise Mitigation Measures

#### Construction

The mitigation measures described in this section will be employed to reduce construction-related noise. These measures will reduce the impact on non-motorized recreational boaters and fishermen in the area. Construction equipment will be operated on an as-needed basis only during the construction period and maintained to the manufacturer's specifications. Equipment engine covers will be in place and mufflers will be in good working condition during installation of the tower structure, FSRU, and offshore pipeline. Delivery of crews and materials will follow normal vessel routes that avoid sensitive receptors, and the number of trips to bring crews to the construction site will be limited by utilizing the full capacity of shuttles as much as possible.

#### Facility Operation

During operation of the FSRU, some equipment will be located below deck and enclosures will be used on certain equipment to reduce noise emissions. By implementing these controls, noise generated on the FSRU should be reduced such that only boaters just outside the boundary of the assumed safety and security zone may notice the increased noise but will not be adversely affected by it. The projected sound levels shown in Table 9-18 at and beyond 500 yards would likely not be noticed onboard a boat due to the sound generated by its own engine. Shuttle vessels can be operated during daytime hours in order to limit adverse impacts near shore. The number of trips can be limited by utilizing the full capacity of shuttles as much as possible.

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# APPENDIX A

# CONSTRUCTION EMISSIONS STUDY

BROADWATER

# BROADWATER ENERGY

## Air Emissions for Pipeline Installation Equipment

**Document No.: BE-P-ECI-8213**

PCS®

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| B | 9/29/05 | For Client Review- Revised Info. | MPF | JHR | DT |
| A | 8/04/05 | For Client Review | MPF | HS | DT |
| Issue | Date | Description | Preparer | QA Check | Approval |

PUBLIC

## Table of Contents

# 1.0 Calculation Summary

## 1.1 MMS Spreadsheet Background

The air emission estimation is based on the calculations performed on a published spreadsheet prepared by the Department of the Interior, Mineral Management Service (MMS). This spreadsheet was initially developed to estimate the emissions for oil and gas production facilities. Depending on the area of construction, the MMS requires an estimate of the emissions for pipeline construction. Therefore, this spreadsheet was customized to prepare the estimate of emissions for the construction of the Broadwater pipeline. The focal part of the spreadsheet is the calculation page of annual air emission. This spreadsheet is separated into distinct pages to provide the total tonnage of air emissions per calendar year. On each page, five types of air emissions are calculated and tabulated. Each of these pages, labeled "EMISSIONS", uses a common set of emission factors based on the horsepower of each piece of equipment. The factors used in the calculation of emissions come from the latest AP-42 (Compilation of Air Pollutant Emission Factors prepared by the US Environmental Protection Agency) references or from industry standards.

## 1.2 Data Entry into Air Emissions Calculations

The items of data necessary to complete the spreadsheet are the number and type of equipment on a vessel that will produce emissions, the horsepower of the equipment to be used, the number of hours per day, and the number of days (per calendar year) that the equipment will be used. After inputting these values, the spreadsheet calculates the air emissions in maximum pounds per hour and estimated tons (per calendar year). To calculate these values, the factors described above are used. It should be noted that the factors used in these calculations should be adjusted for the horsepower of one engine. For instance, if a vessel has two engines with a total horsepower of 1,400 HP, the correct factors to use would be the factors for an engine with greater than 600 HP (one engine has 700 HP). But, if a vessel has two engines with a total combined horsepower of 1,000 HP, the factors used should be the factors for an engine with less than 600 HP (one engine has 500 HP). The spreadsheet allows for the change of factors by altering the formula in the corresponding row of cells.

The number, type, and use of the vessels contained in the air emissions calculations in Appendix B are from the latest revision of the Vessel Summary. The Vessel Summary is contained in Appendix A. The first emissions page of the spreadsheet details the equipment and work for the Year 1. The second emissions page details the equipment and work for the Year 2. The third emissions page details the optional dredging and backfilling for the pipeline (in Year 2) if plowing cannot be performed across the Middle Shoal. The dredging emissions are separated from the main emission calculations because this work may not be done and therefore presented as an option. The fourth emissions page details the backfilling of the pipeline route option that would coincide with the lowering of the pipeline along the route (in Year 2). These emissions are separated from the main emission calculations because the backfilling may not be done and is therefore presented as an option.

Refer to the summary page of the spreadsheet located in Appendix B for the estimated pipeline construction equipment air emissions as calculated using the MMS-provided emission factors and formulas.

**Appendix A –**
**Vessel Summary**

**Broadwater Energy Pipeline Construction Vessel Operation Chart**
rev E
(modified for Optional Activities- 092905)

| Activity | DURATION FOR VESSEL | Diving Support Vessel | | Lay Barge | | Anchor Handling Tug | | Support Vessel | | Pipe Hauler Tug | | Material Hauler Tug | | Survey | | Security Vessel | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Security | 446 | | 0 | | 0 | | 0 | 1 | 446 | | 0 | | 0 | | 0 | 1 | 446 |
| IGTS Hot-Tap Installation (Excavation, Installation, and Protection) | 14 | 1 | 14 | | 0 | | 0 | 1 | 14 | | 0 | 1 | 14 | | | | |
| Survey Vessel | 172 | | 0 | | 0 | | 0 | 1 | 172 | | 0 | | 0 | 1 | 172 | | 0 |
| Prelay Diving Operations | 22 | 1 | 22 | | 0 | | 0 | 2 | 44 | | 0 | 1 | 22 | | 0 | | 0 |
| Pipelay Operations | 42 | | 0 | 1 | 42 | 2 | 84 | 2 | 84 | 6 | 252 | | 0 | | 0 | | 0 |
| Pipeline Lowering | 41 | | 0 | 1 | 41 | 2 | 82 | 2 | 82 | | 0 | | 0 | | 0 | | 0 |
| Hot-Tap Connecting Spool (Spool #1) with Lay Barge | 5 | | 0 | 1 | 5 | 2 | 10 | 2 | 10 | | 0 | 1 | 5 | | 0 | | 0 |
| FSRU Pipeline Tie-in Spool (Spool #3) with Lay Barge | 4 | | 0 | 1 | 4 | 2 | 8 | 2 | 8 | | 0 | 1 | 4 | | 0 | | 0 |
| Crossing Completion and Cover Placement | 15 | 1 | 15 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| Additional Construction Requirements | 22 | 1 | 22 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| Filling, Treating, and Cleaning | 8 | 2 | 16 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| Check and Isolation Valve Spool (Spool #4) | 12 | 1 | 12 | | 0 | | 0 | 1 | 12 | | 0 | 1 | 12 | | 0 | | 0 |
| Hydrostatically Test Pipeline with Treated Water | 3 | 2 | 6 | | 0 | | 0 | 2 | 6 | | 0 | | 0 | | 0 | | 0 |
| Acceptance of Hydrostatic Test | 1 | 2 | 2 | | 0 | | 0 | 2 | 2 | | 0 | | 0 | | 0 | | 0 |
| IGTS Pipeline Tie-in Spool (Spool #2) | 10 | 1 | 10 | | 0 | | 0 | 1 | 10 | | 0 | 1 | 10 | | 0 | | 0 |
| FSRU Tie-in (Spool #1 and Spool #2) | 15 | 1 | 15 | | 0 | | 0 | 1 | 15 | | 0 | 1 | 15 | | 0 | | 0 |
| Dewatering & Drying (Pre-Commissioning and Commissioning) | 21 | 2 | 42 | | 0 | | 0 | 2 | 42 | | 0 | | | | 0 | | 0 |
| | | | | | | | | | | | | | | | 0 | | 0 |
| | **DAYS:** | **176** | | **92** | | **184** | | **947** | | **252** | | **82** | | **172** | | **446** | |
| **Optional Activities** | | | | | | | | | | | | | | | | | |
| Backfilling | 34 | | | 1 | 34 | 1 | 34 | 1 | 34 | | | | | | | | |
| | | | | | | | | | | **Dredging Vessel** | | **Hopper Barge /Tug** | | | | | |
| Dredging | 20 | 1 | 20 | | | | | 1 | 20 | 1 | 20 | | | 1 | 20 | | |
| Backfilling (from Dredging) | 20 | | | | | | | | | | | 2 | 40 | 1 | 20 | | |

| Vessel Type | Vessel Name |
|---|---|
| Diving Support Vessel | Defender |
| Lay Barge | DLB 801 |
| Ocean Transport Tug | M/V Provider 1800 |
| Anchor Handling Tug | M/V Crosby Pride 1200 |
| Support Vessel | Multiple |
| Security Vessel | Multiple |
| Pipe Hauler Tug | M/V Aaron Joseph 1000 |
| Material Hauler Tug | M/V Aaron Joseph 1000 |
| Survey Vessel | R/V Connecticut |

* Listing company and vessel name is soley to describe in detail the type of vessel used in that operation. It by no means insinuates they will be choosen or given favor for the work.

**Appendix B –**
**MMS Spreadsheet for Calculation of Air Emissions in the Gulf of Mexico**

# GULF OF MEXICO AIR EMISSION CALCULATIONS INSTRUCTIONS

## General

This document (DOCD_AQ.XLS) was prepared through the cooperative efforts of those professionals in the oil industry including the API/OOC Gulf of Mexico Air Quality Task Force, and the Minerals Management service (MMS), who deal with air emission issues. This document is intended to

standardize the way we estimate our potential air emissions for Development Operations Coordination Documents (DOCD) approved by the Minerals Management Service (MMS). It is intended to be thorough but flexible to meet the needs of different operators. This first file gives the basis for the emission factors used in the emission spreadsheet as well as some general instructions.
The following files, Title Sheet, Factors Sheet,Emissions Spreadsheet,and Summary Sheet will describe and calculate emissions from an activity.

## Title Sheet

The Title Sheet requires input of the company's name, area, block, OCS-G number, platform and/or well(s) in the necessary lines. This data will automatically be transferred to the spreadsheet and summary sheet.

## Factor Sheet

The emission factors were compiled from the latest AP-42 references or from industry studies if no AP-42 reference was available. Factors can be revised as more data becomes available. A change to this Factor Sheet will be automatically changed in Emission Spreadsheet. A sulfur content table was added in 1996. A change in this table will automatically revise the SOx factor which will revise emissions.

The basis for the factors is as follows:

1. NG Turbines Fuel usage scf/hr = HP X 9.524 (10,000 btu/HP-hr / 1050 btu/scf)
2. NG Engines Fuel usage scf/hr = HP X 7.143 (7,500 btu/HP-hr / 1050 btu/scf)
3. Diesel Fuel usage gals/hr = HP X 0.0483 (7,000 btu/HP-hr / 145,000 btu/gal)

<u>Emission Factors</u>

*Natural Gas Prime Movers*

1. TNMOC refers to total non-methane organic carbon emissions and these can be assumed equivalent to VOC emissions.

2. The sulfur content assumed is 2000 grains /mmscf (3.33 ppm). If your concentration is different then revise the ppm in the sulfur table immediately below the factors table.

*Diesel-Fired Prime Movers*

1. Diesel sulfur level 0.4% by wt. If your sulfur content is different change % wt. in the sulfur table.

2. For boats use > 600 HP factors based on AP-42 Vol. II, Table II-3-3.

   Those figures closely match the above values. Include the emissions from all vessels associated with your activities for their time of operation within a 25 mile radius of your facility.

3. For diesel engines <600 HP VOC emissions equal total HC emissions; for diesel engines>600 HP VOC emissions equal non-methane HC emissions.

*Heaters/Boilers/Firetubes/NG-Fired*

1. The assumed NG Sulfur content is 2000 gr. per mcf(3.33 ppm). You may revise the sulfur content by changing the ppm in the sulfur table, if your content is different.

2. The VOCs emissions are based on total non-methane HCs.

*Gas Flares*

1. It is assumed that the flare is non-smoking.

2. A heating value of 1050 btu/cu. ft. for NG is assumed.

3. The sulfur content assumed is 2000 grains /mmscf (3.33 ppm). If your concentration is different then revise the ppm in the sulfur table, or you may use the following formula:

   H2S flared (lbs/hr) = Gas flared (cu ft/hr) X ppm H2S X 34/(379X1000000)

   SOx emis (lbs/hr) = H2S flared (lbs/hr) X 64/34

*Liquid Flares*

1. Assumes 1% by wt sulfur maximum in the crude oil. Revise the percent sulfur in the sulfur table if your value is different.

2. VOCs equal non-methane HCs

3. Particulate emissions assumes Grade 5 oil.

*Tanks*

1. Tank emissions assumes uncontrolled fixed roof tank.

2. The EPA TANKS model is an acceptable alternative. If you use TANKS you must provide sufficient information for MMS to verify your results.

*Fugitives*

1. Fugitives are based on the 1995 Star Environmental Report. It requires that you count or estimate your components. The factor is based on average leak rate for light oil / gas facility.

*Glycol Dehydrator Vent*

1. The rate of the gas being dehydrated (throughput) in SCF/HR must be entered in the spreadsheet.

   The emission factor is from the compilation of the Louisiana Survey and an average emissions per gas rate.

*Gas Venting*

1.The emission factor is based on venting unburned natural gas of average weight.

**Emissions Spreadsheets (EMISSIONS1 through EMISSIONS5)**

The emissions from an operation should be presented for a calendar year (1999, 2000, etc.). The operation may include production only or production in conjunction with other activities such as drilling or construction operations. For additional years the Emissions Spreadsheet is renamed Emissions 2, 3, etc. The different operating parameters for each year should be entered to calculate revised emissions for that year. The spreadsheet will calculate maximum fuel usage (UNIT/HR) using the known horsepower. It will assume maximum fuel usage is equal to actual fuel (UNIT/DAY) usage unless the actual fuel usage is known. If so, insert actual fuel usage in appropriate column. The emissions will be calculated calculated as follows:

Emission rate (lb/hr) = (HP or fuel rate) X Emission Factor (Potential to emit)

Emissions (tpy)=Emission rate (lb/hr) X load factor( Act Fuel/Max Fuel) X hrsX daysX ton/2000 lbs

(Actual emissions)

To customize the spreadsheet for your application it is possible to delete lines for non-applicable equipment/activities or copy/insert an entire line if more than one similiar type of equipment is present.

Also, the production equipment can be customized further by adding the use of the equipment behind each type of engine, i.e.,

PUBLIC

BW002284

Turbine
Turbine - Gas Compressor

Burner
Burner - Line Heater

**Summary Sheet**

The Summary Sheet is designed to show a proposed estimate of emissions from an activity over a future period of time. In this example ten years was chosen. The first line (Row 7) of the

summary sheet is linked to the yearly totals in the Emissions1 Spreadsheet. The second line (Row 8)

is referenced to Emissions2 Spreadsheet. The third line (Row 9) is referenced to Emissions3, Row 10 to Emissions 4, Row 11 to Emissions 5. If more years of calculations are necessary to reach a constant then a spreadsheet can be copied and linked to the summary sheet for future years. Once emissions are constant the values are carried to the end of the ten year period.

The **Paperwork Reduction Act of 1995** (44 U.S.C. Chapter 35) requires us to inform you that MMS collects this information as part of an applicant's DOCD submitted for MMS approval. We use the information to facilitate our review and data entry for OCS plans. We will protect proprietary data according to the Freedom of Information Act and 30 CFR 250.196. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid Office of Management and Budget (OMB) control number. Responses are mandatory. The reporting burden for this form is included in the burden for preparing DOCDs. We estimate that burden to average 580 hours per response, including the time for reviewing instructions, gathering and maintaining the data, and completing and reviewing the form. Direct comments on the burden estimate or any other aspect of this form to the Information Collection Clearance Office, Mail Stop 4230, Minerals Management Service, 1849 C Street, N. W., Washington, DC 20240.

## DOCD AIR QUALITY SCREENING CHECKLIST

OMB Control No. 1010-0049
OMB Approval Expires: August 31, 2006

| | |
|---|---|
| **COMPANY** | Broadwater Energy |
| **AREA** | Long Island Sound, New York |
| **BLOCK** | N/A |
| **LEASE** | N/A |
| **PLATFORM** | Floating Storage Regasification Unit |
| **WELL** | N/A |
| **COMPANY CONTACT** | Stephen Marr |
| **TELEPHONE NO.** | |
| **REMARKS** | 30 Inch Pipeline Installation |

| **LEASE TERM PIPELINE CONSTRUCTION INFORMATION:** | | |
|---|---|---|
| YEAR | NUMBER OF PIPELINES | TOTAL NUMBER OF CONSTRUCTION DAYS |
| 1 | 1 | 81 |
| 2 | 1 | 365 |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# AIR EMISSION COMPUTATION FACTORS

| Fuel Usage Conversion Factors | Natural Gas Turbines | | Natural Gas Engines | | Diesel Recip. Engine | | REF. | DATE |
|---|---|---|---|---|---|---|---|---|
| | SCF/hp-hr | 9.524 | SCF/hp-hr | 7.143 | GAL/hp-hr | 0.0483 | AP42 3.2-1 | 4/76 & 8/84 |

| **Equipment/Emission Factors** | units | PM | SOx | NOx | VOC | CO | REF. | DATE |
|---|---|---|---|---|---|---|---|---|
| NG Turbines | gms/hp-hr | | 0.00247 | 1.3 | 0.01 | 0.83 | AP42 3.2-1& 3.1-1 | 10/96 |
| NG 2-cycle lean | gms/hp-hr | | 0.00185 | 10.9 | 0.43 | 1.5 | AP42 3.2-1 | 10/96 |
| NG 4-cycle lean | gms/hp-hr | | 0.00185 | 11.8 | 0.72 | 1.6 | AP42 3.2-1 | 10/96 |
| NG 4-cycle rich | gms/hp-hr | | 0.00185 | 10 | 0.14 | 8.6 | AP42 3.2-1 | 10/96 |
| | | | | | | | | |
| Diesel Recip. < 600 hp. | gms/hp-hr | 1 | 1.468 | 14 | 1.12 | 3.03 | AP42 3.3-1 | 10/96 |
| Diesel Recip. > 600 hp. | gms/hp-hr | 0.32 | 1.468 | 11 | 0.33 | 2.4 | AP42 3.4-1 | 10/96 |
| Diesel Boiler | lbs/bbl | 0.084 | 2.42 | 0.84 | 0.008 | 0.21 | AP42 1.3-12,14 | 9/98 |
| | | | | | | | | |
| NG Heaters/Boilers/Burners | lbs/mmscf | 7.6 | 0.593 | 100 | 5.5 | 84 | P42 1.4-1, 14-2, & 14 | 7/98 |
| NG Flares | lbs/mmscf | | 0.593 | 71.4 | 60.3 | 388.5 | AP42 11.5-1 | 9/91 |
| Liquid Flaring | lbs/bbl | 0.42 | 6.83 | 2 | 0.01 | 0.21 | AP42 1.3-1 & 1.3-3 | 9/98 |
| Tank Vapors | lbs/bbl | | | | 0.03 | | E&P Forum | 1/93 |
| Fugitives | lbs/hr/comp. | | | | 0.0005 | | API Study | 12/93 |
| Glycol Dehydrator Vent | lbs/mmscf | | | | 6.6 | | La. DEQ | 1991 |
| Gas Venting | lbs/scf | | | | 0.0034 | | | |

| **Sulfur Content Source** | **Value** | **Units** |
|---|---|---|
| Fuel Gas | 3.33 | ppm |
| Diesel Fuel | 0.4 | % weight |
| Produced Gas( Flares) | 3.33 | ppm |
| Produced Oil (Liquid Flaring) | 1 | % weight |

## AIR EMISSION CALCULATIONS - FIRST YEAR

| COMPANY | AREA | BLOCK | LEASE | PLATFORM | | | WELL | CONTACT | | PHONE | REMARKS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broadwater Energy | Long Island Sound, New York | N/A | N/A | Floating Storage Regasification Unit | | | N/A | Stephen Marr | | | #REF! | | | | | |
| OPERATIONS | EQUIPMENT | RATING | MAX. FUEL | ACT. FUEL | RUN TIME | | MAXIMUM POUNDS PER HOUR | | | | | ESTIMATED TONS | | | | |
| | Diesel Engines | HP | GAL/HR | GAL/D | | | | | | | | | | | | |
| | Nat. Gas Engines | HP | SCF/HR | SCF/D | | | | | | | | | | | | |
| | Burners | MMBTU/HR | SCF/HR | SCF/D | HR/D | DAYS | PM | SOx | NOx | VOC | CO | PM | SOx | NOx | VOC | CO |
| DRILLING | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER diesel | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | AUXILIARY EQUIP<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(tugs) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PIPELINE INSTALLATION | | | | | | | | | | | | | | | | |
| **Security** | **Security Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 24 | 81 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 1.07 | 1.57 | 14.99 | 1.20 | 3.24 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 81 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.27 | 0.39 | 3.75 | 0.30 | 0.81 |
| **Survey Support** | **Survey Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 825 | 39.8475 | 956.34 | 24 | 56 | 0.58 | 2.67 | 19.99 | 0.60 | 4.36 | 0.39 | 1.79 | 13.43 | 0.40 | 2.93 |
| | Bow Thruster | 205 | 9.9015 | 237.64 | 24 | 56 | 0.45 | 0.66 | 6.32 | 0.51 | 1.37 | 0.30 | 0.45 | 4.25 | 0.34 | 0.92 |
| | Generators (2) | 125 | 6.0375 | 144.90 | 24 | 56 | 0.28 | 0.40 | 3.85 | 0.31 | 0.83 | 0.19 | 0.27 | 2.59 | 0.21 | 0.56 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 56 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.19 | 0.27 | 2.59 | 0.21 | 0.56 |
| **IGTS Hot Tap Installation** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 14 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.50 | 2.28 | 17.10 | 0.51 | 3.73 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 14 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.19 | 0.87 | 6.51 | 0.20 | 1.42 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 14 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.14 | 0.65 | 4.88 | 0.15 | 1.07 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 14 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.12 | 0.18 | 1.73 | 0.14 | 0.37 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 14 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.02 | 0.03 | 0.27 | 0.02 | 0.06 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 14 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.05 | 0.07 | 0.65 | 0.05 | 0.14 |
| **Prelay Diving Operations** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 22 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.78 | 3.59 | 26.87 | 0.81 | 5.86 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 22 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.30 | 1.37 | 10.23 | 0.31 | 2.23 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 22 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.22 | 1.02 | 7.68 | 0.23 | 1.67 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 22 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.19 | 0.28 | 2.71 | 0.22 | 0.59 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 22 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.03 | 0.04 | 0.43 | 0.03 | 0.09 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 22 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.07 | 0.11 | 1.02 | 0.08 | 0.22 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 22 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.07 | 0.11 | 1.02 | 0.08 | 0.22 |
| **Pipeline Construction Operations** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 34 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.58 | 2.64 | 19.77 | 0.59 | 4.31 |
| | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 34 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.45 | 0.66 | 6.29 | 0.50 | 1.36 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 34 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.12 | 0.18 | 1.70 | 0.14 | 0.37 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 34 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.06 | 0.26 | 1.98 | 0.06 | 0.43 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 34 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.34 | 0.50 | 4.78 | 0.38 | 1.03 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 34 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.40 | 0.59 | 5.66 | 0.45 | 1.23 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 34 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.26 | 1.19 | 8.90 | 0.27 | 1.94 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 34 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.26 | 1.19 | 8.90 | 0.27 | 1.94 |
| | **Pipe Hauler Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |
| | **Pipe Hauler Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |
| | **Pipe Hauler Tug 3** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |
| | **Pipe Hauler Tug 4** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |
| | **Pipe Hauler Tug 5** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Pipe Hauler Tug 6** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 34 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.30 | 0.44 | 4.19 | 0.34 | 0.91 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 34 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.05 | 0.07 | 0.66 | 0.05 | 0.14 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 34 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.11 | 0.16 | 1.57 | 0.13 | 0.34 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 34 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.11 | 0.16 | 1.57 | 0.13 | 0.34 |
| FACILITY | DERRICK BARGE diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INSTALLATION | MATERIAL TUG diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PRODUCTION | RECIP.<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | SUPPORT VESSEL diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TURBINE nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.2 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle rich nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER nat gas | 0 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **MISC.** | **BPD** | **SCF/HR** | **COUNT** | | | | | | | | | | | | |
| | TANK- | 0 | | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FLARE- | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | PROCESS VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FUGITIVES- | | | 0.0 | | 0 | | | | 0.00 | | | | | 0.00 | |
| | GLYCOL STILL VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| DRILLING | OIL BURN | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WELL TEST | GAS FLARE | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | **YEAR 1 TOTAL** | | | | | | **52.90** | **121.24** | **1025.26** | **58.00** | **222.74** | **9.86** | **25.94** | **212.92** | **10.72** | **46.30** |
| **EXEMPTION CALCULATION** | **DISTANCE FROM LAND IN MILES** | | | | | | | | | | | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | 0.0 | | | | | | | | | | | | | | | |



PUBLIC

# AIR EMISSIONS CALCULATIONS - SECOND YEAR

| COMPANY | AREA | BLOCK | LEASE | PLATFORM | | | WELL | CONTACT | | PHONE | REMARKS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broadwater Energy | Long Island Sound, New York | N/A | N/A | Floating Storage Regasification Unit | | | N/A | Stephen Marr | | | #REF! | | | | | |
| OPERATIONS | EQUIPMENT | RATING | MAX. FUEL | ACT. FUEL | RUN TIME | | MAXIMUM POUNDS PER HOUR | | | | | ESTIMATED TONS | | | | |
| | Diesel Engines | HP | GAL/HR | GAL/D | | | | | | | | | | | | |
| | Nat. Gas Engines | HP | SCF/HR | SCF/D | | | | | | | | | | | | |
| | Burners | MMBTU/HR | SCF/HR | SCF/D | HR/D | DAYS | PM | SOx | NOx | VOC | CO | PM | SOx | NOx | VOC | CO |
| DRILLING | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER diesel | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | AUXILIARY EQUIP<600hp diesel | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(tugs) | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PIPELINE INSTALLATION | | | | | | | | | | | | | | | | |
| **Security** | **Security Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 24 | 365 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 4.82 | 7.08 | 67.53 | 5.40 | 14.62 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 365 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 1.21 | 1.77 | 16.88 | 1.35 | 3.65 |
| **Survey Support** | **Survey Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 825 | 39.8475 | 956.34 | 24 | 116 | 0.58 | 2.67 | 19.99 | 0.60 | 4.36 | 0.81 | 3.71 | 27.82 | 0.83 | 6.07 |
| | Bow Thruster | 205 | 9.9015 | 237.64 | 24 | 116 | 0.45 | 0.66 | 6.32 | 0.51 | 1.37 | 0.63 | 0.92 | 8.80 | 0.70 | 1.90 |
| | Generators (2) | 125 | 6.0375 | 144.90 | 24 | 116 | 0.28 | 0.40 | 3.85 | 0.31 | 0.83 | 0.38 | 0.56 | 5.37 | 0.43 | 1.16 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 116 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.38 | 0.56 | 5.37 | 0.43 | 1.16 |
| **Pipeline** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| **Construction** | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 8 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.14 | 0.62 | 4.65 | 0.14 | 1.01 |
| **Operations** | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 8 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.11 | 0.16 | 1.48 | 0.12 | 0.32 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 8 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.03 | 0.04 | 0.40 | 0.03 | 0.09 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 8 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.01 | 0.06 | 0.47 | 0.01 | 0.10 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 8 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.08 | 0.12 | 1.12 | 0.09 | 0.24 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 8 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.10 | 0.14 | 1.33 | 0.11 | 0.29 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 8 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.06 | 0.28 | 2.09 | 0.06 | 0.46 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 8 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.06 | 0.28 | 2.09 | 0.06 | 0.46 |
| | **Pipe Hauler Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Pipe Hauler Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Pipe Hauler Tug 3** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Pipe Hauler Tug 4** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Pipe Hauler Tug 5** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Pipe Hauler Tug 6** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 8 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.07 | 0.10 | 0.99 | 0.08 | 0.21 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 8 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.15 | 0.01 | 0.03 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 8 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.03 | 0.04 | 0.37 | 0.03 | 0.08 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 8 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.03 | 0.04 | 0.37 | 0.03 | 0.08 |
| **Pipeline** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| **Lowering** | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 41 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.69 | 3.18 | 23.84 | 0.72 | 5.20 |
| | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 41 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.54 | 0.80 | 7.59 | 0.61 | 1.64 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 41 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.15 | 0.21 | 2.05 | 0.16 | 0.44 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 41 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.07 | 0.32 | 2.38 | 0.07 | 0.52 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 41 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.41 | 0.60 | 5.77 | 0.46 | 1.25 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 41 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.49 | 0.72 | 6.83 | 0.55 | 1.48 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 41 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.31 | 1.43 | 10.73 | 0.32 | 2.34 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 41 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.31 | 1.43 | 10.73 | 0.32 | 2.34 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 41 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.14 | 0.20 | 1.90 | 0.15 | 0.41 |



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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 41 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.14 | 0.20 | 1.90 | 0.15 | 0.41 |
| **IGTS Hot-Tap** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| **Spool Piece #1** | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 5 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.08 | 0.39 | 2.91 | 0.09 | 0.63 |
| | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 5 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.07 | 0.10 | 0.93 | 0.07 | 0.20 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 5 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.02 | 0.03 | 0.25 | 0.02 | 0.05 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 5 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.01 | 0.04 | 0.29 | 0.01 | 0.06 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 5 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.05 | 0.07 | 0.70 | 0.06 | 0.15 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 5 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.06 | 0.09 | 0.83 | 0.07 | 0.18 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 5 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.04 | 0.17 | 1.31 | 0.04 | 0.29 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 5 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.04 | 0.17 | 1.31 | 0.04 | 0.29 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 5 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.04 | 0.06 | 0.62 | 0.05 | 0.13 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 5 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.01 | 0.10 | 0.01 | 0.02 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 5 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.02 | 0.02 | 0.23 | 0.02 | 0.05 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 5 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.02 | 0.02 | 0.23 | 0.02 | 0.05 |
| **FSRU Pipeline** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| **Spool Piece #3** | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 4 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.07 | 0.31 | 2.33 | 0.07 | 0.51 |
| | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 4 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.05 | 0.08 | 0.74 | 0.06 | 0.16 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 4 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.01 | 0.02 | 0.20 | 0.02 | 0.04 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 4 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.01 | 0.03 | 0.23 | 0.01 | 0.05 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 4 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.04 | 0.06 | 0.56 | 0.04 | 0.12 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 4 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.05 | 0.07 | 0.67 | 0.05 | 0.14 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 4 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.03 | 0.14 | 1.05 | 0.03 | 0.23 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 4 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.03 | 0.14 | 1.05 | 0.03 | 0.23 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 4 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.04 | 0.05 | 0.49 | 0.04 | 0.11 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 4 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.01 | 0.08 | 0.01 | 0.02 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 4 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.01 | 0.02 | 0.19 | 0.01 | 0.04 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 4 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.01 | 0.02 | 0.19 | 0.01 | 0.04 |
| **Crossing** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| **Completion** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 15 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.53 | 2.44 | 18.32 | 0.55 | 4.00 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 15 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.20 | 0.93 | 6.98 | 0.21 | 1.52 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 15 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.15 | 0.70 | 5.23 | 0.16 | 1.14 |
| **Additional** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| **Construction** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 22 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.78 | 3.59 | 26.87 | 0.81 | 5.86 |
| **Requirements** | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 22 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.30 | 1.37 | 10.23 | 0.31 | 2.23 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 22 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.22 | 1.02 | 7.68 | 0.23 | 1.67 |
| **Filling, Treating,** | **Diving Support Vessel 1** | | | | | | | | | | | | | | | |
| **and Cleaning** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 8 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.28 | 1.30 | 9.77 | 0.29 | 2.13 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 8 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.11 | 0.50 | 3.72 | 0.11 | 0.81 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 8 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.08 | 0.37 | 2.79 | 0.08 | 0.61 |
| | **Diving Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 8 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.28 | 1.30 | 9.77 | 0.29 | 2.13 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 8 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.11 | 0.50 | 3.72 | 0.11 | 0.81 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 8 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.08 | 0.37 | 2.79 | 0.08 | 0.61 |
| **FSRU Check and** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| **Isolation Valve** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 12 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.43 | 1.96 | 14.65 | 0.44 | 3.20 |
| **Spool (Spool #4)** | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 12 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.16 | 0.74 | 5.58 | 0.17 | 1.22 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 12 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.12 | 0.56 | 4.19 | 0.13 | 0.91 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 12 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.11 | 0.16 | 1.48 | 0.12 | 0.32 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 12 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.02 | 0.02 | 0.23 | 0.02 | 0.05 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 12 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.04 | 0.06 | 0.56 | 0.04 | 0.12 |
| **Hydrostatic** | **Diving Support Vessel 1** | | | | | | | | | | | | | | | |
| **Testing** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 3 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.11 | 0.49 | 3.66 | 0.11 | 0.80 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 3 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.04 | 0.19 | 1.40 | 0.04 | 0.30 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 3 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.03 | 0.14 | 1.05 | 0.03 | 0.23 |
| | **Diving Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 3 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.11 | 0.49 | 3.66 | 0.11 | 0.80 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 3 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.04 | 0.19 | 1.40 | 0.04 | 0.30 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 3 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.03 | 0.14 | 1.05 | 0.03 | 0.23 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 3 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.01 | 0.01 | 0.14 | 0.01 | 0.03 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 3 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.01 | 0.01 | 0.14 | 0.01 | 0.03 |
| **Acceptance of** | **Diving Support Vessel 1** | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrostatic Test** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 1 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.04 | 0.16 | 1.22 | 0.04 | 0.27 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 1 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.01 | 0.06 | 0.47 | 0.01 | 0.10 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 1 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.01 | 0.05 | 0.35 | 0.01 | 0.08 |
| | **Diving Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 1 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.04 | 0.16 | 1.22 | 0.04 | 0.27 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 1 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.01 | 0.06 | 0.47 | 0.01 | 0.10 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 1 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.01 | 0.05 | 0.35 | 0.01 | 0.08 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 1 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.00 | 0.00 | 0.05 | 0.00 | 0.01 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 1 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.00 | 0.00 | 0.05 | 0.00 | 0.01 |
| **IGTS Pipeline** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| **Spool Piece #2** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 10 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.36 | 1.63 | 12.21 | 0.37 | 2.66 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 10 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.14 | 0.62 | 4.65 | 0.14 | 1.01 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 10 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.10 | 0.47 | 3.49 | 0.10 | 0.76 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 10 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.09 | 0.13 | 1.23 | 0.10 | 0.27 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 10 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.01 | 0.02 | 0.19 | 0.02 | 0.04 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 10 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.03 | 0.05 | 0.46 | 0.04 | 0.10 |
| **FSRU Tie-in** | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| **Spool Pieces #1,2** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 15 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.53 | 2.44 | 18.32 | 0.55 | 4.00 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 15 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.20 | 0.93 | 6.98 | 0.21 | 1.52 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 15 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.15 | 0.70 | 5.23 | 0.16 | 1.14 |
| | **Material Hauler Tug** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 8 | 15 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.13 | 0.19 | 1.85 | 0.15 | 0.40 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 8 | 15 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.02 | 0.03 | 0.29 | 0.02 | 0.06 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 15 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.05 | 0.07 | 0.69 | 0.06 | 0.15 |
| **Dewatering** | **Diving Support Vessel 1** | | | | | | | | | | | | | | | |
| **& Drying** | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 21 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.75 | 3.42 | 25.64 | 0.77 | 5.60 |
| **(Pre-commissioning** | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 21 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.28 | 1.30 | 9.77 | 0.29 | 2.13 |
| **and Commissioning)** | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 21 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.21 | 0.98 | 7.33 | 0.22 | 1.60 |
| | **Diving Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 21 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.75 | 3.42 | 25.64 | 0.77 | 5.60 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 21 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.28 | 1.30 | 9.77 | 0.29 | 2.13 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 21 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.21 | 0.98 | 7.33 | 0.22 | 1.60 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 21 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.07 | 0.10 | 0.97 | 0.08 | 0.21 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 21 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.07 | 0.10 | 0.97 | 0.08 | 0.21 |
| FACILITY | DERRICK BARGE diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| INSTALLATION | MATERIAL TUG diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PRODUCTION | RECIP.<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | SUPPORT VESSEL diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TURBINE nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.2 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle rich nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER nat gas | 0 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **MISC.** | **BPD** | **SCF/HR** | **COUNT** | | | | | | | | | | | | |
| | TANK- | 0 | | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FLARE- | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | PROCESS VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FUGITIVES- | | | 0.0 | | 0 | | | | 0.00 | | | | | 0.00 | |
| | GLYCOL STILL VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| DRILLING | OIL BURN | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WELL TEST | GAS FLARE | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | **YEAR 2 TOTAL** | | | | | | **165.60** | **488.97** | **3924.30** | **178.47** | **854.08** | **22.36** | **67.33** | **538.41** | **24.06** | **117.19** |
| **EXEMPTION CALCULATION** | **DISTANCE FROM LAND IN MILES** | | | | | | | | | | | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | 0.0 | | | | | | | | | | | | | | | |



PUBLIC

BW002292

## AIR EMISSIONS CALCULATIONS - YEAR 2 Dredging Option

| COMPANY | AREA | BLOCK | LEASE | PLATFORM | | | WELL | CONTACT | | PHONE | REMARKS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broadwater Energy | Long Island Sound, New York | N/A | N/A | Floating Storage Regasification Unit | | | N/A | Stephen Marr | | | #REF! | | | | | |
| **OPERATIONS** | **EQUIPMENT** | **RATING** | **MAX. FUEL** | **ACT. FUEL** | **RUN TIME** | | **MAXIMUM POUNDS PER HOUR** | | | | | **ESTIMATED TONS** | | | | |
| | **Diesel Engines** | **HP** | **GAL/HR** | **GAL/D** | | | | | | | | | | | | |
| | **Nat. Gas Engines** | **HP** | **SCF/HR** | **SCF/D** | | | | | | | | | | | | |
| | **Burners** | **MMBTU/HR** | **SCF/HR** | **SCF/D** | **HR/D** | **DAYS** | **PM** | **SOx** | **NOx** | **VOC** | **CO** | **PM** | **SOx** | **NOx** | **VOC** | **CO** |
| DRILLING | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER diesel | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | AUXILIARY EQUIP<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(tugs) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PIPELINE INSTALLATION | | | | | | | | | | | | | | | | |
| **Dredging** | **Dredging Vessel** | | | | | | | | | | | | | | | |
| **(Optional)** | Main Engine | 3500 | 169.05 | 4057.20 | 24 | 20 | 2.47 | 11.32 | 84.80 | 2.54 | 18.50 | 0.59 | 2.72 | 20.35 | 0.61 | 4.44 |
| | **Survey Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 825 | 39.8475 | 956.34 | 24 | 20 | 0.58 | 2.67 | 19.99 | 0.60 | 4.36 | 0.14 | 0.64 | 4.80 | 0.14 | 1.05 |
| | Bow Thruster | 205 | 9.9015 | 237.64 | 24 | 20 | 0.45 | 0.66 | 6.32 | 0.51 | 1.37 | 0.11 | 0.16 | 1.52 | 0.12 | 0.33 |
| | Generators (2) | 125 | 6.0375 | 144.90 | 24 | 20 | 0.28 | 0.40 | 3.85 | 0.31 | 0.83 | 0.07 | 0.10 | 0.93 | 0.07 | 0.20 |
| | **Diving Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 4200 | 202.86 | 4868.64 | 24 | 20 | 2.96 | 13.58 | 101.76 | 3.05 | 22.20 | 0.71 | 3.26 | 24.42 | 0.73 | 5.33 |
| | Bow Thrusters (2) | 1600 | 77.28 | 1854.72 | 24 | 20 | 1.13 | 5.17 | 38.77 | 1.16 | 8.46 | 0.27 | 1.24 | 9.30 | 0.28 | 2.03 |
| | Stern Thrusters (2) | 1200 | 57.96 | 1391.04 | 24 | 20 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.20 | 0.93 | 6.98 | 0.21 | 1.52 |
| | **Support Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 20 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.07 | 0.10 | 0.93 | 0.07 | 0.20 |
| **Backfilling** | **Hopper Barge/Tug 1** | | | | | | | | | | | | | | | |
| **(Optional)** | Main Engines (2) | 1000 | 48.3 | 1159.20 | 24 | 20 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.53 | 0.78 | 7.40 | 0.59 | 1.60 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 24 | 20 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.08 | 0.12 | 1.16 | 0.09 | 0.25 |
| | **Hopper Barge/Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1000 | 48.3 | 1159.20 | 24 | 20 | 2.20 | 3.23 | 30.84 | 2.47 | 6.67 | 0.53 | 0.78 | 7.40 | 0.59 | 1.60 |
| | Anchor Towing Winch | 157 | 7.5831 | 181.99 | 24 | 20 | 0.35 | 0.51 | 4.84 | 0.39 | 1.05 | 0.08 | 0.12 | 1.16 | 0.09 | 0.25 |
| | **Survey Vessel** | | | | | | | | | | | | | | | |
| | Main Engine | 825 | 39.8475 | 956.34 | 24 | 20 | 0.58 | 2.67 | 19.99 | 0.60 | 4.36 | 0.14 | 0.64 | 4.80 | 0.14 | 1.05 |
| | Bow Thruster | 205 | 9.9015 | 237.64 | 24 | 20 | 0.45 | 0.66 | 6.32 | 0.51 | 1.37 | 0.11 | 0.16 | 1.52 | 0.12 | 0.33 |
| | Generators (2) | 125 | 6.0375 | 144.90 | 24 | 20 | 0.28 | 0.40 | 3.85 | 0.31 | 0.83 | 0.07 | 0.10 | 0.93 | 0.07 | 0.20 |
| FACILITY INSTALLATION | DERRICK BARGE diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | MATERIAL TUG diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PRODUCTION | RECIP.<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | SUPPORT VESSEL diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TURBINE nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.2 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle rich nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER nat gas | 0 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **MISC.** | **BPD** | **SCF/HR** | **COUNT** | | | | | | | | | | | | |
| | TANK- | 0 | | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FLARE- | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | PROCESS VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FUGITIVES- | | | 0.0 | | 0 | | | | 0.00 | | | | | 0.00 | |
| | GLYCOL STILL VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| DRILLING | OIL BURN | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WELL TEST | GAS FLARE | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | **YEAR 2 Dredging Option TOTAL** | | | | | | **16.22** | **50.52** | **401.51** | **17.40** | **87.41** | **3.69** | **11.83** | **93.59** | **3.95** | **20.38** |
| **EXEMPTION CALCULATION** | **DISTANCE FROM LAND IN MILES** | | | | | | | | | | | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | 0.0 | | | | | | | | | | | | | | | |



PUBLIC

BW002293

# AIR EMISSIONS CALCULATIONS - YEAR 2 Route Backfilling Option

| COMPANY | AREA | BLOCK | LEASE | PLATFORM | | | WELL | CONTACT | | PHONE | REMARKS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broadwater Energy | Long Island Sound, New York | N/A | N/A | Floating Storage Regasification Unit | | | N/A | Stephen Marr | | | #REF! | | | | | |
| **OPERATIONS** | **EQUIPMENT** | **RATING** | **MAX. FUEL** | **ACT. FUEL** | **RUN TIME** | | **MAXIMUM POUNDS PER HOUR** | | | | | **ESTIMATED TONS** | | | | |
| | **Diesel Engines** | **HP** | **GAL/HR** | **GAL/D** | | | | | | | | | | | | |
| | **Nat. Gas Engines** | **HP** | **SCF/HR** | **SCF/D** | | | | | | | | | | | | |
| | **Burners** | **MMBTU/HR** | **SCF/HR** | **SCF/D** | **HR/D** | **DAYS** | **PM** | **SOx** | **NOx** | **VOC** | **CO** | **PM** | **SOx** | **NOx** | **VOC** | **CO** |
| DRILLING | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | PRIME MOVER>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER diesel | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | AUXILIARY EQUIP<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(tugs) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PIPELINE INSTALLATION | | | | | | | | | | | | | | | | |
| **Backfilling** | **Pipeline Lay Barge** | | | | | | | | | | | | | | | |
| **(Optional)** | Main Power Generators (2) | 2000 | 96.6 | 2318.40 | 24 | 34 | 1.41 | 6.47 | 48.46 | 1.45 | 10.57 | 0.58 | 2.64 | 19.77 | 0.59 | 4.31 |
| | Winch Engines (4) | 2000 | 96.6 | 2318.40 | 6 | 34 | 4.41 | 6.47 | 61.67 | 4.93 | 13.35 | 0.45 | 0.66 | 6.29 | 0.50 | 1.36 |
| | Boom Engine | 405 | 19.5615 | 469.48 | 8 | 34 | 0.89 | 1.31 | 12.49 | 1.00 | 2.70 | 0.12 | 0.18 | 1.70 | 0.14 | 0.37 |
| | Hoist Engine | 600 | 28.98 | 695.52 | 8 | 34 | 0.42 | 1.94 | 14.54 | 0.44 | 3.17 | 0.06 | 0.26 | 1.98 | 0.06 | 0.43 |
| | Generator Engines (3) | 1140 | 55.062 | 1321.49 | 8 | 34 | 2.51 | 3.69 | 35.15 | 2.81 | 7.61 | 0.34 | 0.50 | 4.78 | 0.38 | 1.03 |
| | Deck Crane | 540 | 26.082 | 625.97 | 20 | 34 | 1.19 | 1.75 | 16.65 | 1.33 | 3.60 | 0.40 | 0.59 | 5.66 | 0.45 | 1.23 |
| | **Anchor Handling Tug 1** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 34 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.26 | 1.19 | 8.90 | 0.27 | 1.94 |
| | **Anchor Handling Tug 2** | | | | | | | | | | | | | | | |
| | Main Engines (2) | 1200 | 57.96 | 1391.04 | 18 | 34 | 0.85 | 3.88 | 29.07 | 0.87 | 6.34 | 0.26 | 1.19 | 8.90 | 0.27 | 1.94 |
| | **Support Vessel 1** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 34 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.11 | 0.16 | 1.57 | 0.13 | 0.34 |
| | **Support Vessel 2** | | | | | | | | | | | | | | | |
| | Main Engine | 500 | 24.15 | 579.60 | 6 | 34 | 1.10 | 1.62 | 15.42 | 1.23 | 3.34 | 0.11 | 0.16 | 1.57 | 0.13 | 0.34 |
| FACILITY INSTALLATION | DERRICK BARGE diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | MATERIAL TUG diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(crew) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | VESSELS>600hp diesel(supply) | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PRODUCTION | RECIP.<600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.>600hp diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | SUPPORT VESSEL diesel | 0 | 0 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TURBINE nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.2 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle lean nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | RECIP.4 cycle rich nat gas | 0 | 0 | 0.00 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | BURNER nat gas | 0 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **MISC.** | **BPD** | **SCF/HR** | **COUNT** | | | | | | | | | | | | |
| | TANK- | 0 | | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FLARE- | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | PROCESS VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| | FUGITIVES- | | | 0.0 | | 0 | | | | 0.00 | | | | | 0.00 | |
| | GLYCOL STILL VENT- | | 0 | | 0 | 0 | | | | 0.00 | | | | | 0.00 | |
| DRILLING | OIL BURN | 0 | | | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| WELL TEST | GAS FLARE | | 0 | | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| | **YEAR 2 Route Backfilling Option TOTAL** | | | | | | **14.72** | **32.61** | **277.95** | **16.18** | **60.37** | **2.69** | **7.54** | **61.12** | **2.91** | **13.30** |
| **EXEMPTION CALCULATION** | **DISTANCE FROM LAND IN MILES** | | | | | | | | | | | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| | 0.0 | | | | | | | | | | | | | | | |



PUBLIC

BW002294

## AIR EMISSION CALCULATIONS

OMB Control No. 1010-0049
OMB Approval Expires: August 31, 2006

| COMPANY | AREA | BLOCK | LEASE | PLATFORM | WELL |
|---|---|---|---|---|---|
| Broadwater Ene | Long Island Sound, Ne | N/A | N/A | Floating Storage Regas | N/A |

| Year | Emitted | | Substance | | |
|---|---|---|---|---|---|
| | PM | SOx | NOx | VOC | CO |
| 1 | 9.86 | 25.94 | 212.92 | 10.72 | 46.30 |
| 2 | 22.36 | 67.33 | 538.41 | 24.06 | 117.19 |
| 2 Dredging Option | 3.69 | 11.83 | 93.59 | 3.95 | 20.38 |
| 2 Route Backfilling Option | 2.69 | 7.54 | 61.12 | 2.91 | 13.30 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Allowable | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

# APPENDIX B

# EMISSIONS CALCULATIONS WORKBOOK

**ATTACHMENT A - TABLE OF CONTENTS**

**Table 1**
**SUMMARY OF SOURCES**

| Source Description | Fuel | Rating | Rating Units | Annual Hours of Operation (hr/yr) | Annual Operating Conditions | Annual Operating Conditions Units |
|---|---|---|---|---|---|---|
| Turbine 1 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 2 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 3 (Backup) | diesel | 264 | MMBtu/hr | 500 | 132,000 | MMBtu/hr |
| Process Heater 1 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 2 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 3 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 4 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 5 (Standby) | nat gas | 1.8 | MMBtu/hr | 8,760 | 15 | MMcf/yr |
| Fire Pump Engine 1 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Fire Pump Engine 2 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Emergency Generator 1 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 2 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 3 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| LNG Carrier Unloading | HFO | - | - | - | - | - |

Key:

HFO = Heavy fuel oil (also known as residual oil or bunker fuel)

Notes:

1. Rating for turbines based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
2. Rating for Process Heaters 1-4 based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
3. Rating for Process Heaters 5 based the operation of 24 pilots operating at 75,000 Btu/hr while heater is standby mode. (Ref. 6).
4. Rating for fire pump engines and emergency generators based on data provided by Shell (Ref. 2).
5. Annual hours of operation of Turbines 1-2 and all process heaters based on continuous operation.
6. Annual operation value for Turbine 3, fire pumps, & emergency generators used by USEPA to estimate potential emissions for emergency equipment.

**Table 2**
**SUMMARY OF STACK PARAMETERS**

| Source Description | Stack Height Above Water Level (m) | Stack Exit Inside Diameter (m) | Deviation of Stack Angle (deg) | Base Elevation Above Water Level (m) | Stack Gas Temp. (K) | Stack Gas Exit Velocity (m/s) | Stack Gas Exit Flowrate (acm/s) |
|---|---|---|---|---|---|---|---|
| Turbine 1 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 2 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 3 (Backup) | 45 | 3.96 | 0 | 25 | 523 | 10.3 | 127 |
| Process Heater 1 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 2 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 3 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 4 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 5 (Standby) | 45 | 4.57 | 0 | 25 | 450 | 0.025 | 0.41 |
| Fire Pump Engine 1 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Fire Pump Engine 2 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Emergency Generator 1 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 2 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 3 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |

Notes:

1. Stack heights, stack exit diameters, and stack angles for turbines and process heaters from Shell (Ref. 1, Table 1).
2. Stack heights and stack exit diameters of fire pump engines, emergency generators, and LNG carrier are strictly estimates.
3. Base elevation for all FSRU equipment based on Trunk Deck height above sea level (Ref. 9).
4. Stack angles of fire pump engines, emergency generators, and LNG carrier assumed equal to data for turbines and process heaters.
5. Stack temperature and flowrate for turbines estimated by calculating effects of waste heat recovery unit (WHRU) on data provided by Shell for operation at 60 F and 100% Load (Ref. 7).
6. Stack temperature and flowrate for Process Heaters 1-4 based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
7. Stack temperature and flowrate for process heaters based on data in Table 4 (Load @ 0.73%).
8. Stack temperature and flowrate for fire pump engines based on 50% load for Caterpillar 3608 (Ref 5).
9. Stack temperature and flowrate for emergency generators based on 80% load for Caterpillar 3608 (Ref 5).
10. Stack velocity for all sources calculated from stack exit diameter and stack exit flowrate.

Table 3
SUMMARY OF EMISSION RATES FOR MODELING

| Source Description | 1-Hour to 8-Hour Periods | | | | | 24-Hour Periods | | | Annual | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NO_x$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) |
| Turbine 1 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 2 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 3 (Backup) | 0.110 | 0.399 | 0.399 | 0.050 | 0.568 | 0.399 | 0.399 | 0.050 | 0.334 | 0.023 | 0.023 | 0.0028 | 0.032 |
| Process Heater 1 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 2 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 3 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 4 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 5 (Standby) | 0.013 | 0.0016 | 0.0016 | 0.00013 | 0 | 0.0016 | 0.0016 | 0.00013 | 0.010 | 0.0016 | 0.0016 | 0.00013 | 0 |
| Fire Pump Engine 1 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Fire Pump Engine 2 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Emergency Generator 1 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 2 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 3 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |

Notes:

1. Annual emission rates for Turbines 1-2 and Process Heaters 1-4 based on 50 startups and 50 shutdowns each year per unit.
2. CO and NOx emission rates for Turbines 1-2 based on information provided by Shell for normal operation and by GE for startup/shutdown conditions (see Tables 4 and 6).
3. NH3 emission rates for Turbines 1-3 based on information provided by Shell for normal operation (see Table 4). Emissions assumed to be constant during startup and shutdown.
4. PM2.5, PM10, and SO2 emission rates for Turbines 1-2 based on equipment rating and AP-42 emission factors for natural gas turbines (see Tables 1 and 7). Emissions assumed to be constant during startup and shutdown.
5. Air pollutant (except NOx and NH3) emission rates for Turbine 3 based on equipment rating and AP-42 emission factors for diesel turbines (see Tables 1 and 7). NOx emissions for Turbine 3 are based on estimate control of SCR at 80%.
6. NOx emission rates for Turbine 3 based on a NOx concentration of 64 ppmvd @ 15%O2 (see Table 4). This concentration reflects NOx limit in 6 NYCRR 227-2 (NOx RACT) for emissions for diesel-fired combined cycle turbines.
7. CO and NOx emission rates for Process Heaters 1-4 based on information provided by Shell for normal operation and startup/shutdown conditions (see Tables 4, 5 and 6).
8. NH3 emission rates for Process Heaters 1-4 based on information provided by Shell for normal operation (see Table 4). Emissions assumed to be constant during startup and shutdown.
9. PM2.5, PM10, and SO2 emission rates for Process Heaters 1-4 based on equipment rating and AP-42 emission factors (see Tables 1 and 8).
10. CO and NOx emission rates for Process Heater 5 extrapolated from data provided for Shell for normal operation and uncontrolled conditions (no SCR) to 1.8 MMBtu/hr (0.73% Load) (see Table 4).
11. NH3 emission rate for Process Heater 5 is 0 lb/hr based on assumption that SCR is not operational.
12. PM2.5, PM10, and SO2 emission rates for Process Heater 5 based on equipment rating and AP-42 emission factors (see Tables 1 and 8).
13. All air pollutant emission rates for fire pump engines and emergency generators based on equipment rating and AP-42 emission factors (see Tables 1 and 9).

**Table 4**
**SUMMARY OF MAXIMUM HOURLY EMISSION RATES**

| Source Description | Maximum Hourly Emission Rate (lb/hr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ | VOC | $NH_3$ | $CO_2$ |
| Turbine 1 | 6.1 | 2.6 | 1.7 | 1.7 | 0.17 | 1.1 | 4.1 | 37,501 |
| Turbine 2 | 6.1 | 2.6 | 1.7 | 1.7 | 0.17 | 1.1 | 4.1 | 37,501 |
| Turbine 3 (Backup) | 0.87 | 46.5 | 3.2 | 3.2 | 0.40 | 0.11 | 4.5 | - |
| Process Heater 1 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 2 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 3 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 4 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 5 (Standby) | 0.10 | 0.078 | 0.013 | 0.013 | 0.0010 | 0.003 | 0 | 206 |
| Fire Pump Engine 1 | 29 | 48 | 0.84 | 0.87 | 0.023 | 1.2 | 0 | 2,492 |
| Fire Pump Engine 2 | 29 | 48 | 0.84 | 0.87 | 0.023 | 1.2 | 0 | 2,492 |
| Emergency Generator 1 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |
| Emergency Generator 2 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |
| Emergency Generator 3 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |

Table 5
SUMMARY OF ANNUAL POTENTIAL-TO-EMIT

| Source Description | Annual Emissions (tpy) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **CO** | **$NO_x$** | **$PM_{2.5}$** | **$PM_{10}$** | **$SO_2$** | **VOC** | **$NH_3$** | **$CO_2$** |
| Turbine 1 | 15 | 11.3 | 8 | 8 | 0.7 | 5 | 18 | 164,255 |
| Turbine 2 | 15 | 11.3 | 8 | 8 | 0.7 | 5 | 18 | 164,255 |
| Turbine 3 (Backup) | 0.2 | 11.6 | 0.8 | 0.8 | 0.1 | 0.03 | 1.1 | - |
| **Subtotal Gas Turbines** | **29.7** | **34.3** | **16.1** | **16.1** | **1.6** | **9.4** | **36.6** | **328,509** |
| Process Heater 1 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 2 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 3 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 4 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 5 (Standby) | 0.4 | 0.3 | 0.06 | 0.06 | 0.005 | 0.02 | 0 | 901 |
| **Subtotal Process Heaters** | **49.3** | **20.5** | **31.4** | **31.4** | **2.5** | **8.4** | **29.6** | **495,466** |
| Fire Pump Engine 1 | 1 | 2 | 0.0 | 0.0 | 0.001 | 0.1 | 0 | 125 |
| Fire Pump Engine 2 | 1 | 2 | 0.0 | 0.0 | 0.001 | 0.1 | 0 | 125 |
| Emergency Generator 1 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| Emergency Generator 2 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| Emergency Generator 3 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| **Subtotal-FSRU Sources** | **88** | **71** | **48** | **48** | **4** | **18** | **66** | **824,788** |
| **LNG Carrier Unloading** | **2** | **29** | **10** | **10** | **222** | **0** | **0** | **13,032** |
| **TOTAL** | **90** | **99** | **58** | **58** | **226** | **19** | **66** | **837,820** |

**Table 6**
**SUMMARY OF STACK PARAMETERS FOR TURBINES AND PROCESS HEATERS**

| Source Description | Ambient Temp & Load | Fuel Flow (MMBtu/hr) | Exhaust Gas Temp. (F) | Actual Exhaust Gas Flowrate (acfm) | Normalized Exhaust Gas Flowrate[2] (dscfm) | Stack Gas Parameters [Wet Basis] (% vol) | | Stack Gas Parameters [Dry Basis] (% vol) | Air Pollutant Gas Concentrations | | | | | Air Pollutant Concentrations (ppmvd) | | | | Air Pollutant Concentrations[4] (lb/dscf) | | | | Air Pollutant Rates (lb/hr) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $O_2$ | $H_2O$ | $O_2$ | CO | $NO_x$ | VOC[3] | $NH_3$ | Units | CO | $NO_x$ | VOC[3] | $NH_3$ | CO | $NO_x$ | VOC[3] | $NH_3$ | CO | $NO_x$ | VOC[3] | $NH_3$ |
| Turbine (Natural Gas) | 0 F & 100% Load | 282.1 | 876 | 410,822 | 152,563 | 14.1 | 6.07 | 14.98 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 10.0 | 3.64E-07 | 2.99E-07 | 1.25E-07 | 4.42E-07 | 3.3 | 2.7 | 1.1 | 4.1 |
| | 0 F & 75% Load | 243.8 | 915 | 352,435 | 126,864 | 13.8 | 6.28 | 14.77 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.2 | 2.6 | 3.1 | 10.4 | 3.77E-07 | 3.10E-07 | 1.29E-07 | 4.58E-07 | 2.9 | 2.4 | 1.0 | 3.5 |
| | 0 F & 50% Load | 182.3 | 884 | 285,191 | 105,664 | 14.5 | 5.69 | 15.39 | 5 | 2.5 | 5 | 10 | ppmvd @ 15% $O_2$ | 4.7 | 2.3 | 4.7 | 9.3 | 3.39E-07 | 2.79E-07 | 1.94E-07 | 4.12E-07 | 2.2 | 1.8 | 1.2 | 2.6 |
| | 60 F & 100% Load | 264.0 | 977 | 398,084 | 135,714 | 13.61 | 7.23 | 14.68 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.6 | 3.2 | 10.5 | 3.83E-07 | 3.15E-07 | 1.31E-07 | 4.65E-07 | 3.1 | 2.6 | 1.1 | 3.8 |
| | 60 F & 75% Load | 215.8 | 954 | 338,337 | 117,603 | 13.99 | 6.90 | 15.03 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 9.9 | 3.61E-07 | 2.97E-07 | 1.24E-07 | 4.39E-07 | 2.5 | 2.1 | 0.9 | 3.1 |
| | 60 F & 50% Load | 174.8 | 1005 | 279,529 | 93,696 | 13.89 | 6.99 | 14.93 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.1 | 2.5 | 3.0 | 10.1 | 3.67E-07 | 3.02E-07 | 1.26E-07 | 4.46E-07 | 2.1 | 1.7 | 0.7 | 2.5 |
| | 100 F & 100% Load | 222.8 | 1020 | 354,071 | 113,917 | 13.20 | 9.82 | 14.64 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.7 | 3.2 | 10.6 | 3.85E-07 | 3.16E-07 | 1.32E-07 | 4.68E-07 | 2.6 | 2.2 | 0.9 | 3.2 |
| | 100 F & 75% Load | 184.4 | 1010 | 304,751 | 98,989 | 13.51 | 9.56 | 14.94 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 10.1 | 3.67E-07 | 3.01E-07 | 1.26E-07 | 4.45E-07 | 2.2 | 1.8 | 0.7 | 2.6 |
| | 100 F & 50% Load | 153.8 | 1085 | 256,107 | 78,939 | 13.23 | 9.80 | 14.66 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.6 | 3.2 | 10.6 | 3.84E-07 | 3.15E-07 | 1.32E-07 | 4.66E-07 | 1.8 | 1.5 | 0.6 | 2.2 |
| Turbine (Diesel) | 0 F & 100% Load | 282.1 | 876 | 424,039 | 160,941 | 14.1 | 4 | 14.66 | | | | 10 | ppmvd @ 15% $O_2$ | | | | 10.6 | | | | 4.67E-07 | | | | 4.5 |
| Process Heater | 60 F & 50% Load | 123.5 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 10 | 2.5 | 3 | 10 | ppmvd @ 3% $O_2$ | 10.0 | 2.5 | 3.0 | 10.0 | 7.27E-07 | 2.98E-07 | 1.25E-07 | 4.41E-07 | 1.4 | 0.6 | 0.2 | 0.8 |
| | 60 F & 0.73% Load | 1.8 | 350 | 860 | 465 | 2.48 | 17 | 2.99 | 50 | 23.3 | 3 | 10 | ppmvd @ 3% $O_3$ | 50.0 | 23.3 | 3.0 | 10.0 | 3.63E-06 | 2.78E-06 | 1.25E-07 | 4.41E-07 | 0.10 | 0.078 | 0.003 | 0.0 |
| | 60 F & 100% Load | 247 | 350 | 117,768 | 63,717 | 2.48 | 17 | 2.99 | 10 | 2.5 | 3 | 10 | ppmvd @ 3% $O_2$ | 10.0 | 2.5 | 3.0 | 10.0 | 7.27E-07 | 2.98E-07 | 1.25E-07 | 4.41E-07 | 2.8 | 1.1 | 0.5 | 1.7 |

Notes:

1. Except for Process Heater @ 0.73% Load and Tubine (Diesel), following data from Ref. 1, Table 2a: Fuel Flow, Exhaust Gas Temp, Actual Gas Flowrate, Stack Gas Parameters [wet], air polluant gas concentrations (ppmvd corrected to 15%02 or 3%O2).
2. Based on dry conditions with with standard temperature ($68^{o}$ F) and pressure (29.92 in Hg).
3. VOC include total hydrocarbons except methane and ethane.
4. Based on stack pressure of 1 atm (29.92 mmHg).
5. For Turbine (Diesel), dry standard flowrate derived from flowrate with natural gas at 0 F and 100% load and F factors contained in EPA Method 19. Moisture content assumed to be 4%. Actual flowrate derived from dry standard flowrate and moisture content. Exit temperature and O2 content assumed equal to those with natural gas at 0 F and 100% load.
6. For Process Heater @ 0.73% Load, actual gas flowrate extrapolated from 100% load data and air pollutant concentrations assumed based on uncontrolled emission data.

Table 7
**SUMMARY OF STACK PARAMETERS FOR PROCESS HEATERS DURING STARTUP AND SHUTDOWN**

| Source Description | Ambient Temp & Load | Duration (min) | Exhaust Gas Temp. (F) | Actual Exhaust Gas Flowrate (acfm) | Normalized Exhaust Gas Flowrate[2] (dscfm) | Stack Gas Parameters [Wet Basis] (% vol) | | Stack Gas Parameters [Dry Basis] (% vol) | Air Pollutant Gas Concentrations | | | Air Pollutant Concentrations (ppmvd) | | Air Pollutant Concentrations[4] (lb/dscf) | | Emissions (lb) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $O_2$ | $H_2O$ | $O_2$ | CO | $NO_x$ | Units | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ |
| Process Heater | Startup | 15 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 50 | 23.3 | ppmvd @ 3% $O_2$ | 50.0 | 23.3 | 3.63E-06 | 2.78E-06 | 1.7 | 1.3 |
| | Shutdown | 15 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 50 | 23.3 | ppmvd @ 3% $O_2$ | 50.0 | 23.3 | 3.63E-06 | 2.78E-06 | 1.7 | 1.3 |

Notes:

1. Following data from Ref. 1, Tables 3b and 4b : Fuel Flow, Exhaust Gas Temp, Actual Gas Flowrate, Stack Gas Parameters [wet], air polluant gas concentrations (ppmvd corrected to 15%02 or 3%O2).
2. Based on dry conditions with with standard temperature (68$^{o}$ F) and pressure (29.92 in Hg).
3. VOC include total hydrocarbons except methane and ethane.
4. Based on stack pressure of 1 atm (29.92 mmHg).

**Table 8**
**CO AND NOx EMISSION RATES FOR TURBINES AND PROCESS HEATERS BASED ON STARTUP AND SHUTDOWN**

| Source Description | Ambient Temp & Load | Normal Operation Air Pollutant Rates[1] (lb/hr) | | Startup Emissions[2] (lb) | | Duration of Startup[3] (min) | Shutdown Emissions[2] (lb) | | Duration of Shutdown[3] (min) | Anticipated No. of Annual Startup / Shutdown[4] (#/yr) | 1-Hour Average CO Rate During Startup (lb/hr) | 8-Hour Average CO Rate During Startup (lb/hr) | 1-Hour Average CO Rate During Shutdown (lb/hr) | 8-Hour Average CO Rate During Shutdown (lb/hr) | Annual Average NOx Rate with Startups and Shutdown (lb/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CO | $NO_x$ | CO | $NO_x$ | | CO | $NO_x$ | | | | | | | |
| Turbine | 0 F & 100% Load | 3.3 | 2.7 | 3.0 | 2.6 | 10 | 2.0 | 1.7 | 8 | - | 5.8 | 3.6 | 4.9 | 3.5 | - |
| | 60 F & 100% Load | 3.1 | 2.6 | 3.5 | 2.6 | 10 | 2.23 | 1.96 | 8 | 50 | 6.1 | 3.5 | 4.9 | 3.3 | 2.6 |
| | 100 F & 100% Load | 2.6 | 2.2 | 2.5 | 2.0 | 10 | 1.88 | 1.55 | 8 | - | 4.7 | 2.9 | 4.2 | 2.8 | - |
| Process Heater | 60 F & 100% Load | 2.8 | 1.1 | 1.74 | 1.3 | 15 | 1.7 | 1.3 | 15 | 50 | 3.8 | 2.9 | 3.8 | 2.9 | 1.2 |

Notes:

1. Emission results from Table 4.
2. Emission data from Ref. 8.
3. Turbine data from Ref. 8; process heater data from Ref. 1, Tables 3b and 4b.
4. Number of startups and shutdowns is strictly an estimate.

**Table 9**
**EMISSION FACTORS FOR TURBINES**

| Pollutant | Emission Factors[1,3,4,5,6] | |
|---|---|---|
| | Natural Gas (lb/MMBtu) | Diesel (lb/MMBtu) |
| $NO_x$ | see Note 2 | 0.176 |
| VOC | see Note 2 | 0.00041 |
| CO | see Note 2 | 0.0033 |
| $SO_2$ | 0.00064 | 0.0015 |
| $PM_{2.5}$ | 0.0066 | 0.012 |
| $PM_{10}$ | 0.0066 | 0.012 |
| $CO_2$ (see note 6) | 37,501.1 | - |

Notes:

1. Except, where noted, emission factors from AP-42, Section 3.1 (Ref 12).
2. Manufacturers emission rate data used instead of AP-42.
3. $NO_x$ emission factor for diesel incorporates estimated SCR control of 80% in uncontrolled factor obtained from AP-42.
4. $SO_2$ emission factor for natural gas based on sulfur content of 0.00068% (5 mg/$m^3$).
5. $SO_2$ emission factor for diesel is based on sulfur content of 15 ppm.
6. See reference 14 - $CO_2$ emission factor for natural gas fired turbine in lb/hr taken from GE spec sheet for 59F/100% load LM2500+DLE

**Table 10**
**EMISSION FACTORS FOR PROCESS HEATERS**

| **Pollutant** | **Emission Factor ($lb/10^6\ ft^3$)** |
|---|---|
| $SO_2$ | 0.6 |
| $PM_{2.5}$ | 7.6 |
| $PM_{10}$ | 7.6 |
| $CO_2$ | 120,000.00 |

Notes:
1. Emission factors from AP-42, Section 1.4 (Ref. 12).

**Table 11**
**EMISSION FACTORS FOR FIRE PUMP ENGINES AND EMERGENCY GENERATORS**

| Pollutant | Emission Factors for Diesel Engines >600 hp | |
|---|---|---|
| | (lb/MMBtu) | (lb/hp-hr) |
| $NO_x$ | 3.2 | 0.024 |
| VOC | 0.082 | 0.00064 |
| CO | 1.9 | 0.0055 |
| $SO_2$ | 0.0015 | 0.00809 |
| $PM_{2.5}$ | 0.0556 | 0.00056 |
| $PM_{10}$ | 0.0573 | 0.00057 |
| $CO_2$ | 165 | 1.16 |

Notes:

1. Emission factors from AP-42, Section 3.4 (Ref 12).
2. $SO_2$ emission factor based on sulfur content of 15 ppm.

**Table 12**
**EMISSION FACTORS FOR LNG CARRIER**

| Pollutant | Sulfur Content of Fuel (wgt %) | Emission Factor (g/kW-hr) | Emission Factor (g/kW-hr) | Emission Factor (lb/MMBtu) |
|---|---|---|---|---|
| | | Steam Turbine | Slow Speed Diesel | Gas Turbine |
| | | Heavy Fuel Oil | Heavy Fuel Oil | LNG |
| $NO_x$ | - | 2.1 | 19.67 | 0.32 |
| VOC | - | 0.03 | 0.6 | 0.0021 |
| CO | - | 0.12 | 1.59 | 0.082 |
| $SO_2$ | 2.67 | 16.3 | 11.63 | 0.00064 |
| | 4.5 | 27.5 | na | not applicable |
| $PM_{2.5}$ | - | 0.75 | 1.64 | 0.0066 |
| $PM_{10}$ | - | 0.75 | 1.64 | 0.0066 |
| $CO_2$ | - | 956 | 682 | 110.0 |

Notes:

1. All emission factors for steam turbines, except for $SO_2$ with fuel sulfur content of 4.5%, from Ref. 13, Table D.9.

2. $SO_2$ emission factor for 4.5% sulfur fuel based on fuel consumption of 305 g/kW-hr (Ref.11, Table 2.8) and sulfur content of fuel.

3. All emission factors for slow speed diesel from Ref.13. Table D.9

4. Heavy Fuel Oil is same as Residual Oil.

5. All emission factors for gas turbines from AP-42, Section 3.1 (uncontrolled emissions); assume sulfur content of natural gas of 6.8 ppm.

Table 13

SUMMARY OF EMISSION RATES FOR LNG CARRIERS OF VARIOUS CARGO CAPACITY AND LOADING RATE WHILE AT THE FSRU

| | | | |
|---|---|---|---|
| Daily Natural Gas Delivery | 1 | bcf/day | Estimated average daily natural gas delivery rate. |
| | 21,095 | Mg/day | Calculated from ideal gas law using standard temperature and pressure. |
| Annual LNG Delivery Rate by Mass | 7,700,000 | metric tons/yr | Maximum annual LNG delivery to FSRU |
| | 7,700,051 | Mg/yr | |
| LNG Density | 470 | kg/m$^3$ | Design data from RR13 |
| LNG Annual Delivery Rate by Volume | 16,383,086 | m$^3$/yr | Calculated from Annual LNG Delivery Rate by Mass and LNG Density |

| Vessel Type | Vessel Size (m$^3$) | LNG Loading (m$^3$/hr) | Annual Vessel Dockings (#/yr) | Vessel Duration at FSRU: LNG Loading (hr) | Vessel Duration at FSRU: No Loading (hr) | Power Supplied by Engines[1]: LNG Pumps (kW) | Power Supplied by Engines[1]: Other Equip. (kW) | Fuel Use by Vessel at FSRU[2,3] (tons) | Maximum Hourly Emissions[4] (lb/hr): $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | Maximum Hourly Emissions with No Loading[5] (lb/hr): $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | Average Hourly Emission Over 24-Hour Period[6] (lb/hr): $SO_2$ | $PM_{10}$ ($PM_{2.5}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Existing** | | | | | | | | | | | | | | | | | | |
| Conventional LNGC | 125,000 | 10,000 | 132 | 12.5 | 8 | 4,500 | 1,900 | 32 | 30 | 0.4 | 1.7 | 13,489 | 230 | 11 | 115 | 3.1 | 158 | 7 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 132 | 9.6 | 8 | 5,750 | 1,900 | 30 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 224 | 6 |
| Steam turbine propulsion | | 15,000 | 132 | 8.3 | 8 | 6,650 | 1,900 | 29 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 218 | 6 |
| Conventional LNGC | 140,000 | 10,000 | 118 | 14.0 | 8 | 4,500 | 1,900 | 35 | 30 | 0.4 | 1.7 | 13,489 | 387 | 11 | 115 | 3.1 | 264 | 7 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 118 | 10.8 | 8 | 5,750 | 1,900 | 33 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 246 | 7 |
| Steam turbine propulsion | | 15,000 | 118 | 9.3 | 8 | 6,650 | 1,900 | 32 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 240 | 7 |
| Conventional LNGC | 160,000 | 10,000 | 103 | 16.0 | 8 | 4,500 | 1,900 | 40 | 30 | 0.4 | 1.7 | 13,489 | 387 | 11 | 115 | 3.1 | 297 | 8 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 103 | 12.3 | 8 | 5,750 | 1,900 | 37 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 276 | 8 |
| Steam turbine propulsion | | 15,000 | 103 | 10.7 | 8 | 6,650 | 1,900 | 36 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 268 | 7 |
| **Vessels On-Order (in-service about 2008)** | | | | | | | | | | | | | | | | | | |
| New Design LNGC | 160,000 | 10,000 | 103 | 16.0 | 8 | 4,500 | 2,700 | 29 | 312 | 9.5 | 25.2 | 10,825 | 185 | 26 | 69 | 9.8 | 146 | 21 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 103 | 12.3 | 8 | 5,750 | 2,700 | 27 | 366 | 11.2 | 29.6 | 12,705 | 217 | 31 | 69 | 9.8 | 134 | 19 |
| Slow Speed Diesel | | 15,000 | 103 | 10.7 | 8 | 6,650 | 2,700 | 26 | 405 | 12.4 | 32.8 | 14,058 | 240 | 34 | 69 | 9.8 | 130 | 18 |
| New Large LNGC | 215,000 | 10,000 | 77 | 21.5 | 8 | 4,500 | 3,000 | 40 | 325 | 9.9 | 26.3 | 11,276 | 192 | 27 | 77 | 10.8 | 180 | 25 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 77 | 16.5 | 8 | 5,750 | 3,000 | 36 | 379 | 11.6 | 30.7 | 13,156 | 224 | 32 | 77 | 10.8 | 179 | 25 |
| Slow Speed Diesel | | 15,000 | 77 | 14.3 | 8 | 6,650 | 3,000 | 35 | 418 | 12.8 | 33.8 | 14,509 | 247 | 35 | 77 | 10.8 | 173 | 24 |
| **Concept Vessels (in-service beyond 2010)** | | | | | | | | | | | | | | | | | | |
| New Very Large LNGC | 250,000 | 10,000 | 66 | 25.0 | 8 | 4,500 | 3,200 | 47 | 334 | 10.2 | 27.0 | 11,577 | 197 | 28 | 82 | 11.6 | 197 | 28 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 66 | 19.2 | 8 | 5,750 | 3,200 | 42 | 388 | 11.8 | 31.4 | 13,457 | 229 | 32 | 82 | 11.6 | 200 | 28 |
| Slow Speed Diesel(7) | | 15,000 | 66 | 16.7 | 8 | 6,650 | 3,200 | 41 | 427 | 13.0 | 34.5 | 14,810 | 253 | 36 | 82 | 11.6 | 200 | 28 |
| New Very Large LNGC | 250,000 | 10,000 | 66 | 25.0 | 8 | 4,500 | 2,300 | n/a | 20 | 0.13 | 5.0 | 6,732 | 0.04 | 0.40 | 0.01 | 0.14 | 0.04 | 0.40 |
| LNG fuel only | | 13,000 | 66 | 19.2 | 8 | 5,750 | 2,300 | n/a | 23 | 0.15 | 5.9 | 7,970 | 0.05 | 0.48 | 0.01 | 0.14 | 0.04 | 0.41 |
| Gas Turbine Propulsion[8,9] | | 15,000 | 66 | 16.7 | 8 | 6,650 | 2,300 | n/a | 26 | 0.17 | 6.6 | 8,861 | 0.05 | 0.53 | 0.01 | 0.14 | 0.04 | 0.41 |

| Vessel Type | Annual Emissions - LNG Loading (tpy): $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | Annual Emissions - No Loading (tpy): $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | Annual Emissions - Total (tpy): $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Existing** | | | | | | | | | | | | | | | | | | |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,128 | 190 | 9 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 29 | 0.4 | 1.7 | 13,242 | 226 | 10 |
| Heavy Fuel Oil (2.7%S) | 22 | 0.3 | 1.3 | 10,232 | 174 | 8 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 27 | 0.4 | 1.5 | 12,346 | 210 | 10 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,911 | 169 | 8 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 26 | 0.4 | 1.5 | 12,025 | 205 | 9 |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,142 | 190 | 9 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 29 | 0.4 | 1.6 | 13,032 | 222 | 10 |
| Heavy Fuel Oil (2.7%S) | 23 | 0.3 | 1.3 | 10,244 | 175 | 8 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 27 | 0.4 | 1.5 | 12,134 | 207 | 10 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,923 | 169 | 8 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 26 | 0.4 | 1.5 | 11,813 | 201 | 9 |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,115 | 189 | 9 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 28 | 0.4 | 1.6 | 12,764 | 217 | 10 |
| Heavy Fuel Oil (2.7%S) | 22 | 0.3 | 1.3 | 10,220 | 174 | 8 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 26 | 0.4 | 1.5 | 11,869 | 202 | 9 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,899 | 169 | 8 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 25 | 0.4 | 1.4 | 11,549 | 197 | 9 |
| **Vessels On-Order (in-service about 2008)** | | | | | | | | | | | | | | | | | | |
| New Design LNGC | 257 | 7.8 | 20.8 | 8,920 | 152 | 21 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 306 | 9.3 | 24.7 | 10,593 | 181 | 25 |
| Heavy Fuel Oil (2.7%S) | 232 | 7.1 | 18.8 | 8,053 | 137 | 19 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 280 | 8.6 | 22.7 | 9,725 | 166 | 23 |
| Slow Speed Diesel | 223 | 6.8 | 18.0 | 7,723 | 132 | 19 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 271 | 8.3 | 21.9 | 9,395 | 160 | 23 |
| New Large LNGC | 269 | 8.2 | 21.8 | 9,334 | 159 | 22 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 309 | 9.4 | 25.0 | 10,723 | 183 | 26 |
| Heavy Fuel Oil (2.7%S) | 242 | 7.4 | 19.5 | 8,377 | 143 | 20 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 282 | 8.6 | 22.8 | 9,766 | 167 | 23 |
| Slow Speed Diesel | 231 | 7.0 | 18.7 | 8,007 | 137 | 19 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 271 | 8.3 | 21.9 | 9,396 | 160 | 23 |
| **Concept Vessels (in-service beyond 2010)** | | | | | | | | | | | | | | | | | | |
| New Very Large LNGC | 275 | 8.4 | 22.3 | 9,551 | 163 | 23 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 312 | 9.5 | 25.2 | 10,821 | 185 | 26 |
| Heavy Fuel Oil (2.7%S) | 246 | 7.5 | 19.9 | 8,540 | 146 | 21 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 283 | 8.6 | 22.9 | 9,810 | 167 | 24 |
| Slow Speed Diesel(7) | 235 | 7.2 | 19.0 | 8,145 | 139 | 20 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 272 | 8.3 | 22.0 | 9,416 | 161 | 23 |
| New Very Large LNGC | 16 | 0.11 | 4 | 5,554 | 0.03 | 0.33 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 18 | 0.12 | 4.6 | 6,155 | 0.04 | 0.37 |
| LNG fuel only | 15 | 0.10 | 4 | 5,058 | 0.03 | 0.30 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 16 | 0.11 | 4.2 | 5,659 | 0.03 | 0.34 |
| Gas Turbine Propulsion[8,9] | 14 | 0.09 | 4 | 4,873 | 0.03 | 0.29 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 16 | 0.10 | 4.1 | 5,474 | 0.03 | 0.33 |

Notes:

1. Based on data supplied in Ref 4. LNG Pumps operate only during "LNG Loading". Other Equip. operates during "LNG Loading" and "No Loading"
2. Steam Turbine fuel use based on engine flow rate of 305 g/kW-hr (Ref. 11, Table 2.8). Steady operation while unloading is consistent with "at sea" operations.
3. Slow speed diesel fuel use based on fuel flow rate of 195 g/kW-hr (Ref. 11, Table 2.8). Steady operation while unloading is consistent with "at sea" operations.
4. Maximum hourly emission rate based on operation of vessel auxiliary engines needed to power LNG Pumps and Other Equipment.
5. Maximum hourly emission rate based on operation of vessel auxiliary engines needed to power only Other Equipment.
6. Weighted values based on emissions during Loading and No Loading periods.
7. New Very Large LNGC vessel assumed to use slow speed diesel on HFO only. Vessel will have a LNG reliquefaction plant on-board, no boil off gas available for propulsion.
8. New Very Large LNGC vessel assumed to use gas turbine capable of 22MW generation. No vessels of this type under design yet; specifications speculative only. No reliquefaction plant used.
9. Fuel rate of gas turbines estimated at 9,000 Btu/kW-hr.

**Table 14**
**REFERENCES**



| No. | Description |
|---|---|
| 1 | Spreadsheet: *Emission Sources Parameters 22Jul05.xls* (29-Jul-05 E-Mail from David Carpenter to Sandra Barnett). |
| 2 | Spreadsheet: *Diesel Engine NOX_CO Calc.xls* (29-Jul-05 E-Mail from David Carpenter to Sandra Barnett). |
| 3 | *Broadwater, RR13 Phase - Flare Height Study, 312383-SAI-CAL-601* (Saipem America, Inc., 02-Aug-05). |
| 4 | *13-Jul-05 E-Mail from David Carpenter to Paul Van Kerkhove* (Subject: Broadwater - LNG Transfer from Carriers to FSRU) |
| 5 | *Caterpillar 3608.pdf: "Gen Set Performance Data"* (RR13 Part B, 3-Aug-05). |
| 6 | 16-Aug-05 Telephone Contact Report with OPFI (Contact Report_08_16_2005 OPFI.doc) |
| 7 | WFRU Calculations.doc (Internal E & E document) |
| 8 | *GE LM2500+ Graphs: NOx and CO Emissions During Start-up and Shutdown* (provided to GE to E & E in six pdf files on 15-Aug-2005) |
| 9 | *Broadwater, RR13 Phase - Topsides Section View Fore Area, 312383-SAI-DWG-403.03 Rev. 0* (Saipem America, Inc., 02-Aug-05). |
| 10 | LNG Carrier Aux Equip Calculations.doc (Internal E & E document) |
| 11 | *Quantification of Emissions from Ships Associated with Ship Movements Between Ports in the European Community* (Entec, 2002) |
| 12 | *AP-42: Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (USEPA) |
| 13 | *The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory* (Starcrest, 2003) |
| 14 | GE Estimated Average Engine Performance, run 06/01/05, time 3:49:01 pm, version 3.3.2, LM2500 standard DLE |

Table 15

LNG IN TRANSIT AND OPERATIONAL SUPPORT VESSEL EMISSIONS

| | | Nat Gas | Units* | Tugs Diesel | Units | HFO | Units |
|---|---|---|---|---|---|---|---|
| **Emission Factors** | NOx | 0.275 | lb/MMBtu | 13.32 | g/kW-hr | 2.11 | g/kW-hr |
| | CO | 0.082 | lb/MMBtu | 1.69 | g/kW-hr | 0.12 | g/kW-hr |
| | VOC | 0.0054 | lb/MMBtu | 0.61 | g/kW-hr | 0.03 | g/kW-hr |
| | PM | 0.0075 | lb/MMBtu | 0.51 | g/kW-hr | 0.75 | g/kW-hr |
| | SO2 | 0.0006 | lb/MMBtu | 3.92 | g/kW-hr | 16.29 | g/kW-hr |
| | CO2 | 117.65 | lb/MMBtu | 721.3 | g/kW-hr | 956.07 | g/kW-hr |

LNG Carrier speed at rated power 19 knots
HFO used on outbound trip
90% Nat Gas/10% HFO used on inbound trip
Tug emission factors from NY, North NJ, Long Island Nonattainment Area Commercial Marine Vessel Emission Inventory prepared by Port Authority NY, NJ
*AP-42 Tables 1.4-1 and 1.4-2 (divided by 1020 Btu/scf) uncontrolled boiler pre-NSPS

| | | |
|---|---|---|
| Annual Carrier dockings (140K m3 vessel) | 118 | Berthings/yr |
| Annual Supply vessel Transits to Shore | 118 | per yr<br>(1 per LNGC mooring) |

berthings based on 3/week as stated in RR1 and annual limit of 7.7 million metric tons LNG to pipeline

| | | | | |
|---|---|---|---|---|
| Total Power LNG Carrier | 28,590 | bhp | 21,320 | kW |
| Total Power (3 assist Tugs) | 21,000 | bhp | 15,660 | kW |
| Total Power (2 assist Tugs) | 14,000 | bhp | 10,440 | kW |
| Total Power (1 assist Tug) | 7,000 | bhp | 5,220 | kW |

LNG power based on Shell typical LNG carrier in brochure

Used NY, NJ, LI emission inventory survey of tug sizes, used largest HP tug

**LNG Carrier and Assist Tugs**

| Vessel | Activity | Duration (hr) | Engine Use (%) | Engine Rating (bhp) | Engine Rating (kW) | Natural Gas Flow (MMBtu/hr) | Activity Emissions (lb) NOx | CO | VOC | PM | SO2 | CO2 | Annual Emissions (tpy) NOx | CO | VOC | PM | SO2 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LNG Carrier | Pilot pickup @ 47.9 n. miles out to 4 n. miles out @ 12 knots | 3.7 | 80% | 22872 | 17056 | 167.0 | 182 | 47 | 3 | 15 | 227 | 78714 | 10.8 | 2.79 | 0.20 | 0.86 | 13.39 | 4644.14 |
| Inbound | Slowing zone from 4 n. miles out to safety zone avg 3 kts | 1.3 | 20% | 5718 | 4264 | 41.7 | 16 | 4 | 0 | 1 | 20 | 6914 | 0.9 | 0.24 | 0.02 | 0.08 | 1.18 | 407.93 |
| 90%Natural Gas | Maneuvering in Safety Zone | 3.0 | 10% | 2859 | 2132 | 20.9 | 18 | 5 | 0 | 1 | 23 | 7978 | 1.1 | 0.28 | 0.020 | 0.09 | 1.36 | 470.69 |
| 10% Residual oil | **Subtotal** | **8.0** | - | - | - | - | **217** | **56** | **4** | **17** | **270** | **93606** | **12.8** | **3.3** | **0.24** | **1.0** | **15.9** | **5523** |
| LNG Carrier | Prep/Unmoore/Maneuvering in Safety Zone | 2.0 | 10% | 2859 | 2132 | n/a | 20 | 1.1 | 0.3 | 7 | 153 | 8987 | 1.2 | 0.07 | 0.017 | 0.42 | 9.03 | 530.26 |
| Outbound | Transit from Safety Zone to 4 n. miles out @avg 8 kts | 0.5 | 20% | 5718 | 4264 | n/a | 10 | 1 | 0.1 | 4 | 77 | 4494 | 0.6 | 0.03 | 0.01 | 0.21 | 4.52 | 265.13 |
| 100% Residual Oil | 4 n. miles out to pilot drop 47.9 n. miles out @ 9 knots | 4.9 | 80% | 22872 | 17056 | n/a | 389 | 22 | 5.5 | 138 | 3001 | 176154 | 22.9 | 1.30 | 0.33 | 8.15 | 177.08 | 10393.09 |
| | **Subtotal** | **7.4** | | | | | **419** | **24** | **6** | **149** | **3231** | **189635** | **24.7** | **1.4** | **0.35** | **8.8** | **190.6** | **11188.5** |
| | 2 tugs transit from port to pick up Carrier (47.9 naut mi @10 kts) | 4.8 | 80% | 11200 | 8352 | n/a | 1177 | 149 | 54 | 45 | 346 | 63750 | 69 | 9 | 3 | 3 | 20 | 3761 |
| Tugs (assist) | 2 tugs escort LNG carrier from Race through LI Sound (47.9 n. mi) | 4.8 | 80% | 11200 | 8352 | n/a | 1177 | 149 | 54 | 45 | 464.6 | 63749.6 | 69.5 | 8.81 | 3.18 | 2.66 | 27.411 | 3761.226 |
| | 1 tug comes from Port to assist berthing ops | 1.2 | 80% | 5600 | 4176 | n/a | 147 | 19 | 7 | 6 | 58.1 | 7968.7 | 8.7 | 1.10 | 0.40 | 0.33 | 3.426 | 470.153 |
| | 2 tugs Assist Carrier in safety zone to FSRU | 1.2 | 40% | 5600 | 4176 | n/a | 147 | 19 | 7 | 6 | 58.1 | 7968.7 | 8.7 | 1.10 | 0.40 | 0.33 | 3.426 | 470.153 |
| Diesel | 3 tugs assist carrier berth alongside FSRU | 0.3 | 100% | 21000 | 15660 | n/a | 138 | 18 | 6 | 5 | 54.4 | 7470.7 | 8.1 | 1.03 | 0.37 | 0.31 | 3.212 | 440.769 |
| | 2 tugs back away into Safety Zone | 0.2 | 20% | 2800 | 2088 | n/a | 12 | 2 | 1 | 0 | 4.8 | 664.1 | 0.7 | 0.09 | 0.03 | 0.03 | 0.286 | 39.179 |
| | 2 tugs hold station in Safety Zone during delivery | 22.0 | 10% | 1400 | 1044 | n/a | 674 | 86 | 31 | 26 | 266.2 | 36523.2 | 39.8 | 5.05 | 1.82 | 1.52 | 15.704 | 2154.869 |
| | 1 tug back to port during delivery (12 n.mi RT@ 10 kts.) | 1.2 | 80% | 5600 | 4176 | n/a | 147 | 19 | 7 | 6 | 58.1 | 7968.7 | 8.7 | 1.10 | 0.40 | 0.33 | 3.426 | 470.153 |
| | 2 tugs power up maneuver to Carrier when ready to undock | 0.2 | 20% | 2800 | 2088 | n/a | 12 | 2 | 1 | 0 | 4.8 | 664.1 | 0.7 | 0.09 | 0.03 | 0.03 | 0.286 | 39.179 |
| | 2 tugs full power push/tow away from FSRU | 0.3 | 100% | 14000 | 10440 | n/a | 92 | 12 | 4 | 4 | 36.3 | 4980.4 | 5.4 | 0.69 | 0.25 | 0.21 | 2.141 | 293.846 |
| | 2 tugs assist Carrier to safety zone perimeter | 0.5 | 40% | 5600 | 4176 | n/a | 61 | 8 | 3 | 2 | 24.2 | 3320.3 | 3.6 | 0.46 | 0.17 | 0.14 | 1.428 | 195.897 |
| | 2 tugs escort LNG carrier from FSRU to race | 4.8 | 50% | 7000 | 5220 | n/a | 736 | 93 | 34 | 28 | 290.4 | 39843.5 | 43.4 | 5.51 | 1.99 | 1.66 | 17.132 | 2350.766 |
| | 2 tugs transit from release of Carrier to port (47.9 naut mi @ 10 kts) | 4.8 | 80% | 16800 | 12528 | n/a | 1766 | 224 | 81 | 68 | 520 | 95624.4 | 104 | 13 | 5 | 4 | 31 | 5642 |
| | **Subtotal** | **46.3** | | | | | **6287.8** | **797.8** | **288.0** | **240.7** | **2186.1** | **340495.9** | **371.0** | **47.1** | **17.0** | **14.2** | **129.0** | **20089.3** |
| **TOTAL** | | | | | | | **6923** | **878** | **298** | **407** | **5687** | **623737** | **408.5** | **51.8** | **17.6** | **24.0** | **335.5** | **36800.5** |

**Supply Transit to NY Shore (Port Jefferson)**

| Vessel | Activity | Duration (hr) | Engine Use (%) | Engine Rating (bhp) | Engine Rating (kW) | Fuel Flow (MMBtu/hr) | Activity Emissions (lb) NOx | CO | VOC | PM | SO2 | CO2 | Annual Emissions (tpy) NOx | CO | VOC | PM | SO2 | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tug or similar vessel | Finish Load in port, prep to depart engine on | 0.5 | 10% | 700 | 522 | n/a | 8 | 1 | 0 | 0 | 2 | 83 | 0.45 | 0.06 | 0.02 | 0.02 | 0.13 | 4.90 |
| 1/LNGC visit | Transit to FSRU 12 naut mi @10 kts | 1.2 | 80% | 5600 | 4176 | n/a | 147 | 19 | 7 | 6 | 43 | 5312 | 8.68 | 1.10 | 0.40 | 0.33 | 2.56 | 313.44 |
| | Load/Unload at FSRU | 4.5 | 1% | 70 | 52.2 | n/a | 7 | 1 | 0 | 0 | 2 | 1 | 0.41 | 0.05 | 0.02 | 0.02 | 0.12 | 0.05 |
| | Transit to shore 12 naut mi @ 10 kts | 1.2 | 80% | 5600 | 4176 | n/a | 147 | 19 | 7 | 6 | 43 | 5312 | 8.68 | 1.10 | 0.40 | 0.33 | 2.56 | 313.44 |
| | Tie up in port, unload | 0.50 | 10% | 700 | 522 | n/a | 8 | 1 | 0 | 0 | 2 | 83 | 0.45 | 0.06 | 0.02 | 0.02 | 0.13 | 4.90 |
| | **TOTAL** | **7.9** | | | | | **316.5** | **40.2** | **14.5** | **12.1** | **93.2** | **10791.8** | **18.7** | **2.4** | **0.9** | **0.7** | **5.50** | **636.71** |

**TOTAL**

| Annual Emissions (tpy) NOx | CO | VOC | PM | SO2 | CO2 |
|---|---|---|---|---|---|
| **427.1** | **54.2** | **18.4** | **24.7** | **341.0** | **37,437.2** |

## APPENDIX C

## AIR QUALITY MODELING REPORT

# Air Quality Modeling Analysis
# Broadwater LNG Project
# Long Island Sound, New York

**January 2006**

**Prepared by:**

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**PUBLIC**

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# Executive Summary

Broadwater Energy proposes to construct and operate a Floating Storage and Regasification Unit (FSRU) in Long Island Sound for the purpose of receiving liquified natural gas (LNG) from cargo vessels, regasifying LNG, and delivering the regasified LNG in the form of pipeline-quality natural gas to the existing Iroquois Gas Transmission System (IGTS) pipeline crossing Long Island Sound. The proposed FSRU would be moored in place in the Sound, approximately 9 miles from the Long Island shore, due north of Wading River, New York.

The air quality modeling analysis examined impacts associated with potential emissions from the facility, including oxides of nitrogen ($NO_x$), carbon monoxide (CO), sulfur dioxide ($SO_2$), and particulate matter with aerodynamic diameters less than or equal to 10 microns ($PM_{10}$) and less than or equal to 2.5 microns ($PM_{2.5}$). Maximum emission rates for use in the Significant Impact Levels (SILs) analysis were determined by examining gas turbine manufacturer's data, the Broadwater engineering team's process heater information, and associated emission rate data for this equipment category in the EPA AP-42 emission factor document. Broadwater will install gas turbine and process heater equipment using an "N+1" sparing philosophy. Three gas turbines and five process heaters will be installed; one of each will be used as a spare to provide Broadwater with backup to maintain continuous operation. Maximum impacts were determined using a one-year overwater and overland meteorological data set in the Offshore and Coastal Dispersion (OCD) model. Startup and shutdown emissions associated with the gas turbines were accounted for in the emission rates. The geometry of the coast on the north and south shore of Long Island Sound was incorporated into the modeling study using digitized coastline data available in OCD.

The results of this modeling study are intended to be used to evaluate the air quality impacts associated with the proposed Broadwater FSRU. Comparison of the results produced using the OCD model to SILs show that the FSRU emissions will not result in ambient concentrations exceeding any SIL.

A building downwash/cavity analysis also was conducted to determine the aerodynamic influence of the ship structure on stack emissions and resulting pollutant concentration in the atmosphere in near- and far-wake regions around the FSRU

structure. This analysis was conducted using the AERMOD-PRIME model. The analysis indicates that the maximum concentration is found at a location on the safety and security zone boundary. For 1-hour CO, annual $NO_x$, and annual and 24-hour $PM_{10}$ and $PM_{2.5}$, the AERMOD-PRIME modeled maximum concentrations are above the applicable SILs but well below the NAAQS (with background concentrations included). The concentration drops off rapidly over a short distance away from the potential safety and security zone boundary.

$NO_x$, CO, and volatile organic compound (VOC) emissions will be controlled by use of selective catalytic reduction (SCR) and an oxidation catalyst on each gas turbine and process heater on the FSRU. All process heaters and gas turbines will use boil-off gas (natural gas) as fuel. The boil-off gas results from the normal vaporization of LNG while stored on the FSRU.

# 1 Introduction

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and interconnected subsea pipeline for the importation, storage, regasification, and transportation of natural gas. In addition, Broadwater Energy will file an application for an air pollution control permit from the New York State Department of Environmental Conservation (NYSDEC). The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS).

The Project would be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters, as shown on Figure 1. The LNG terminal facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcf/d) and will be capable of delivering a peak throughput of 1.25 bcf/d. The Project will deliver the regasified LNG to the existing natural gas pipeline system via a subsea interconnection to the (IGTS) pipeline. The terminal will deliver a maximum of 7.7 million metric tons per year of natural gas to the IGTS pipeline.

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU), a ship-like facility approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [$m^3$] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas) with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. Process heat required for LNG vaporization and all power for the regasification process will be provided by

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\\BUFSDL4\GIS\\Pensacola\LNG\BROADWATER\Maps\MXD\Resource_Reports_Final\RR9\fig_1site_map_with_Eastchester.mxd 01/11/2006


Source: ESRI StreetMap, 2002.

Figure 1
Proposed Broadwater Project
Location in Long Island Sound

equipment onboard the FSRU. Three gas turbines of 22 MW generating capacity each and five process heaters, each with a heat input rating of 247 MMBtu/hr, will be installed. Two diesel engine fire water pumps and three diesel engine emergency electrical generators also will be installed.

The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 $m^3$ up to a potential future size of 250,000 $m^3$ at the frequency of two to three carriers per week. LNG carriers will supply their own power needs during unloading and will not connect to the FSRU's power system during unloading. The LNG carriers will be owned and operated by entities other than Broadwater Energy, TCPL LNG USA, Inc., or Shell Broadwater Holdings LLC.

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the stationary tower also serves the purpose of securing the FSRU in such a manner to allow it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS), allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [$m^2$]).

As described in the Air Quality Modeling Protocol (*see* Appendix A), the potential to emit estimate for the Project places it below Prevention of Significant Deterioration (PSD) applicability thresholds. Thus, modeling was performed to evaluate only the impacts of emissions from the FSRU alone, and a cumulative source impact study was not performed.

Ambient air quality impacts were evaluated using emission rates based on equipment design parameters identified by Broadwater.

# 2 Objective and General Approach

The overall objective of the modeling study is to compare data on the expected maximum ambient impacts to various threshold levels and standards in a step-wise fashion, beginning with a comparison to SILs following EPA's New Source Review (NSR) procedure (EPA 1990). This modeling information is being used to support the FERC Resource Report No. 9 Air quality analysis document and Broadwater's air permit application for a State Facility air permit.

Dispersion modeling was used to analyze the ambient air quality impacts due to air pollutants emitted from FSRU emission sources. The location of the FSRU in the Sound required the use of an air quality dispersion model specifically designed to evaluate overwater sources. The model used was the Offshore and Coastal Dispersion Model (OCD) developed by Hanna et al. (Hanna et al. 1985). The AERMOD-PRIME model was used to evaluate emission impacts associated with structure downwash in the near- and far-wake regions around the FSRU.

The modeling methodology was developed following modeling guidance documents from the United States Environmental Protection Agency (EPA), New York State Department of Environmental Conservation (NYSDEC), and Minerals Management Service (MMS), as well as model User's Guides. Guidance also was obtained during preliminary air quality analysis project meetings with NYSDEC and EPA. Based on this information, a draft modeling protocol was prepared. Comments were received from NYSDEC and EPA on the initial modeling protocol submittal in May 2005 (NYSDEC 2005; EPA 2005), and a revised model protocol was submitted in October 2005. Subsequent to the October 2005 modeling protocol, additional information was obtained and actions affecting the modeling protocol occurred. A project air quality update meeting was held with NYSDEC in late October 2005; EPA issued a final rule promulgating the AERMOD model in November 2005; and EPA issued a proposed rule to implement the fine particle (i.e., $PM_{2.5}$) NAAQS. The proposed rule has implications with respect to evaluating $PM_{2.5}$ and potential precursor compounds for New Source Review. NYSDEC Policy CP-33 provides guidance at the state level for $PM_{2.5}$ requirements, including modeling requirements. Continued evaluation of the central Sound buoy meteorological data resulted in the acquisition of backup data-logger data and more new data that improved the data capture statistics for regulatory modeling use. Thus, the modeling protocol was revised to incorporate these items and a revised protocol was issued in January 2006. The revised modeling protocol describing the modeling approach in detail is presented in Appendix A. Also attached to the protocol is a compilation of the comments received from NYSDEC and EPA Region II, as well as responses from Broadwater.

The OCD model is suited to evaluating the transport and dispersion of emissions from an offshore source such as an FSRU over water to a shoreline. While similar to overland Gaussian dispersion models such as ISCST3 and SCREEN3, OCD is optimized for estimating dispersion in an overwater environment by incorporating stability calculation procedures that account for the effect of water/air temperature differences and by explicitly treating the transition from overwater to overland dispersion at the shoreline. The OCD model also contains a downwash calculation procedure to evaluate air quality impacts over water in the immediate vicinity of the FSRU due to aerodynamic effects of air flow over the FSRU. Although this calculation was performed as part of the OCD runs, downwash results from AERMOD-PRIME were used based on comments received from NYSDEC. The OCD model was used to estimate impacts at receptors over water beyond an assumed 500-yard safety and security zone and onshore in New York and Connecticut. While the safety and security zone has not yet been identified by the United States Coast Guard, a 500-yard safety and security zone was assumed in order to reflect a most conservative scenario with respect to evaluating air quality impacts close to the FSRU.

AERMOD-PRIME is an EPA-approved model for evaluating the impact of stationary sources that are land-based. Due to the model's formulation for overland use, only results near the FSRU (i.e., in an area at and just beyond the assumed safety and security zone boundary where the wake region from the FSRU may exist) were used, where the PRIME downwash calculation in the model likely dominates. Thus, the model was limited to evaluating impacts at and just beyond the safety and security zone boundary. The OCD model was used to evaluate dispersion well beyond the assumed 500-yard safety and security zone boundary.

As detailed in the modeling protocol (*see* Appendix A), extensive meteorological data sets for offshore and onshore sites were used in the OCD model. Regional background (existing) air pollutant concentration levels also were obtained from New York State stations located on Long Island and onshore Connecticut stations near the north shore of the Sound (*see* Appendix A). These data were obtained for use as regional background data in a National Ambient Air Quality Standards (NAAQS) analysis, if necessary. If an SIL is exceeded outside the assumed safety and security zone boundary, other large sources are screened to determine whether they potentially affect the FSRU's SIL area. As discussed later in this report, modeled air quality concentrations from OCD runs based on FSRU emissions are below SILs; maximum modeled air quality concentrations from AERMOD-PRIME on the assumed safety and security zone boundary are above SILs for some pollutants but do not exceed any NAAQS.

The modeling protocol also defines how operation of the FSRU was input into the models. Emissions and subsequent ambient air quality impacts are affected by the number of emission sources operating at any given time, the load being placed on each unit (e.g., operating at 50% or 100% of capacity), and the type of fuel being used. Operating scenarios were developed and evaluated in the modeling study to characterize long-term (i.e., annual) impacts on air quality and short-term (i.e., 1-, 3-, 8-, and 24-hour) impacts. These time periods correspond to those used for criteria pollutants in the SILs and NAAQS. The data input to the model runs is described in Section 3.

# 3 Model Input and Options

## 3.1 Facility Description: Emission Source Type, Size, and Operation

The FSRU air emission sources included in the analysis are summarized in Table 1. This table outlines fuel type, rating, and potential operational hours per year for each air emission source. The equipment ratings were derived from the following sources:

- Gas turbines: provided by Broadwater;
- Process heaters: correspondence with Broadwater design engineers;
- Fire pump engines: correspondence with Broadwater design engineers; and
- Emergency generator engines: correspondence with Broadwater design engineers.

As described in the modeling protocol, three gas turbines will be installed on the FSRU; however, only two gas turbines will operate at any time, with the third unit being held as a spare. The heat input rating of each turbine will be 264 million British thermal units per hour (MMBtu/hr) based on an annual average ambient temperature of 60°F, and each turbine will be capable of generating up to 22 megawatts (MW) of electricity. Each turbine will be equipped with a non-fired waste heat recovery unit (WHRU), an SCR for $NO_X$ control, and an oxidation catalyst for CO/VOC reduction. Two of the three gas turbines will operate only on natural gas resulting from the boil-off of LNG that naturally occurs during storage; the third gas turbine will also operate on natural gas but will have dual-fuel capability in order to provide electric power when no natural gas is available onboard (e.g., during initial commissioning). It is anticipated that the dual-fuel capability will not be used once the FSRU is in routine operation; however, an annual operation of 500 hours on diesel was included in the modeling study to account for potential use of oil for an extended time if needed. Diesel use in the spare gas turbine was incorporated into short-term and annual emission rates.

**Table 1 Summary of Emission Sources**

| Source Description | Fuel | Rating[(1)] | Rating Units | Annual Hours of Operation (hr/yr) | Annual Operating Conditions | Annual Operating Conditions Units |
|---|---|---|---|---|---|---|
| Turbine 1 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 2 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 3 (spare) | diesel | 264 | MMBtu/hr | 500 | 132,000 | MMBtu/hr |
| Process Heater 1 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 2 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 3 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 4 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 5 (standby) | nat gas | 1.8 | MMBtu/hr | 8,760 | 15 | MMcf/yr |
| Fire Pump Engine 1 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Fire Pump Engine 2 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Emergency Generator 1 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 2 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 3 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |

(1) Heat input rating based on 60°F ambient temperature.

Five process heaters will be installed to heat a water/glycol mixture that will circulate in a closed-loop system to the shell and tube vaporizers (STVs). One of the five process heaters will be a spare. The process heaters will burn natural gas resulting from the boil-off of stored LNG, and each heater will have a heat input rating of 247 MMBtu/hr. Each heater will be equipped with an SCR for $NO_X$ control and an oxidation catalyst for CO/VOC control. The water/glycol fluid will exchange its heat in the STVs to regasify the LNG. The regasification in the STV results in no emissions from that point.

Equipment that will be installed aboard the FSRU for emergency use only consists of two diesel engines attached to fire water pumps and three diesel engines for driving emergency electrical generators. This equipment is also shown in Table 1 and was evaluated using a 100-hour/year operating limit. This limit was based on information from Broadwater regarding anticipated use, including routine maintenance test runs and provision for use during emergencies.

A flare will also be installed onboard the FSRU, but it will not be ignited for routine or maintenance purposes; thus, it will not operate simultaneously with other emission sources. Its sole purpose is to provide emergency release of natural gas from the storage tanks if an upset condition were to occur. Because this source is not in routine use and is unlikely to see operation during any year, it was not included in the modeling study.

The FSRU is designed to continuously vaporize LNG such that a constant supply to the IGTS pipeline is maintained. A nominal 1.0 bcf/d of natural gas will be delivered with a peak volume of 1.25 bcf/d. This latter volume can be accommodated with two gas turbines and four process heaters operating at 100% load; therefore, for modeling to evaluate annual average concentrations, this equipment was assumed to operate at 100% load for an entire year, although this peak operating level will not be maintained continuously for an entire year. For short-term average concentrations, the highest emission rate for each pollutant, based on an evaluation of full-load or partial-load conditions at varying ambient temperature was used in the study to account for periods when the facility is not operating at peak. The FSRU also will operate under an annual delivery limit to the pipeline of 7.7 million metric tons of natural gas. This latter limit does not affect the operation of the FSRU's emission sources; at a nominal 1.0 bcf/d, the FSRU can operate a full year and not exceed the annual limit.

## 3.2 Stack Parameters

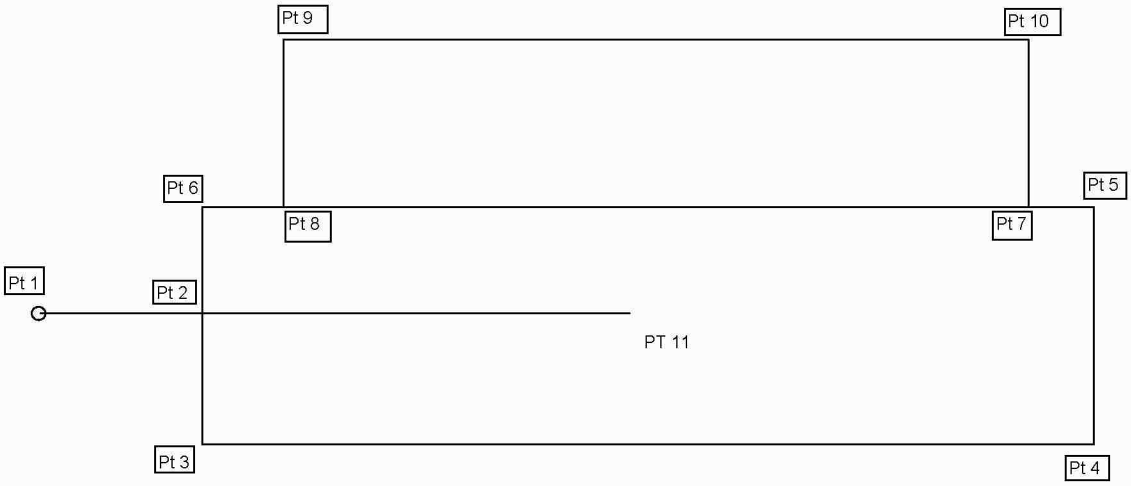
All emission sources on the FSRU are categorized as point sources (i.e., stacks). Model input parameters, including stack height, stack gas temperature, stack exit inside diameter, stack gas exit velocity, stack angle from vertical (OCD only), and elevation of stack base above water surface, are summarized in Table 2. A plot plan of the FSRU is shown in Appendix E.

A schematic drawing of the FSRU with stack coordinates is shown on Figure 2.

**Table 2 Summary of Stack Parameters used in Modeling**

| Source Description | Stack Height Above Water Level (m) | Stack Exit Inside Diameter (m) | Deviation of Stack Angle (deg) | Base Elevation Above Water Level (m) | Stack Gas Temp (K) | Stack Gas Exit Velocity (m/s) | Stack Gas Exit Flow Rate (acm/s) |
|---|---|---|---|---|---|---|---|
| Turbine 1 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 2 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 3 (spare - diesel) | 45 | 3.96 | 0 | 25 | 523 | 10.3 | 127 |
| Process Heater 1 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 2 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 3 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 4 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 5 (spare) | 45 | 4.57 | 0 | 25 | 450 | 0.025 | 0.41 |
| Fire Pump Engine 1 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Fire Pump Engine 2 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Emergency Generator 1 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 2 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 3 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |

| | | | | | |
|---|---|---|---|---|---|
| Assumptions | Direction from YMS toward FSRU in degrees = | 180 | | (N = 0, E = 90, S = 180, W = 270) | |
| | A = Distance from YMS to Front of FSRU = | 50 | m | 164 | ft |
| | B = Width of FSRU = | 60 | m | 197 | ft |
| | C = Length of FSRU = | 366 | m | 1201 | ft |
| | D = Length of LNG Carrier = | 289 | m | 948 | ft |
| | E = Width of LNG Carrier = | 41 | m | 135 | ft |
| | F = Distance from LNG Carrier Stern to FSRU Stern = | 15 | m | 49 | ft |
| | G = Distance between FSRU and LNG Carrier | 5 | m | 16 | ft |




| | | East (m) | North (m) | Safety Boundary | East (m) | North (m) |
|---|---|---|---|---|---|---|
| Pt 1 | Center of YMS | 680910 | 4552135 | Pt12 | 680910 | 4552402 |
| Pt 2 | Midpoint of front (bow) of FSRU | 680910 | 4552085 | Pt13 | 681264 | 4552256 |
| Pt 3 | Port Bow of FSRU | 680880 | 4552085 | Pt14 | 681410 | 4551902 |
| Pt 4 | Port Stern of FSRU | 680880 | 4551719 | Pt15 | 681264 | 4551548 |
| Pt 5 | Starboard Stern of FSRU | 680940 | 4551719 | Pt16 | 680910 | 4551402 |
| Pt 6 | Starboard Bow of FSRU | 680940 | 4552085 | Pt17 | 680556 | 4551548 |
| Pt 6a | | 680940 | 4551758 | Pt18 | 680410 | 4551902 |
| Pt 7 | Port Stern of LNG Carrier | 680940 | 4551753 | Pt19 | 680556 | 4552256 |
| Pt 8 | Port Bow of LNG Carrier | 680940 | 4552047 | | | |
| Pt 9 | Starboard Bow of LNG Carrier | 680981 | 4552047 | | | |
| Pt 10 | Starboard Stern of LNG Carrier | 680981 | 4551758 | | | |
| Pt 11 | Center of FSRU | 680910 | 4551902 | | | |

| | | Distance to Bow (m) | Distance to Port (m) | Distance to Bow (ft) | Distance to Port (ft) | East (m) | North (m) |
|---|---|---|---|---|---|---|---|
| S1 | Turbine 1 | 292 | 25 | 958 | 82 | 680905 | 4551793 |
| S2 | Turbine 2 | 292 | 37 | 958 | 121 | 680917 | 4551793 |
| S3 | Turbine 3 | 292 | 48 | 958 | 157 | 680928 | 4551793 |
| S4 | Process Heater 1 | 323 | 8 | 1060 | 26 | 680888 | 4551762 |
| S5 | Process Heater 2 | 329 | 8 | 1079 | 26 | 680888 | 4551756 |
| S6 | Process Heater 3 | 323 | 31 | 1060 | 102 | 680911 | 4551762 |
| S7 | Process Heater 4 | 329 | 31 | 1079 | 102 | 680911 | 4551756 |
| S8 | Process Heater 5 | 323 | 54 | 1060 | 177 | 680934 | 4551762 |
| S9 | Fire Pump Engine 1 | 341 | 6 | 1119 | 20 | 680886 | 4551744 |
| S10 | Fire Pump Engine 2 | 11 | 30 | 36 | 98 | 680910 | 4552074 |
| S11 | Emergency Generator 1 | 341 | 8 | 1119 | 26 | 680888 | 4551744 |
| S12 | Emergency Generator 2 | 343 | 6 | 1125 | 20 | 680886 | 4551742 |
| S13 | Emergency Generator 3 | 343 | 8 | 1125 | 26 | 680888 | 4551742 |

**Figure 2 FSRU Stack and Structure Coordinates**

## 3.3 Pollutant Emission Rates

For pollutants with short-term averaging periods (1-hour to 24-hour), model runs were conducted using the highest hourly emission rate based on evaluation of emission rates under ambient temperatures from 0°F to 100°F and load ratings from 50% to 100%. The maximum emission rate used as model input was developed through an examination of the equipment emissions under normal operations and based on a peak send-out rate of 1.25 bcf/d. Fifty startup/shutdown cycles were incorporated into these emission rates. Calculation spreadsheets used in determining startup/shutdown emissions are shown in Appendix B, Table B-8.

For pollutants with annual averaging periods, model runs were conducted using the highest hourly emission rate that would occur during delivery of natural gas up to an annual maximum limit of 7.7 million metric tons into the pipeline. In this case, the hourly emission rate was calculated by dividing annual emissions by 8,760 hours per year. Fifty startup/shutdown conditions were incorporated into the annual averaging period emission rates.

Pollutant emission rates used in the modeling are summarized in Table 3. Tables showing the calculations used to derive these emission rates and startup/shutdown emission rates are included in Appendix B.

$NO_X$ emissions from these sources will be in the form of NO and $NO_2$. Following release to the atmosphere, a significant portion of NO is oxidized to $NO_2$. Since New Source Review (NSR) significance levels and NAAQS are expressed in terms of $NO_2$, the model result expressed in terms of $NO_X$ must be converted to an $NO_2$ value. As described in the modeling protocol, the first tier procedure for this conversion is to assume complete conversion of $NO_X$ to $NO_2$; as such, complete conversion was assumed in this study.

## 3.4 Building and Structure Parameters

Building and nearby structure data were included as OCD model inputs to account for potential building wake effects (downwash) on emission plumes. The lengths and widths of the FSRU and LNG carrier are shown on Figure 2. The deck heights (not including the heights of structures on the deck) of the FSRU and LNG carrier were assumed to be 25 m and 15 m, respectively.

For input to AERMOD-PRIME, a more detailed configuration of the FSRU was used as input to the BPIP-PRIME program (BPIP-PRIME prepares the building/wind direction specific data file for use by AERMOD-PRIME). The FSRU was configured as a two-tier structure; Tier 1 corresponds to the length, width and height of the main hull of the FSRU; Tier 2 corresponds to the length, width and height of the accommodation area aft on the FSRU. In addition, a representation of an LNG carrier docked alongside the FSRU was also included in the model;

## Table 3 Summary of Emission Rates for Modeling

| Source Description[1] | 1-Hour to 8-Hour Periods | | | | | 24-Hour Periods | | | Annual | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NO_x$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) |
| Turbine 1 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 2 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 3 (Spare/distillate) | 0.110 | 0.399 | 0.399 | 0.050 | 0.568 | 0.399 | 0.399 | 0.050 | 0.334 | 0.023 | 0.023 | 0.0028 | 0.032 |
| Process Heater 1 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 2 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 3 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 4 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 5 (Standby) | 0.013 | 0.0016 | 0.0016 | 0.00013 | 0 | 0.0016 | 0.0016 | 0.00013 | 0.010 | 0.0016 | 0.0016 | 0.00013 | 0 |
| Fire Pump Engine 1 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Fire Pump Engine 2 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Emergency Generator 1 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 2 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 3 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |

[1] Fifty startup/shutdown cycles for the gas turbines and process heaters are included in the short-term and annual emission rates shown. See Appendix B, Table 8, for startup/shutdown cycle emission rate derivation.

this also was configured as a two-tier structure similar to the FSRU, but with dimensions applicable to a average size LNG carrier.

Tier heights for the vessel structures are:

- • FSRU Tier 1 height 25 meters;
- • FSRU Tier 2 height 45 meters;
- • LNG carrier Tier 1 height 15 meters; and
- • LNG carrier Tier 2 height 30 meters.

As currently configured, the stack heights (height above the water) for the gas turbines and process heaters are equal to the height (height above the water) of the FSRU Tier 2 structure. Stack heights on the FSRU need to be as low as possible (i.e., within the height profile of the overall FSRU) to minimize the visual impact of the FSRU as much as possible.

## 3.5 Meteorological Data

As described in the modeling protocol, the OCD model requires surface meteorological data and upper air data from representative measurement sites over land and over water. These data are combined into two meteorological data files for use in the model: an overwater file and an overland file. The overwater surface data from the central Sound station (buoy 44039) were obtained from the National Data Buoy Center and the University of Connecticut. This buoy is operated by the University of Connecticut and is the data buoy located closest to the proposed FSRU location (University of Connecticut 2005a).

Meteorological sensors manufactured by R.M. Young, Inc., were installed on the central Sound station (buoy 44039) and the western Sound station (buoy 44040) during the data collection period. According to the manufacturer's sensor specification data, the sensors meet EPA PSD monitoring requirements. The accuracy specifications for the equipment are presented in Table 4 and are shown to comply with EPA requirements.

**Table 4 Buoy 44039 and 44040 Meteorological Sensor Specifications**

| Parameter | Sensor Accuracy | EPA Accuracy Requirement[(1)] |
|---|---|---|
| Wind speed | +\- 0.2 m/sec or 1% of observed | +\- 0.2 m/s +5% of observed |
| Wind direction | +\- 3 degrees | +\- 5 degrees |
| Air temperature | +\- 0.3 C | +\- 0.5 C |
| Barometric pressure | +\- 0.5 mb | +\- 3mb |
| Dew Point | Not used | +\- 1.5 C |
| Relative Humidity | +\- 2% | Not given |

(1) Reference: Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005

Quality assurance methods, calibration procedures, and data management are described in a quality assurance plan developed by the University of Connecticut for the buoy measurement program as part of the 'My Sound' project (UConn 2003). The QAP was submitted to the EPA New England Regional Laboratory.

Table 5 lists the sources of overwater and overland surface meteorological data available in the general Project region that were evaluated for use. The two closest routinely operated surface meteorological data sites are Islip MacArthur and Shirley Brookhaven airports. Both sites are approximately the same distance inland from the north and south shores of Long Island. Islip has the advantage of a longer history of operation and well understood site characteristics; therefore, the overland surface data used in OCD and AERMOD-PRIME modeling was obtained from the National Climatic Data Center (NCDC) Integrated Surface Hourly (ISH) database for Islip. The upper air (radiosonde) overland data were obtained for Upton (Brookhaven), New York (World Meteorological Organization [WMO] station number 72501, WBAN station number 14297) from the radiosonde archive of the National Oceanic and Atmospheric Administration (NOAA-RAOB-FSL)(NOAA 2005). Surface and upper air data at these two sites are collected according to NWS procedures. The Islip site is an NWS/FAA ASOS site and the Brookhaven upper air station is part of the nationwide NWS twice-daily radiosonde network.

As described in the first draft modeling protocol, a two-year data set from the central Sound station (buoy 44039) was initially evaluated for modeling use. After evaluating this data set and discussion/comment from NYSDEC and EPA, the raw data recovery from this period was not sufficient for regulatory modeling purposes (raw data recover was less than the 90% minimum required by modeling guidance). Therefore, another data period was selected from available central Sound station (buoy 44039) data.

The data period used in this analysis is 0000 LST December 9, 2004, through 2300 LST December 8, 2005. Raw data recovery statistics for this period are shown in Table 6. One major outage of data occurred during September 2005 when the buoy was removed from the Sound for upgrading of sensor and data transmission equipment. Overall, data from the period meets the 90% recovery requirement on a seasonal basis except for fall 2005; on an annual basis the raw data recovery essentially equals 90%.

**Table 5 Meteorological Stations Near Proposed FSRU Location**

| Station Name | Location | Description | Proximity to FSRU | Operator | Meteorological Sensors | Station No. | Data Availability | Comments |
|---|---|---|---|---|---|---|---|---|
| **Overwater Data Stations** | | | | | | | | |
| Central Long Island Sound Station | Center of Long Island Sound. | Remote Buoy-Mounted. | ~10 mi E | University of Connecticut – Dept. of Marine Sciences | wind speed/direction barometric pressure<br>relative humidity<br>air temperature<br>surface water temperature | 44039 (NOAA NDBC) | Jan 2003 to Dec 2005 | Unedited data available from internet. Logger data available from Univ. Conn. Water depth 90 feet. |
| Ledge Light Station | Northern shore of Long Island Sound, near mouth of Thames River. | Man-made structure about 1-mile offshore | ~40 mi NE | University of Connecticut – Dept. of Marine Sciences | wind speed/direction/gust<br>barometric pressure<br>relative humidity<br>air temperature | LDLC3 (NOAA NDBC) | Jan 1994 to Dec 2005 | Unedited data available from internet. Water temp not measured. |
| Western Long Island Sound Station | Western Long Island Sound; 3 miles offshore of Greenwich CT. | Remote Buoy-Mounted | ~35 mi SW | University of Connecticut – Dept. of Marine Sciences | wind speed/direction<br>barometric pressure<br>relative humidity<br>air temperature<br>surface water temperature | 44040 (NOAA NDBC) | Jun 2003 to Dec 2005 | Unedited data available from internet. Logger data available from Univ. Conn. Water depth 60 feet. |
| **Overland Data Stations** | | | | | | | | |
| BNL (10 m) | ~6 mi S of southern shore of Long Island Sound. | Manned Station | ~15 mi S | BNL – Meteorology Services | **wind speed/direction/gust**<br>**barometric pressure**<br>relative humidity<br>air temperature<br>precipitation<br>solar radiation | LI001 (BNL) | Unknown | Data measurements from Aug 1948 to Present |
| BNL (88 m Tower) | ~6 mi S of southern shore of Long Island Sound. | Manned Station | ~15 mi S | BNL – Meteorology Services | wind speed/direction/gust<br>barometric pressure<br>relative humidity<br>air temperature | LI002 (BNL) | Unknown | At BNL. Real-time data available on BNL web site. |
| Smith Point | South shore of Long Island | Automated (assumed) | ~25 mi S | BNL – Meteorology Services | wind speed/direction/gust<br>barometric pressure<br>relative humidity<br>air temperature | LI003 (BNL) | Unknown | On south shore of Long Island. Real-time data available on BNL web site. |
| Orient Point | Far east end of Long Island | Automated (assumed) | ~40 mi E | BNL – Meteorology Services | wind speed/direction/gust<br>barometric pressure<br>relative humidity<br>air temperature | LI004 (BNL) | Unknown | Data no longer reported on BNL web site. |

## Table 5 Meteorological Stations Near Proposed FSRU Location

| Station Name | Location | Description | Proximity to FSRU | Operator | Meteorological Sensors | Station No. | Data Availability | Comments |
|---|---|---|---|---|---|---|---|---|
| USCG Southern Coastal Station | Unknown | Unknown | Unknown | Unknown | Unknown | LI005 (BNL) | Unknown | Listed on BNL Website early 2005, no longer listed in 2006. |
| Bridgeport Sikorsky Airport | ~1 mi N of northern shore of Long Island Sound. | Automated | ~18 mi NW | NWS/ASOS | wind speed/direction barometric pressure<br>dew point<br>air temperature<br>visibility<br>sky conditions | 14740 (WBAN) | Jul 1996 to Dec 2005 | Edited data available from NCDC. ASOS ASOS-NWS-COOP |
| Shirley Brookhaven Airport | ~ 10 mi S of southern shore of Long Island Sound | Automated | ~20 mi S | NWS/FAA | wind speed/direction barometric pressure<br>dew point<br>air temperature<br>visibility<br>sky conditions | 54790 (WBAN) | Sept 29 1999 to present | Unedited data available from NCDC. ASOS ASOS-FAA |
| Islip MacArthur Airport | ~12 mi S of southern shore of Long Island Sound. | Automated | ~25 mi SW | NWS/ASOS/ FAA | wind speed/direction barometric pressure<br>dew point<br>air temperature<br>visibility<br>sky conditions | 04781 (WBAN) | Jul 1996 to Dec 2005 | Edited data available from NCDC. ASOS ASOS-FAA COOP |
| New Haven Airport | ~1 mi N of northern shore of Long Island Sound. | Automated | ~12 mi N | FAA | wind speed/direction barometric pressure<br>relative humidity<br>air temperature | 14758 (WBAN) | Nov 2001 to Feb 2005 | Unedited data available from NCDC. ASOS ASOS-FAA SAWRS. Slightly inland. |
| Long Island Ferry | Service from Port Jefferson, NY to Bridgeport, CT | Ferry | ~15 mi W | Sound Science | wind speed/direction/gust baro-metric pressure<br>relative humidity<br>air temperature<br>surface water temperature | 10 Different Id's for different loca-tions along route. (NOAA NDBC) | 2004 | Measurements began in 2003. Intermittent. |
| SUNY Stony Brook | ~5 mi S of southern shore of Long Island Sound. | Manned Station | ~19 mi SW | SUNY Stony Brook | wind speed/direction barometric pressure<br>relative humidity<br>air temperature | Unknown | Unknown | |

Key:

ASOS = Automated Surface Observation System
BNL = Brookhaven National Laboratory
COOP = Cooperative Station
FAA = Federal Aviation Administration
NDBC = National Data Buoy Center
NWS = National Weather Service
SAWRS = Supplementary Airways Reporting Station
WBAN = Weather Bureau - Army - Navy

Table 6 Raw Data Recovery for Buoy 44039

| Data Period | Total Hours | Data Hours (Air T, Winds, RH) | Data Hours (water temp) | Percent Recovery (Air T, Winds, RH) | Percent Recovery (water T) |
|---|---|---|---|---|---|
| 1st quarter (Dec 9-Mar 9) | 2190 | 2139 | 2139 | 97.7 | 97.7 |
| 2nd quarter (Mar 10 – June 8) | 2190 | 2190 | 2190 | 100 | 100 |
| 3rd quarter (June 9 – Sept 8) | 2190 | 2031 | 2031 | 92.7 | 92.7 |
| 4th quarter (Sept 9 – Dec 8) | 2190 | 1484 | 1437 | 67.8 | 65.6 |
| 12 month | 8760 | 7844 | 7797 | 89.5 | 89.0 |

### Upper Air Data

There are no stations that collect overwater upper air data along the immediate coastline of Long Island Sound or over the Sound itself. The closest site collecting upper air data is Upton (Brookhaven), New York, approximately 15 miles south of the proposed FSRU location. Brookhaven is located approximately midway between the north and south coasts of Long Island, approximately 7.5 miles from each coast. At this location, Long Island is approximately 15 miles wide. Although the land surface will influence the very near surface conditions differently than over water, the long fetch over the ocean to the south of Brookhaven and the approximately 20-mile fetch over the water in Long Island Sound to the north of Brookhaven impart a strong maritime signature in the low-altitude atmospheric conditions. Thus, the Brookhaven overland upper air data were deemed an appropriate representation for the Project area and for overwater upper air observations.

**Processing Upper Air Data for OCD.** The Brookhaven sounding data obtained from the NOAA-RAOB-FSL database are in the form of measurements of temperature, dew point, wind speed and direction, altitude, and pressure. In order to develop the hourly mixing heights needed for the OCD modeling study from these data, the Brookhaven radiosonde data were processed using the EPA's Mixing Height program (EPA 1998). This program reads in the radiosonde data along with concurrent surface meteorological data (obtained for Islip, New York) and computes twice-daily (morning and afternoon) mixing heights. The radiosonde data were obtained from NOAA in the original FSL format. The Islip (MacArthur Airport), New York, surface meteorological data were converted to the Hourly United States Weather Observation (HUSWO) format as required prior to use in the Mixing Height program.

Based on output from the mixing height analysis, for the meteorological record period (December 9, 2004, to December 8, 2005) the average annual morning and afternoon mixing heights are 707 and 780 meters, respectively. These mixing heights are lower than typical average overland values and thus appear to reflect the general expectation that mixing heights are lower over large water bodies or areas near large water bodies.

The twice-daily mixing height file output from the Mixing Height program was used as input to the PCRAMMET meteorological preprocessor to prepare the model-ready hourly overland surface file for use in OCD. Use of PCRAMMET for the preparation of overland meteorological data is discussed next.

**Processing Upper Air Data for AERMOD-PRIME.** Upper air data for AERMOD-PRIME are processed using the AERMET meteorological preprocessing program. The requirements for mixing height data in AERMOD-PRIME are significantly different than for OCD. AERMOD-PRIME uses the morning radiosonde data in various boundary layer calculations. Use of the EPA mixing height program data is not needed in AERMOD-PRIME. The Brookhaven sounding data were processed through Stage 1 of AERMET for quality assurance checks. The quality checked data output from Stage 1 was then merged with Islip surface data in Stage 2 of AERMET. The resulting merged file was then processed in Stage 3 of AERMET to form the surface and profile files required for running AERMOD.

### Overland Meteorological Surface Data Processing for OCD

Overland surface meteorological data are used in the Mixing Height program discussed above and in PCRAMMET to prepare the overland meteorological file used in the OCD model. PCRAMMET is a meteorological data processor program provided by EPA for use in preparing a "model-ready" meteorological data file. PCRAMMET version 99169 was used (EPA 1999).

PCRAMMET was run using the twice-daily mixing height file from the Mixing Height program and the Islip (MacArthur Airport), New York, surface data. Since deposition calculations were not being performed for this study, the PCRAMMET input for this was set to "none"; other user input for operation of PCRAMMET includes entering the surface station latitude and longitude (40.783N and 73.1W for Islip, New York) and time zone from GMT (4).

PCRAMMET processes the input data to obtain an hourly meteorological data file for the year in a format that is compatible with OCD. During processing, the program calculates stability class and converts the twice-daily mixing heights to hourly mixing heights using the method developed by Holzworth as described in the PCRAMMET User's Guide (EPA 1999).

The OCD model cannot process meteorological data that crosses a change in year (i.e., from December 31, 2004, to January 1, 2005) because it uses a Julian day counter, which is reset on January 1 to Julian day 1. Therefore, the Julian day counter for the starting day of the meteorological data set (December 9, 2004) was set as Julian day 1; subsequent days were numbered sequentially from this starting point.

## Overwater Meteorological Data Processing

The overwater file required by OCD contains surface meteorological data (wind direction and speed, air temperature, and relative humidity), surface water temperature data, and hourly mixing height data. Several steps are required to prepare this data file for use in OCD. Although the OCD model package has a meteorological data processor (OCDPRO), it is of limited usefulness since it is intended to be used only as a final step in preparing the overwater file after all sources of substitute overwater data have been exhausted. OCDPRO aids in building the overwater file by substituting default values for various parameters (e.g., 500 m for a missing mixing height).

As shown earlier, much of the central Sound station (buoy 44039) data was complete outside of the fall 2005 period. Filling in of the short duration missing data during the winter, spring, and summer periods was accomplished using Microsoft Excel spreadsheets; missing values were filled in either by interpolation and/or persistence for short periods following EPA guidance and procedures described in the OCD model User's Guide (DOI 1997 and 1989).

Missing data in the central Sound station (buoy 44039) data set during the 4th quarter of the data period was due primarily to the buoy being taken out of the water for various equipment upgrades. The data missing from this period were substituted with data from the western Sound station for air and water temperature and relative humidity and from Bridgeport Sikorsky Memorial Airport for wind direction and speed.

The western Sound station was deemed representative of meteorological conditions such as air temperature, water temperature, and relative humidity because it is influenced by the Sound similarly to the Central Sound station (buoy 44039). The Bridgeport Sikorsky Memorial Airport meteorological station was selected as the primary site for obtaining representative wind direction and speed data for filling in missing data during the 4th quarter period. Of the available sites for obtaining wind data for substitution, this location is the closest to the central Sound station (buoy 44039) and is located within 1 mile of the coastline on a small peninsula extending slightly into the Sound. Wind conditions at this location exhibits a substantial influence of the Sound.

Other in-Sound sites or coastal stations, such as the Ledge Light weather station, were not used. Ledge Light is located just offshore from the mouth of the Thames River (near New London, Connecticut) but is further away than Bridgeport and was deemed to be not representative of central Sound conditions.

The air/water temperature difference is used to determine the overwater atmospheric stability and, thus, the degree to which pollutants are mixed upward or trapped near the surface over water. When the water temperature is warmer than the air temperature, the atmosphere is in an unstable condition since heat is transferred from the water to the near-surface air, warming it and increasing its buoyancy compared to air above it, causing it to rise. Conversely, when air temperature is warmer than the water temperature, upward air motion is limited or nonexistent, and a stabilizing effect occurs since heat is transferred from the air to the water. Emissions released into an unstable atmosphere will be mixed upwards to a greater extent and would be expected to result in lower surface concentrations of air pollutants than would be observed in a stable atmosphere.

The OCD default procedure of setting the air and water temperatures equal results in a neutral stability condition that does not bias stability in either direction. In doing so, the frequency of occurrence of stable and unstable conditions is likely underestimated. The effect on model results on an annual concentration basis is likely insignificant, since over a year the periods of stable and unstable conditions may balance out, resulting in neutral stability on an annual average basis. The effect on short-term concentration estimates is more difficult to estimate. For 1-hour concentration estimates, if there are enough valid 1-hour data periods in a data set, then the maximum concentration can be approximated; with increasing length of the short-term averaging period (i.e., 3, 8 and 24 hours), the use of neutral stability may result in a larger error due to under- or overestimation of concentrations. This influence on short-term concentrations would be especially important if modeled concentrations were near applicability thresholds, since it would lead to less confidence in predicted concentrations. For model results that are substantially below any thresholds, use of the OCD default setting for air/water temperature difference is not expected to influence results such that exceeding a threshold would otherwise occur.

Due to the availability of data from the western Sound station (buoy 44040) and the uncertainties introduced by the default OCD procedure discussed above, the default procedure of setting the air and water temperature equal to each other was not used. Representative water temperature data for substitution from the western Sound station (buoy 44040) was deemed the best available given the western Sound station's (buoy 44040) location in similar water depth and reasonably close location. When water temperature was missing in the central Sound station (buoy 44039) data set, the air and water temperature pair from the western Sound station (buoy 44040) were substituted into the central Sound station (buoy 44039) data set to maintain the single site location for the air/water temperature data pair, as recommended in OCD model guidance. Other coastal Sound stations that potentially could be used for substitution either recorded water temperature in a location near shore or near the mouth of a river emptying into the Sound, which would cause the data to not reasonably represent central Sound conditions, or had missing data for the same periods as in the central Sound station (buoy 44039) data set. Since water temperature does not vary as quickly as air temperature or other meteorological parameters, it was possible to use interpolation and/or persistence to fill in missing data for periods of short duration.

Overwater mixing height data were not available from any overwater or coastline stations. As discussed previously, mixing height determined from Upton (Brookhaven), New York, radiosonde data were determined to be representative of the overwater atmosphere due to the significant amount of water body (Atlantic Ocean and Long Island Sound) surface area compared to land mass area in the region and the influence the water surface has on the atmosphere in the region.

Thus, hourly rural mixing height data from the PCRAMMET output file were incorporated into the OCD overwater meteorological file.

## 3.6 Receptors

### OCD

Ambient air quality impacts were analyzed at specific receptor locations input into the model. Three receptor grids were used: the highest-density receptor grid pattern (a Cartesian grid) was nested inside of two less-dense polar receptor grids as follows:

- • A 2-km by 2-km Cartesian grid system was centered on the FSRU with 100-m spacing in the x and y directions between the grid points. Locations within an assumed 500-yard safety and security zone around the FSRU were excluded. To date, the United States Coast Guard (USCG) has not defined a specific safety and security zone for the Project. However, for the purposes of air quality modeling and to assess potential impacts, a representative safety and security zone was included, based on previous safety and security zones established both within Long Island Sound and for other LNG facilities. Following establishment of a defined safety and security zone by the USCG, Broadwater will update the modeling, as necessary, to represent anticipated conditions.

- • Extending out from the boundary of the Cartesian receptor grid described above, a radial (i.e., polar) grid system was established with receptors located on radial arms at 10-degree compass direction intervals centered on the FSRU. On each radial, receptors were placed at 100-m intervals between 1.5 km and 2.5 km; from 2.5 km to 5 km, receptors were placed at 500-m intervals.

A large-scale receptor grid covering an area measuring 20 km-by-20 km centered on the FSRU was used to evaluate transport to shore, with receptors located 3.4 km and 4.1 km apart in the east-west and north-south directions, respectively.

### AERMOD-PRIME

The analysis using AERMOD-PRIME focused on close-in air quality impacts at the assumed safety and security zone boundary distance (500 yards) and in the near-water area beyond the assumed boundary. These locations would most likely be located in the near- and far-wake regions if downwash were to occur. Receptors were placed along the assumed safety and security zone boundary at 25-meter lateral distance separation. A Cartesian grid was used outside of the assumed safety and security zone boundary with a square grid receptor spacing of 35 meters in the east-west and north-south directions; this spacing resulted in a maximum lateral spacing of 50 meters diagonally between receptor locations. The grid extended a minimum distance of 750 meters in the east-west and north-south directions to a maximum distance of 1,330 meters in the northeast/southwest and northwest/southeast directions beyond the assumed safety and security zone boundary.

## 3.7 Land Use

Determination of land use characteristics followed the procedure outlined in the modeling protocol. The surface roughness length for the overland meteorological data in OCD was chosen to be 0.024 m, which is representative of land surfaces near Islip, New York.

## 3.8 Miscellaneous Model Options

The following options were used during OCD model runs: stack-tip downwash, buoyancy-induced dispersion, and terrain adjustments. The gradual plume rise option was not used during the OCD model runs. In accordance with recommendations in the OCD User's Guide, the minimum "miss distance" was set equal to 10 m.

In AERMOD-PRIME, the non-regulatory default option was selected in order that the 'assume flat terrain' option could be chosen. All receptors used in AERMOD-PRIME were located overwater with no intervening land features present.

# 4 Results

The receptor grids used in OCD and AERMOD-PRIME were designed to thoroughly cover the model's respective study areas in order to find the maximum ambient concentration (highest annual and highest first high for short-term averaging periods) for each regulated pollutant for each pollutant's applicable averaging time. Thus, the model's output for all receptors was analyzed to find these specific concentrations. All other receptor locations would have predicted concentrations less than the maximum values.

For pollutants with short-term averaging periods (i.e., 1 hour to 24 hours), the modeled air quality concentrations are based on maximum operation of FSRU gas turbines, process heaters, and diesel engines attached to emergency equipment. The diesel engines attached to the emergency equipment would not normally run during normal operation of emission sources except for routine test purposes; thus, model results for a 1-hour average period would be the most reflective of actual conditions. However, in the modeling study, the maximum hourly emission rate for the diesel engines was used for short-term periods up to 24 hours, even though operating the engines for this duration (i.e., 3, 8, or 24 hours) would not occur concurrently with gas turbine and process heater operation. Annual impacts are based on continuous operation of FSRU turbines and process heaters at full load for a full year (8,760 hours) and operation of diesel engines for fire water pumps and emergency electrical generators for 100 hours per year.

Ambient impacts were compared with significant impact levels defined in NSR regulations. The OCD results and the comparison are presented in Table 7.

**Table 7 OCD Model Results**

| Pollutant | Averaging Period | Significant Impact Level ($\mu g/m^3$) | OCD Maximum Predicted ($\mu g/m^3$) | Exceeds Significant Concentration Level? |
|---|---|---|---|---|
| Carbon monoxide (CO) | 8-Hour | 500 | 111 | No |
| | 1-Hour | 2,000 | 258 | No |
| Nitrogen dioxide ($NO_2$) | Annual | 1 | 0.26 | No |
| $PM_{10}$ | Annual | 1 | 0.05 | No |
| | 24-Hour | 5 | 2.82 | No |

**Table 7 OCD Model Results**

| Pollutant | Averaging Period | Significant Impact Level (µg/m³) | OCD Maximum Predicted (µg/m³) | Exceeds Significant Concentration Level? |
|---|---|---|---|---|
| $PM_{2.5}$ | Annual | 1 | 0.05 | No |
| | 24-Hour | 5 | 2.75 | No |
| Sulfur dioxide ($SO_2$) | Annual | 1 | 0.00 | No |
| | 24-Hour | 25 | 0.15 | No |
| | 3-Hour | 5 | 0.65 | No |
| Ammonia ($NH_3$) | Annual | 100[(1)] | 0.06 | Below AGC |
| | 1-hour | 2,400[(1)] | 9.50 | Below SGC |

(1) Significant concentrations for ammonia taken from NYSDEC DAR-1 guidance, short term guideline concentration/annual guideline concentration (SGC/AGC) table. The 1-hour maximum impact was compared to the SGC, and the annual maximum impact was compared to the AGC.

As shown in Table 7, all predicted maximum concentrations (i.e., the highest concentration found throughout the entire OCD receptor grid) are less than the NSR significance levels applicable to Class II areas. Therefore, the Project is expected to have minimal air quality impacts and does not require further modeling analysis.

OCD model input files, output files, overland and overwater meteorological data sets are included on a CD-ROM in Appendix C.

### Building Downwash Wake Effects and Cavity Analysis – AERMOD PRIME

AERMOD-PRIME was used to evaluate building downwash effects. The purpose was to determine concentrations near the FSRU due to downwash of stack emissions caused by aerodynamic effects of the ship's structure. The locations of maximum concentrations were examined in relationship to an assumed safety and security zone distance of 500 yards. Concentration estimates produced by AERMOD-PRIME, if greater than the maximum concentration estimated from OCD, would be compared to SILs for criteria pollutants with short-term averaging periods (e.g., CO) or against the NYSDEC DAR-1 SGC for ammonia (ammonia is emitted due to use of the SCR for $NO_X$ control). The modeling protocol discusses the implementation of AERMOD-PRIME for this project.

AERMOD-PRIME results are presented in Table 8 and show higher maximums than obtained using OCD. Some maximums are shown to be above the applicable SIL. The locations of these maxima are on or near the assumed safety and security zone boundary. For pollutant and averaging period combinations for which an SIL is exceeded, an additional step in evaluating the impact on ambient air quality was taken.

Air Guide 26 prescribes procedures for determining air quality standards compliance. Two components of the background concentration are nearby source impacts and regional background levels. The regional background values are taken from available ambient air quality monitoring data from stations representative of the region. The second component of the analysis is a nearby source analysis, primarily used if the proposed source is subject to PSD or if the source is below PSD thresholds and is located on land with its significant impact area (SIA) overlapping the location of permanent receptors or other sensitive ecological receptors. In the latter situation, a nearby source analysis may be warranted to evaluate the potential cumulative effect on the local population. The location of the FSRU in the middle of Long Island Sound, approximately 9 miles from the New York shore, indicates that other sources are likely not closer than 9 miles from the facility (there are no other stationary sources in the waters of the middle section of Long Island Sound) and that there are no permanent receptors located within a 9-mile radius of the FSRU. In addition, the significant impact area radii (i.e., distance from the assumed FSRU safety and security boundary outward to the farthest location at which ambient impacts decrease below the SIL) for FSRU emissions are over water. Therefore, the potential for a cumulative impact between other nearby sources and the downwash related impacts at an onshore location is unlikely.

Regional background ambient air concentrations for the New York stations listed in Table 3-8 of the modeling protocol (see Attachment A) were added to the maximum concentration and compared to the NAAQS to address the first component of the Air Guide 26 recommended procedure. The results of this comparison are also shown in Table 8. No NAAQS are exceeded.

Table 8 AERMOD-PRIME

| Pollutant | Averaging Period | Significant Impact Level and NAAQS (SIL/NAAQS) (µg/m³) | AERMOD-PRIME Maximum (µg/ m³) | AERMOD-PRIME Maximum including Background[1] (µg/ m³) | Exceeds SIL/NAAQS? |
|---|---|---|---|---|---|
| Carbon monoxide (CO) | 8-Hour | 500/10,000 | 517 | 3,831 | Y/N |
| | 1-Hour | 2,000/40,000 | 971 | - | N/N |
| Nitrogen dioxide ($NO_2$) | Annual | 1/100 | 2.02 | 24.7 | Y/N |
| $PM_{10}$ | Annual | 1/50 | 1.32 (1st high)<br>1.26 (4th high) | 16.3 | Y/N |
| | 24-Hour | 5/150 | 17.8 | 63.5 | Y/N |
| $PM_{2.5}$ | Annual | 1/15 | 1.32 | 12.5 | Y/N |
| | 24-Hour | 5/65 | 22 | 59 | Y/N |
| Sulfur dioxide ($SO_2$) | Annual | 1/80 | 0.1 | - | N |
| | 24-Hour | 25/365 | 1.5 | - | N |
| | 3-Hour | 5/1,300 | 2.2 | - | N |
| Ammonia ($NH_3$) | Annual | 100[2] | 1.5 | - | Below AGC[1] |
| | 1-hour | 2,400[2] | 32.6 | - | Below SGC[1] |

Notes:
(1) Background concentrations are shown in Table 3-8 of the Modeling Protocol.
(2) Significant concentrations for ammonia taken from NYSDEC DAR-1 guidance, short term guideline concentration/annual guideline concentration (SGC/AGC) table. The 1-hour maximum impact was compared to the SGC, and the annual maximum impact was compared to the AGC.

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# A

# Air Quality Analysis Modeling Protocol

# Air Quality
# And
# Visible Plume Analysis
# Modeling Protocol
# Broadwater LNG Project
# Long Island Sound, New York

**Revised**
**January 2006**

**Submitted To:**

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**Appendix**

# List of Tables

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# List of Abbreviations and Acronyms

| | |
|---|---|
| AERMOD-PRIME | American Meteorological Society/Environmental Protection Agency Regulatory Model-Plume Rise Model Enhancements |
| AQCR | air quality control region |
| bcf | billion cubic feet |
| bcf/d | billion cubic feet per day |
| BNL | Brookhaven National Laboratory |
| BoD | basis-of-design |
| CEC | California Energy Commission |
| CFR | Code of Federal Regulations |
| CO | carbon monoxide |
| CSVP | Combustion Source Visible Plume |
| CTDEP | Connecticut Department of Environmental Protection |
| CWA | Clean Water Act |
| CY | Calendar Year |
| °C | degrees Celsius |
| °F | degrees Fahrenheit |
| DEM | digital elevation model |
| EPA | (United States) Environmental Protection Agency |
| FERC | Federal Energy Regulatory Commission |
| FSL | Forecast Systems Laboratory |
| FSRU | Floating Storage and Regasification Unit |
| IGTS | Iroquois Gas Transmission System |
| ISC | Industrial Source Complex |
| ISC-PRIME | Industrial Source Complex Model with Plume Rise Model Enhancements |
| km | kilometer |
| LNG | liquefied natural gas |
| m | meter |

## List of Abbreviations and Acronyms (cont.)

| | |
|---|---|
| $m^2$ | square meter |
| $m^3$ | cubic meter |
| $\mu g/m^3$ | microgram per cubic meter |
| m/s | meters per second |
| MMBtu/hr | million British thermal units per hour |
| MMS | Minerals Management Service |
| MW | megawatt |
| NAAQS | National Ambient Air Quality Standards |
| NDBC | National Data Buoy Center |
| NO | nitrogen oxide |
| $NO_2$ | nitrogen dioxide |
| NOAA | National Oceanic and Atmospheric Administration |
| $NO_x$ | nitrogen oxides |
| NSR | New Source Review |
| NWS | National Weather Service |
| NYSDEC | New York State Department of Environmental Conservation |
| OCD | Offshore Coastal Dispersion |
| OCD/5 | OCD-Version 5 |
| $PM_{2.5}$ | particulate matter with aerodynamic diameters of 2.5 microns or less |
| $PM_{10}$ | particulate matter with aerodynamic diameters of 10 microns or less |
| ppm | parts per million |
| PSD | Prevention of Significant Deterioration |
| PTE | potential to emit |
| SCR | selective catalytic reduction |
| SIL | significant impact level |
| $SO_2$ | sulfur dioxide |
| STV | shell and tube vaporizer |
| tpy | tons per year |
| TSP | total suspended particulates |
| USCG | United States Coast Guard |
| USGS | United States Geological Survey |
| VOCs | volatile organic compounds |
| WFO | weather forecasting office |

| | |
|---|---|
| YMS | yoke mooring system |

# 1 Introduction

This protocol document provides a description of the data to be used and the air quality and visible plume modeling methods to be employed to evaluate the Broadwater Project. Modeling analyses will be developed and reported in a Resource Report as part of the license application to the Federal Energy Regulatory Commission (FERC) and in an air permit application to the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (EPA) Region 2. In addition to air pollutant dispersion modeling, this protocol discusses the modeling method used to evaluate the potential for a visible (steam) plume. This latter modeling effort will be used in the analysis of aesthetic/visible resource impacts as required as part of the New York State Department of State Coastal Zone Consistency determination process.

## 1.1 Project Background

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and interconnected subsea pipeline for the importation, storage, regasification, and transportation of natural gas. In addition, Broadwater Energy will file an application for an air pollution control permit from the New York State Department of Environmental Conservation (NYSDEC). The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS).

The Project will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters, as shown on Figure 1-1. The LNG terminal facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcfd) and will be capable of delivering a peak throughput of 1.25 bcfd. The Project will deliver the regasified LNG to the existing natural gas pipeline system via a subsea interconnection to the IGTS pipeline.

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Source: ESRI StreetMap, 2002.

Figure 1-1
Proposed Broadwater Project
Location in Long Island Sound

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [$m^3$] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas) with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. Process heat required for LNG vaporization and all power for the regasification process will be provided by equipment onboard the FSRU. Three gas turbines of 22 MW generating capacity each and five process heaters, each with a heat input rating of 247 MMBtu/hr, will be installed. Two diesel engine fire water pumps and three diesel engine emergency electrical generators also will be installed.

The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 $m^3$ up to a potential future size of 250,000 $m^3$ at the frequency of two to three carriers per week. LNG carriers will supply their own power needs during unloading and will not connect to the FSRU's power system during unloading. The LNG carriers will be owned and operated by entities other than Broadwater Energy, TCPL LNG USA, Inc., or Shell Broadwater Holdings LLC.

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the stationary tower also serves the purpose of securing the FSRU in such a manner to allow it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS), allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [$m^2$]).

A 30-inch-diameter subsea natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be installed beneath the seafloor from the FSRU mooring structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. Figure 1-1 presents the proposed pipeline route.

## 1.2 Emission Sources

Broadwater conducted an initial engineering assessment and subsequently developed a revised engineering assessment in August 2005. The initial engineering assessment identified the functional requirements and design premise for the FSRU and was used as the basis for the May 2005 modeling protocol previously submitted to NYSDEC and USEPA. This included identification of the design requirements for equipment to be utilized on the FSRU but it did not include a final engineering design or selection of this equipment. Subsequently, the Broadwater engineering team conducted a control technology evaluation for equipment identified in the initial assessment. Following completion of the control technology evaluation, a revised engineering assessment was prepared that documents equipment design.

For review purposes, the equipment information presented in this revised protocol is based on the revised engineering assessment, which forms the basis of the FERC application package. Although slight changes to details of the FSRU's design may be made during finalization of the design, it is anticipated that the revised engineering assessment will remain a firm basis for modeling and air permit application purposes.

The primary emission sources identified for the FSRU are gas turbines (with unfired waste heat recovery) for power generation and process heaters for the LNG vaporizers. Various types of auxiliary equipment have also been identified as potential emission sources. The number of gas turbines and process heaters/LNG vaporizers will be based on an "N+1" concept, with "N" being the equipment required to achieve nominal operation. Thus, one unit of each equipment type generally serves as a "spare" to the other units.

Three turbines are currently planned for the FSRU; one turbine will be a true spare with only two turbines operating concurrently. Each gas turbine/generator set will provide up to 22 megawatts (MW) of electrical power for FSRU operations. The turbines will combust natural gas as the primary fuel, with diesel fuel available on only one turbine for emergency situations or during initial operation of the FSRU prior to LNG delivery. Each turbine will be equipped with an unfired waste heat recovery unit and each will be equipped with a Selective Catalytic Reduction (SCR) and oxidation catalyst for nitrogen oxides ($NO_X$) and carbon monoxide/volatile organic compound (CO/VOC) reduction, respectively.

The LNG vaporizer technology used will be process heaters with STVs. A process heater incorporates a natural gas burner to heat a water-glycol mixture to be circulated in the closed-loop system of an STV. The heated water-glycol mixture will run through the "shell" side of the system, with LNG running through the "tube" side. Heat transfer between the two sides will vaporize the LNG to natural gas. There is no emission to the atmosphere from an STV during regasification. The design calls for five process heaters (N+1), with each unit capable of firing only natural gas at a rate of 247 million British thermal units per hour (MMBtu/hr). Each process heater will be equipped with an SCR to control $NO_X$ and an oxidation catalyst for CO/VOC reduction.

The FSRU will include the following auxiliary equipment:

- • Three diesel-fired emergency generators (each with an approximate rating of 22.8 MMBtu/hr);
- • Two diesel-fired fire pump engines (each with an approximate rating of 15.1 MMBtu/hr); and
- • One flare not for routine use; to be used only to combust emergency gas releases.

The air pollutants associated with the combustion of natural gas and diesel fuel include:

- • CO;
- • $NO_x$, which includes nitrogen oxide (NO) and nitrogen dioxide ($NO_2$);
- • Particulate matter with aerodynamic diameters of 10 microns or less ($PM_{10}$);
- • Particulate matter with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$);
- • Sulfur dioxide ($SO_2$); and
- • VOCs.

Operation of the SCR units on the gas turbines and process heaters will result in some ammonia emissions due to the "slip" of unreacted ammonia through the catalyst bed.  A feedback control system will be utilized to minimize ammonia slip.

Water vapor emissions occur from the gas turbines and process heaters as a normal by-product of fuel combustion.  In addition, the injection of aqueous ammonia for SCR operation and the production of water from the reaction within the SCR catalyst bed introduces additional water to the exhaust stream.  A visible plume model is used to model water vapor emissions from the gas turbines and process heaters.  Emission of water vapor from the auxiliary equipment (fire pump and emergency generator engines) is expected to be minimal and not of consequence for the visible plume analysis due to infrequent use and small source size.

Basic information describing the stationary sources is summarized in Table 1-1.

**Table 1-1 Summary of Emission Sources**

| Source Description | Fuel | Rating | Rating Units | Annual Hours of Operation (hr/yr) | Annual Operating Conditions | Annual Operating Conditions Units |
|---|---|---|---|---|---|---|
| Turbine 1 | nat gas | 264 | MMBtu/hr | 8,760(1) | 2,312,640 | MMBtu/hr |
| Turbine 2 | nat gas | 264 | MMBtu/hr | 8,760(1) | 2,312,640 | MMBtu/hr |
| Turbine 3 (Spare) | diesel | 264 | MMBtu/hr | 500(1) | 132,000 | MMBtu/hr |
| Process Heater 1 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 2 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 3 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 4 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 5 (Standby) | nat gas | 1.8 | MMBtu/hr | 8,760(2) | 15 | MMcf/yr |
| Fire Pump Engine 1 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Fire Pump Engine 2 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Emergency Generator 1 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 2 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 3 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |

1 For actual operation, turbine 3 may be operated when either turbine 1 or 2 are taken out of service. Combined annual operating hours for all turbines will be 18,020 (8,760*2+500)

2 Process heater 5 will remain on standby unless needed to replace operation of another process heater that is taken out of service for repair, maintenance, or for other reasons goes to a standby condition.

In addition to the stationary emission sources on the FSRU, electric power generating equipment on the LNG carrier will be operated during LNG offloading while the carrier is moored to the FSRU. As combustion source(s), this equipment will emit the same type of pollutants as the FSRU sources. These emissions will occur for a 22-hour period approximately every two to three days.

## 1.3 Existing Air Quality

### 1.3.1 Attainment Status

The proposed FSRU will be located in the waters of Suffolk County, New York. The county is part of the New Jersey-New York-Connecticut Interstate Air Quality Control Region (AQCR). Suffolk County is currently designated as an attainment area for the National Ambient Air Quality Standards (NAAQS) for CO, lead, $NO_2$, $PM_{10}$, and $SO_2$; a moderate nonattainment area for the 8-hour ozone NAAQS; and a nonattainment area for the annual $PM_{2.5}$ NAAQS. The nonattainment designation under the 1-hour ozone NAAQS expired as the area's official designation on June 15, 2005, when it was replaced by the 8-hour ozone designation. However, until the New York State Implementation Plan (SIP) for ozone is revised to implement control programs addressing the 8-hour ozone nonattainment designation, the provisions in the SIP for 1-hour ozone nonattainment remain in effect. New sources applying for permits during the transition period from the 1-hour to the 8-hour ozone SIP need to address 1-hour requirements. Emissions of $NO_x$ and VOCs are regulated to control ozone.

Nonattainment New Source Review (NSR) includes many stringent requirements, including the application of the lowest achievable emission rate (LAER) to source emissions. The emission rates incorporated into the design of the FSRU are consistent with LAER in the current 1-hour ozone nonattainment area. Based on the estimated annual potential emissions (including use of SCR and oxidation catalyst) presented in Table 1-2, and assuming the New York State SIP has been revised for the 8-hour moderate ozone nonattainment designation, potential $NO_x$ and VOC emissions from the facility will be below 100 tpy and 50 tpy, respectively. As a minor stationary source in an ozone nonattainment area, the Project will not be subject to ozone nonattainment requirements in the NSR regulations. If the New York State SIP provisions for the 1-hour severe ozone nonattainment designation remain in effect, the Project will be subject to nonattainment NSR requirements for $NO_X$. In accordance with the New York SIP, federal NSR regulations are administered by NYSDEC under NYCRR Title 6, Part 231 (6 NYCRR 231).

**Table 1-2 Annual Potential to Emit for the Proposed FSRU Stationary Sources and Nonattainment NSR/Title V Major Source Size Thresholds**

| Air Pollutant(1) | Estimated Annual Emissions(2) (tpy) | Major Source Size (tpy) |
|---|---|---|
| $NO_X$(3) | 71 | 100/25 |
| CO | 88 | 100 |
| VOCs(3) | 18 | 50/25 |
| $PM_{10}$ | 48 | 100(4) |
| $PM_{2.5}$ | 48 | 100 |
| $SO_2$ | 4 | 100 |
| Ammonia | 66 | — |
| Total HAPs | 9.4 | 25 |

(1) $NO_X$, VOCs, $SO_2$, and ammonia are also candidate $PM_{2.5}$ precursors as defined in the EPA proposed $PM_{2.5}$ implementation rule.
(2) Emission estimates do not include any mobile source emissions or LNG carrier emissions occurring during LNG unloading.
(3) First value is threshold for 8-hour moderate ozone nonattainment designation, second value is threshold for 1-hour severe ozone nonattainment designation.
(4) DEC Policy CP-33 for fine particulate matter prescribes a significant source size threshold of 15 tpy for $PM_{10}$ as a surrogate measure to determine whether secondary $PM_{2.5}$ effects must be considered (NYSDEC 2003a).

The EPA published a proposed rule on November 1, 2005, in the Federal Register to implement the fine particle (i.e., $PM_{2.5}$) NAAQS and solicited comments on the proposed rule (Federal Register 2005a). The proposed rule prescribes the requirements that NYSDEC (and other states' agencies) must meet in their implementation plans in order to attain the $PM_{2.5}$ NAAQS. The proposed rule suggests states control stationary sources affecting regional $PM_{2.5}$ air quality and sources affecting local $PM_{2.5}$ air quality such as traffic, industrial sources, and other combustion-related activities. The implementation program will focus on direct $PM_{2.5}$ emissions as well as emissions of precursor compounds. The candidate list of precursor compounds includes $NO_x$, $SO_2$, VOCs, and ammonia; the proposed rule does not conclude which of these candidate precursor compounds will be regulated as $PM_{2.5}$ precursors, deferring until the final rule is issued. The proposed rule contains several options with regard to control of $PM_{2.5}$ precursors that states may consider during SIP development. The SIP revision and attainment demonstration are due to EPA by April 2008; this date corresponds to the approximate date that installation of Broadwater facilities will begin in the Sound. The attainment date for the $PM_{2.5}$ NAAQS is April 2010, although EPA may extend the attainment date to no later than April 2015, depending on the severity of the nonattainment situation and the availability and feasibility of control measures.

The proposed rule addresses emission thresholds for direct $PM_{2.5}$ and precursor compounds for determining whether a project is major or minor under NSR. For Prevention of Significant Deterioration (PSD), the current limits of 100 or 250 tpy apply. For nonattainment NSR, the current major source threshold of 100 tpy applies.

Offset ratios for direct $PM_{2.5}$ and $PM_{2.5}$ precursors are not defined in the proposed rule, although they must be at least 1:1 to meet the minimum offset ratio required under the CAA.

During the SIP development period, EPA allows the use of a $PM_{10}$ nonattainment major NSR program as a surrogate program to address $PM_{2.5}$ nonattainment NSR. NYSDEC Policy CP-33 (Assessing and Mitigating Impacts of Fine Particulate Matter Emissions) sets forth guidance on project-specific assessments (NYSDEC 2003a). NYSDEC policy CP-33 follows EPA guidance by using $PM_{10}$ emissions as a surrogate for $PM_{2.5}$. The policy prescribes a $PM_{10}$ emission rate of 15 tpy or greater as a significant emission rate (in this case, DEC uses the term "significant emission rate" as a threshold for any project, including new construction); projects with an annual potential to emit greater than 15 tpy must evaluate secondary formation of $PM_{2.5}$ through an evaluation of precursor emissions. The evaluation includes quantifying potential $PM_{2.5}$ precursor emissions, discussing the potential for secondary $PM_{2.5}$ formation, and demonstrating that the precursor emissions will comply with all state and federal regulations and programs. NYSDEC policy CP-33 also requires a modeling analysis of $PM_{2.5}$ for projects whose $PM_{10}$ emissions are above 15 tpy.

### 1.3.2 Area Classification

Prevention of Significant Deterioration (PSD) regulations provide for a system of area air quality classifications that afford states an opportunity to identify land use goals:

- Class I areas allow only a small degree of air quality deterioration.

- Class II areas can accommodate normal well-managed industrial growth.

- Class III areas provide for the largest amount of development.

The proposed location of the FSRU is in an area designated as Class II.

Areas of special national or regional natural, scenic, recreational, or historic value are designated as Class I areas and are provided with special protections. As discussed later in this protocol, the potential emissions from the FSRU are expected to be below PSD applicability thresholds; therefore, detailed analysis for a Class I area is not required.

# 2 Overall Modeling Approach

## 2.1 Modeling Guidance

Dispersion modeling estimates ambient air quality impacts due to air pollutants emitted from FSRU emission sources. The methodology discussed in this protocol was developed in accordance with the United States Environmental Protection Agency's (EPA's) *Guideline on Air Quality Models* (Revised) (EPA 2003a), incorporated as Appendix W of 40 Code of Federal Regulations (CFR) Part 51, and the New York State Department of Environmental Conservation's (NYSDEC's) *Air Guide 26: NYSDEC Guidelines on Modeling Procedures for Source Impact Analysis* (NYSDEC 1996), referred hereto as EPA Guidance and Air Guide 26, respectively. EPA's *Draft New Source Review Workshop Manual* (EPA 1990, referred hereto as the NSR Manual), which outlines the air quality impact analysis procedures required under PSD regulations, also was consulted for modeling procedures. However, current potential to emit estimates indicate that the Project is not subject to review under PSD. Guidance was also obtained during preliminary air quality analysis project meetings with NYSDEC and EPA Region 2. Comments received on two previous draft modeling protocols and responses are provided as Appendix A. Finally, modeling procedures established by the Minerals Management Service (MMS) for analysis of offshore emission sources were reviewed (MMS 1989).

### 2.1.1 Visible Plume Analysis

Visible plume modeling analyzes the potential for formation of a condensed water plume and, if a plume is shown to form, the frequency of formation and plume size. Modeling methodology was developed by surveying modeling approaches used for similar combustion source type projects. This resulted in discussion with the California Energy Commission (CEC) on the approach used in California to evaluate visible plume formation for new power plant siting applications. The CEC, through the visible plume model developer, provided a copy of the Combustion Source Visible Plume (CSVP) model for this analysis.

## 2.2 General Modeling Steps

The air quality dispersion modeling analysis involves two phases: a preliminary analysis (first phase) and a full impact analysis (second phase). In the preliminary analysis, a comparison of the ambient air quality impacts from FSRU emissions to the air quality impact significance levels for Class II areas (see Table 2-1) is performed. Ambient air pollutant impacts less than significant impact levels at or beyond the facility boundary precludes the need for a full impact analysis for these pollutant(s). Ambient air pollutant impacts greater than or equal to significance levels at or beyond the facility boundary require a full impact analysis be conducted for the applicable pollutant(s).

**Table 2-1 Significance Levels for Air Quality Impacts in Class II Areas (µg/m$^3$)**

| Pollutant | Annual | 24-hour | 8-hour | 3-hour | 1-hour |
|---|---|---|---|---|---|
| $SO_2$ | 1 | 5 | (a) | 25 | (a) |
| $PM_{10}$ | 1 | 5 | (a) | (a) | (a) |
| $PM_{2.5}$ | (a) | (a) | (a) | (a) | (a) |
| $NO_X$ | 1 | (a) | (a) | (a) | (a) |
| CO | (a) | (a) | 500 | (a) | 2,000 |
| $O_3$ | (a) | (a) | (b) | (a) | (a) |

(a) No significant ambient impact concentration has been established.
(b) No significant ambient impact concentration has been established. Instead, an ambient impact analysis must be performed for any net emissions increase of 100 tons per year of VOCs subject to PSD.

In the full impact analysis, total ambient impacts are developed. The boundary of the significant impact area will be determined and the proximity to other large sources evaluated. If other large sources are determined to be nearby as defined in Air-Guide 26, then these sources will be included in a cumulative source inventory developed following Air Guide 36 procedures. If no large sources are located in or near the significant impact area of the Project, then air pollutant background concentrations are added directly to the modeled concentrations to develop total ambient air quality concentrations. These ambient impacts are then compared with NAAQS (see Table 2-2).

**Table 2-2 National Ambient Air Quality Standards**

| Pollutant | Averaging Time | NAAQS | Notes |
|---|---|---|---|
| CO | 1-Hour | 35 ppm (40,000 • g/m$^3$) | Standard not to be exceeded more than once per year. |
| | 8-Hour | 9 ppm (10,000 • g/m$^3$) | Standard not to be exceeded more than once per year. |
| Lead | Calendar Quarter | 1.5 • g/m$^3$ | Standard never to be exceeded. |
| $NO_2$ | Annual | 0.053 ppm (100 • g/m$^3$) | Standard never to be exceeded. |
| Ozone | 8-Hour | 0.08 ppm (156 • g/m$^3$) | Standard is compared to the average of the annual 4th highest 8-hour concentrations over a 3-year period. |

**Table 2-2 National Ambient Air Quality Standards**

| Pollutant | Averaging Time | NAAQS | Notes |
|---|---|---|---|
| $PM_{2.5}$ | 24-Hour | 65 • g/m$^3$ | Standard is compared to the average of the annual 98th percentile of 24-hour concentrations over a 3-year period. |
| | Annual | 15 • g/m$^3$ | Standard is compared to the average of the annual concentrations over a 3-year period. |
| $PM_{10}$ | 24-Hour | 150 • g/m$^3$ | Standard is attained when the expected number of exceedances is less than or equal to 1 per year. |
| | Annual | 50 • g/m$^3$ | Standard (expected annual arithmetic mean or 24-hour concentrations) never to be exceeded. |
| $SO_2$ | 3-Hour | 0.5 ppm (1,300 • g/m$^3$) | Standard not to be exceeded more than once per year. |
| | 24-Hour | 0.14 ppm (365 • g/m$^3$) | Standard not to be exceeded more than once per year. |
| | Annual | 0.03 ppm (80 • g/m$^3$) | Standard never to be exceeded. |

Source: EPA 2004a.

The visible plume modeling analysis involves two steps: collection and preparation of exhaust source temperature and moisture content data; and collection of meteorological data representative of site conditions. The CSVP model subjects the plume to hourly ambient conditions contained in the meteorological data to determine whether plume saturation would occur. The result is a tabulation of occurrence of a visible plume; if plume formation is indicated, then statistical information about plume length and duration is calculated. If plume formation is indicated, the dimensions of the plume serve as input to a visual simulation of the FSRU to show how the FSRU would appear with a visible plume present. There are no standards or other criteria available to quantify the effect of a visible plume. Initial evaluation of the exhaust characteristics (temperature and moisture content) indicate that a visible plume will not form.

## 2.3 Applicability of PSD

Title I of the CAA established guidelines for the preconstruction review of major stationary air emission sources. If construction of a major stationary source in an attainment area results in emissions above major source thresholds, then the Project must be reviewed in accordance with PSD regulations. If construction of a major stationary source in a nonattainment area results in emissions above major source thresholds, then the Project must be reviewed in accordance with nonattainment NSR regulations. Nonattainment NSR review in New York State is currently delegated to NYSDEC. PSD review in New York State is currently conducted by EPA Region 2.

Since the proposed FSRU is located in an area designated as in attainment for NAAQS for some criteria pollutants, the PSD regulations are potentially applicable to the Project. In order for PSD to be applicable, a new facility needs to be classified as a major stationary source. For the 28 listed source categories in 40 CFR 52.21(b)(1)(i)(a), the major source threshold is a potential to emit (PTE) of greater than or equal to 100 tons per year (tpy) for any criteria pollutant. For all other source types, the major source threshold is a PTE greater than or equal to 250 tpy for any criteria pollutant. For the latter source type, if a grouping of emission units is used in operations at the source that by themselves would be considered one of the 28 source categories with the 100-tpy threshold, the 100-tpy threshold applies to those emission units only.

To date, EPA has not made an agency-wide determination as to whether an FSRU would be subject to a PSD threshold of 250 tpy or 100 tpy. Based on a review of available prior applications for other proposed LNG regasification facilities under Section 3 of the Natural Gas Act and the Deep Water Port Act, both 100-tpy and 250-tpy thresholds have been used in the PSD review process. The Gulf Landing project, proposed for a site located 38 miles offshore of Louisiana, recently was approved by EPA Region 6 based on a 250-tpy PSD threshold. The EPA NSR guidance document provides an example case on this issue. The example facility discussed in the NSR Guidance Manual shows that a 250-tpy PSD threshold should be applied to the collective emissions from all emission sources at a facility not specifically listed as one of the 28 source categories (the FSRU) and a 100-tpy PSD threshold should be applied to the gas turbines as a separate group and the process heaters as a separate group (EPA 1990). The analysis set forth below is consistent with EPA guidance.

The FSRU process is not one of the 28 listed source categories. The FSRU is a unique process that requires certain support equipment to properly function. It is expected that the FSRU will operate two gas turbines (with one additional turbine as a backup unit) with waste heat recovery, which will have a combined heat input capacity greater than 250 MMBtu/hr. These turbines will be used to generate electricity solely for use onboard the FSRU. The FSRU also will operate four process heaters (with one additional unit as a backup unit), each with a heat input capacity less than 250 MMBtu/hr but with a combined heat input capacity greater than 250 MMBtu/hr; these will be used to heat a heat-transfer fluid in a closed-loop system that will be used by the vaporizers to regasify the LNG. The gas turbines and heating units, taken individually, will be included, respectively, in the source categories "Fossil Fuel Fired Steam Electric Plants" and "Fossil Fuel Boilers," both of which are one of the 28 listed source categories. Therefore, the 100-tpy threshold applies to the gas turbines and process heaters as separate groups. However, since the primary purpose of the FSRU is the storage and regasification of natural gas and does not fall within the 28 recognized source categories, the 250-tpy threshold applies to the FSRU process.

Emissions from all sources on the FSRU, including the gas turbines and process heaters, are counted in determining the PTE for the FSRU and in subsequent comparison to the 250-tpy threshold, whereas only emissions from the gas turbines are counted in determining the PTE for comparison to the 100-tpy threshold for "Fossil Fuel Fired Steam Electric Plants". Similarly, only emissions from the process heaters are counted in determining the PTE for comparison to the 100-tpy threshold for "Fossil Fuel Boilers."

The air pollutants examined under PSD applicability include CO, $NO_2$, $SO_2$, and $PM_{10}$. An estimate of annual emissions is presented in Table 2-3. The emissions shown in Table 2-3 represent the contribution from combustion sources on the FSRU; as LNG is delivered to the FSRU, vapor displaced by the incoming LNG will be routed to the LNG carrier tanks such that no emissions to the atmosphere will occur. Broadwater has requested a determination from EPA on whether LNG carrier emissions while docked at the FSRU need to be included in the PSD applicability determination. EPA has not provided a determination at this time; therefore, emissions from docked LNG carriers are not included in this total.

**Table 2-3 Annual Potential to Emit for the Proposed FSRU Stationary Sources Compared to PSD Major Source Size Thresholds**

| Air Pollutant | Estimated Annual Potential Emissions(1) (tpy) | PSD Major Source Size (tpy) |
|---|---|---|
| $NO_x$ | 71 | 250 |
| CO | 88 | 250 |
| $PM_{10}$ | 48 | 250 |
| $SO_2$ | 4 | 250 |

(1) Accounts for use of SCR and oxidation catalyst for $NO_x$ and CO/VOC control, respectively. Does not include LNG carrier engine emissions while unloading LNG.

The LNG carrier is a delivery vehicle to the FSRU and thus is considered a mobile source. The Broadwater Project will not use a fleet of dedicated, company-owned LNG carriers to deliver LNG to the FSRU. LNG carrier operations, and hence emissions, will not be under the control of Broadwater. Therefore, Broadwater has no mechanism from these carriers to accept and implement permit conditions on vessels that are not under its control. The lack of control over these emissions precludes them from being considered in the PSD applicability determination for the FSRU.

Notwithstanding the fact that PSD does not apply to the LNG carriers, anticipated emissions from the LNG carriers have been considered in the General Conformity analysis conducted for the Project. General Conformity is discussed in Resource Report No. 9 of the filing to the Federal Energy Regulatory Commission (FERC).

Emission thresholds under PSD regulations are presented in Tables 2-3 and 2-4. Based on the estimated annual potential emissions (with emission controls applied) shown in Tables 2-3 and 2-4, the proposed FSRU would not be classified as a major stationary source under PSD. In addition, the source categories "Fossil Fuel Fired Steam Electric Plants" (gas turbines) and "Fossil Fuel Boilers" (process heaters) and would not individually require a PSD review.

**Table 2-4 Annual Potential to Emit for Emission Units in the PSD 28 Source Category List Compared to PSD Major Source Size Thresholds**

| Air Pollutant | Gas Turbines - Annual Potential Emissions(1) (tpy) | Process Heaters - Annual Potential Emissions(1) (tpy) | PSD 28 Category List Major Source Size (tpy) |
|---|---|---|---|
| $NO_x$ | 34 | 21 | 100 |
| CO | 30 | 49 | 100 |
| $PM_{10}$ | 16 | 31 | 100 |
| $SO_2$ | 1.6 | 2.5 | 100 |

(1) Accounts for use of SCR and oxidation catalyst for $NO_x$ and CO/VOC control, respectively.

If the Project is subject to PSD regulations due to incorporation of all or a portion of the LNG carrier emissions, comparison of air quality impacts predicted under the preliminary analysis to significant monitoring concentrations (see Table 2-5) is also required. The comparison of predicted impacts to these concentrations assesses whether the Project can be exempted from PSD pre-application air quality monitoring requirements.

**Table 2-5 Significant Monitoring Concentrations**

| Pollutant | Averaging Time | Significant Monitoring Concentration |
|---|---|---|
| CO | 8-Hour | 575 • g/$m^3$ (0.52 ppm) |
| Lead | Calendar Quarter | 0.1 • g/$m^3$ |
| $NO_2$ | Annual | 14 • g/$m^3$ (0.0074 ppm) |
| $PM_{10}$ | 24-Hour | 10 • g/$m^3$ |
| $SO_2$ | 24-Hour | 13 • g/$m^3$ (0.0050 ppm) |

Source: EPA 1990, Table C-3.

If a full impact analysis is required and the Project is subject to PSD regulations, the air quality impacts due to the Project and other nearby applicable sources will be compared to PSD increment criteria and NAAQS. PSD increments are the maximum increases to ambient air concentrations allowed to occur above a pollutant's baseline concentration. PSD increments are summarized in Table 2-6. NYSDEC indicates that the baseline area on all of Long Island has been triggered for all three increment consuming pollutants; thus, an analysis to establish a baseline area as stipulated in the NSR Manual is not required.

**Table 2-6 PSD Increments for Class II Areas**

| Pollutant | Annual Average | 24-Hour Average | 3-Hour Average |
|---|---|---|---|
| $NO_2$ | 25 μg/m$^3$ (0.013 ppm) | – | – |
| $PM_{10}$ | 17 μg/m$^3$ | 30 μg/m$^3$ | – |
| $SO_2$ | 20 μg/m$^3$ (0.0077 ppm) | 91 μg/m$^3$ (0.035 ppm) | 512 μg/m$^3$ (0.20 ppm) |

Source: EPA 1990, Table C-2.

### 2.3.1 Environmental Justice

EPA Region 2 provides guidance on addressing environmental justice in their "Interim Environmental Justice Policy" (EPA 2000). The Environmental Justice and Permitting guidelines indicate that an environmental justice analysis should be applied in the context of a new major permit decision, significant modification, or renewal of a major permit. At this time, EPA is in the process of determining whether certain emissions (e.g., LNG carrier emissions) should be included in the facility PSD applicability total. This decision will ultimately determine whether the permit application for the Broadwater Project is treated as a major new permit, or as a New York state facility (i.e., minor) permit. If the Project is a major new permit, then environmental justice analysis procedures, as outlined in the EPA's Interim Environmental Justice Policy, will be addressed.

## 2.4 Model Selection

The Offshore and Coastal Dispersion (OCD) Model is the primary model used to evaluate air quality impacts at onshore and offshore receptor locations in proximity to the FSRU. The OCD model includes a building downwash calculation routine that was developed for offshore sources based on laboratory wind tunnel experiments (MMS 1989, 1997). The AERMOD-PRIME model is used solely to evaluate downwash, wake, and cavity effects, as recommended by NYSDEC in its comments on Broadwater's May 2005 initial modeling protocol. OCD-Version 5 (OCD/5) is the latest version of OCD available. AERMOD-PRIME version 04300 is the latest version available for downwash/cavity evaluation. AERMOD-PRIME incorporates new methods to evaluate downwash not previously available in the SCREEN3 or ISC3 models. The PRIME downwash algorithm has been shown to produce results comparable to data collected in several wind tunnel tests and a tracer field study at a combustion turbine site.

The CSVP Model provides an evaluation of visible plume formation and physical characteristics. The model consists of spreadsheets and a Gaussian dispersion model. The spreadsheets are used to evaluate temperature and moisture conditions of the stack gases, and then determine whether saturation of the stack gas (with respect to water vapor) could have occurred under the hourly meteorological conditions in the meteorological data set. The dispersion component is used to determine whether mixing of the plume with ambient air will cause condensation, and the size of the resulting visible plume.

### 2.4.1 OCD

OCD is a straight-line Gaussian model developed to determine the impact of off-shore emissions from point, area, or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. OCD is recommended for use by the Minerals Management Service (MMS) for emission sources located on the Outer Continental Shelf. Some of the key features of OCD include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation (MMS 1989, 1997).

OCD requires hourly meteorological data from both offshore and onshore locations. OCD is applicable for over-water sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the appropriate reviewing authority.

### 2.4.2 AERMOD-PRIME

AERMOD-PRIME is a Gaussian plume model that replaces the ISC model for evaluating ambient air quality impacts of stationary sources located on land. Model validation studies were performed by EPA for dispersion over land surfaces but not over water surfaces (e.g., as surrounding the Broadwater FSRU location). Therefore, the dispersion portion of the model is not specified for use over water surfaces since it cannot account for the effects of an underlying water surface on lower atmosphere characteristics (EPA 2003c). However, downwash and cavity circulation are not significantly affected by an underlying water surface; thus, the downwash component in the model is applicable to the Broadwater FSRU location. Used in conjunction with the structure data preprocessing program BPIP-PRIME, the evaluation of downwash effects utilizes the latest techniques available for regulatory modeling studies (Schulman et al. 2000).

The plume from a stack is divided into two portions: based on the configuration of the stack and building, a portion is captured in the near-wake region of the building and recirculated; the remainder of the plume is not captured. The PRIME methodology re-emits the captured plume from the cavity region into the far-wake region, where it is merged with the uncaptured plume. The model also has more advanced calculations to determine dispersion within the wake region (EPA 2004c).

### 2.4.3 Combustion Source Visible Plume Model

The analysis process within CSVP consists of preparing hourly meteorological data and combustion source exhaust temperature and moisture data for use in the CSVP model. CSVP consists of two modules, the first being a psychrometric program that steps through the input data to determine whether the stack conditions, when combined with ambient meteorological conditions, would result in saturation of the plume and hence the formation of a visible plume; the second module comprising CSVP determines plume size by modeling the plume and comparing it to saturation values.

# 3 Model Input and Options

OCD and AERMOD-PRIME require the following general input data:

- • Emission rate;
- • Stack parameters;
- • Building/structure parameters;
- • Meteorological data;
- • Receptor data;
- • Land use data; and
- • Miscellaneous model options.

In addition, if modeling results are to be compared to NAAQS, ambient air background concentrations of air pollutants will be incorporated into the modeling study.

The CSVP model uses meteorological data representative of the source location in the determination of plume formation and frequency. The potential for water saturation of the plume (which results in a visible plume forming) is related to the water vapor conditions in the plume and ambient conditions.

Parameters required for the CSVP meteorological data are hourly readings of:

- • Wind Speed and wind direction;
- • Dry Bulb Ambient Temperature;
- • Relative Humidity;
- • Visibility; and

- • Present Weather.

Process exhaust parameters required for performing the CSVP simulation are:

- • Temperature;
- • Moisture Content (weight fraction);
- • Mass Flow Rate (lbs/hr); and
- • Molecular Weight (lbs/lb-mole).

## 3.1 Emission Data

### 3.1.1 Pollutants and Emission Rates

The OCD and AERMOD-PRIME modeling study includes the following pollutants: CO, $NO_2$, $PM_{10}$, $PM_{2.5}$, and $SO_2$. Ammonia is also included in the modeling study since it will be emitted due to use of SCRs on both the combustion turbines and process heaters. The CSVP model study includes evaluation of water vapor emissions.

Emission rates for modeling are shown in Table 3-1. For pollutants with short-term averaging periods (1-hour to 24-hour), the highest hourly emission rate, developed through an examination of the equipment emissions under normal operations and, as applicable, under startup/shutdown conditions. The gas turbines will be subject to periodic startup/shutdown for maintenance, mechanical problems, etc. To accommodate these potential startup/shutdown cycles, emissions rates for the gas turbines include 50 startup/shutdown cycles per year. Thus, the "maximum hours' of emissions" for the gas turbines include emissions due to a percentage of time at normal operation and a percentage of time under startup and/or shutdown.

Model runs for pollutants with annual averaging periods utilize the highest permissible hourly emission rate except for situations when the annual operation of a source is limited. Annual limits of operation applied include 100 hours per year for emergency generators and fire water pumps. In cases of limited annual operation, the modeled hourly emission rate (for annual averaging times) will be calculated by dividing annual emissions (which incorporate annual restrictions) by 8,760 hours per year.

For gas turbines, maximum annual emission estimates include emissions due to startup and shutdown as well as normal operations.

## Table 3-1 Summary of Emission Rates for Modeling

| Source Description | 1-Hour to 8-Hour Periods | | | | | 24-Hour Periods | | | Annual | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NO_x$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) |
| Turbine 1 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 2 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 3 (Spare) | 0.110 | 0.399 | 0.399 | 0.050 | 0.510 | 0.399 | 0.399 | 0.050 | 0.504 | 0.023 | 0.023 | 0.0028 | 0.029 |
| Process Heater 1 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 2 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 3 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 4 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 5 (Standby) | 0.013 | 0.0016 | 0.0016 | 0.00013 | 0 | 0.0016 | 0.0016 | 0.00013 | 0.010 | 0.0016 | 0.0016 | 0.00013 | 0 |
| Fire Pump Engine 1 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Fire Pump Engine 2 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Emergency Generator 1 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 2 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 3 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |

Notes:

1. Annual emission rates for Turbines 1 and 2 and Process Heaters 1 through 4 are based on 50 startups and 50 shutdowns each year per unit.
2. CO and $NO_x$ emission rates for Turbines 1 and 2 are based on information provided by Shell for normal operation and by GE for startup/shutdown conditions.
3. $NH_3$ emission rates for Turbines 1 through 3 are based on normal operation. Emissions are assumed to be constant during startup and shutdown.
4. $PM_{2.5}$, $PM_{10}$, and $SO_2$ emission rates for Turbines 1 and 2 are based on equipment rating and AP-42 emission factors for natural gas turbines. Emissions are assumed to be constant during startup and shutdown.
5. Air pollutant (except $NO_x$ and $NH_3$) emission rates for Turbine 3 are based on equipment rating and AP-42 emission factors for diesel turbines. $NO_x$ emissions for Turbine 3 are based on estimated control of SCR at 80%.
6. $NO_x$ emission rates for Turbine 3 are based on a $NO_x$ concentration of 64 ppmvd @ 15% $O_2$ (see Table 4). This concentration reflects $NO_x$ limit in 6 NYCRR 227-2 ($NO_x$ RACT) for emissions for diesel-fired combined-cycle turbines.
7. CO and $NO_x$ emission rates for Process Heaters 1 through 4 are based on information provided by Broadwater for normal operation and startup/shutdown conditions.
8. $NH_3$ emission rates for Process Heaters 1 through 4 are based on information provided by Broadwater for normal operation. Emissions assumed to be constant during startup and shutdown.
9. $PM_{2.5}$, $PM_{10}$, and $SO_2$ emission rates for Process Heaters 1 through 4 are based on equipment rating and AP-42 emission factors.
10. CO and $NO_x$ emission rates for Process Heater 5 were extrapolated from data provided by Broadwater for normal operation and uncontrolled conditions (no SCR) to 1.8 MMBtu/hr (0.73% Load).
11. $NH_3$ emission rate for Process Heater 5 is 0 lb/hr are based on assumption that SCR is not operational.
12. $PM_{2.5}$, $PM_{10}$, and $SO_2$ emission rates for Process Heater 5 are based on equipment rating and AP-42 emission factors.
13. All air pollutant emission rates for fire pump engines and emergency generators are based on equipment rating and AP-42 emission factors.

### 3.1.2 $NO_2$ Conversion

$NO_x$ emitted from FSRU combustion sources will be in the form of NO or $NO_2$. Following release to the environment, a significant portion of NO is oxidized to $NO_2$. EPA Guidance prescribes use of a tiered screening approach to obtain annual average ambient concentrations of $NO_2$ for comparison to significance levels and/or NAAQS.

In Tier 1 (the initial screen), a total conversion of NO to $NO_2$ is assumed. Thus, ambient $NO_2$ concentrations are set equal to ambient $NO_x$ concentrations predicted by the model. If ambient $NO_2$ concentrations exceed the significance level during Tier 1, the analysis proceeds to Tier 2 (2nd level). In the Tier 2 screening analysis, ambient $NO_x$ concentrations predicted by the model are multiplied by an empirically derived $NO_2/NO_x$ value of 0.75 (annual national default value).

If ambient $NO_2$ concentrations exceed the significance level or NAAQS as a result of applying Tier 2, NYSDEC and EPA will be consulted to determine whether a Tier 3 (3rd level) analysis is appropriate. In a Tier 3 analysis, a detailed screening method may be selected on a case-by-case basis. For point source modeling, other refined screening methods, such as the ozone limiting method, also may be considered.

### 3.1.3 Load Analysis and Ambient Temperature

The effects of equipment operating load levels and ambient temperature were analyzed to determine the appropriate emission rates for gas turbines and/or process heaters to include when modeling maximum short-term and annual impacts. The emission rates shown in Table 3-1 were developed by this procedure.

Combination of load levels (e.g., 50%, 75%, and 100%) and ambient temperatures (e.g., 0°F [-18°C], 60°F [16°C], and 100°F [38°C]) were examined to determine the maximum emission rates for pollutants with short-term averaging times. Maximum emission rates for pollutants with annual average times were developed by examining emissions at various load levels at a single typical annual average temperature (e.g., 59°F [15°C]). Temperature extremes (e.g., 0°F [-18°C] and 100°F [38°C]) are not plausible as annual average temperatures.

Due to the continuous nature of the regasification process, it is anticipated that the gas turbines and process heaters will operate at full load except during periods of startup/shutdown and unless delivery of natural gas to the pipeline is curtailed for any reason.

### 3.1.4 CSVP

Exhaust temperature and moisture content calculations for the gas turbines incorporated use of unfired waste heat recovery units on each turbine exhaust stack. Gas turbine exhaust flow moisture content were augmented by the contribution of water due to use of the SCR; an injection rate of 41.6 kg/hr of 19% ammonia (81% water) solution was used in the calculation. For the process heaters, no modification of the exhaust temperature was needed since no waste heat recovery equipment was used. Process heater exhaust flow moisture content was also augmented by the contribution of water due to use of the SCR; an injection rate of 27.7 kg/hr of 19% ammonia (81% water) solution was used in the calculation for the process heaters.

Lookup tables relating ambient temperature and exhaust moisture content, temperature, and mass flow were developed using regression analyses for turbines and process heaters. The ambient temperature range used was 0 °F to 100 °F. This temperature regime represents the range of ambient temperatures found in the Project location.

## 3.2 Stack Parameters

All emission sources on the FSRU are point sources. OCD model input parameters include stack height, stack gas temperature, stack exit inside diameter, stack gas exit velocity, stack angle from vertical, and elevation of stack base above water surface. AERMOD-PRIME uses most of these parameters but does not use stack angle from vertical data. Stack parameters for the FSRU emission sources are shown in Table 3-2.

**Table 3-2 Summary of Stack Parameters**

| Source Description | Stack Height Above Water Level (m) | Stack Exit Inside Diameter (m) | Deviation of Stack Angle (deg) | Base Elevation Above Water Level (m) | Stack Gas Temp. (K) | Stack Gas Exit Velocity (m/s) | Stack Gas Exit Flow Rate (acm/s) |
|---|---|---|---|---|---|---|---|
| Turbine 1 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 2 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 3 (Spare) | 45 | 3.96 | 0 | 25 | 523 | 10.3 | 127 |
| Process Heater 1 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 2 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 3 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 4 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 5 (Spare) | 45 | 4.57 | 0 | 25 | 450 | 0.025 | 0.41 |
| Fire Pump Engine 1 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Fire Pump Engine 2 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Emergency Generator 1 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 2 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 3 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |

Source: E & E 2005.

No rain caps or other restrictions to flow will be installed on the stacks.

The FSRU will be moored with a bow-mounted, freely weathervaning YMS, which fixes the location of the bow within prescribed limits but allows the vessel to orient in response to prevailing weather conditions. The positions of FSRU (and LNG carrier) equipment stacks, therefore, will not be fixed locations. Initial model runs were performed with the FSRU in a fixed orientation to determine the magnitude of potential onshore impacts. The fixed orientation was evaluated with an FSRU oriented to face north (i.e., with the stern of the FSRU closest to the New York shore). The emission sources on the FSRU are located primarily on the aft quarter of the FSRU; therefore, the emission sources would be at their closest location to the New York shore of Long Island Sound.

Initial impacts using this orientation were below the NSR Significant Impact Levels (SILs) for Class II areas on shore; therefore, refined modeling using a variable FSRU orientation to account for the variability of stack locations is not needed.

## 3.3 Building and Structure Parameters

Structure data is included as model input to account for potential building wake effects (downwash) on emission plumes and cavity trapping of emissions. The structures that may cause wake and cavity effects are the FSRU and FSRU/LNG carrier combination. No other structure at the FSRU location will potentially contribute to downwash.

### 3.3.1 OCD Building and Structure Input Data

Although downwash effects are determined by the AERMOD-PRIME model, the OCD model also incorporates a module to calculate downwash. The OCD module is formulated based on data for typical "at sea" structures such as oil platforms and vessels. OCD requires the "platform height" above the water level as a model input. The model also allows for the input of a single building height and building width per emission source to compute downwash. The height of the FSRU main deck (25 m) will be entered as the platform height. The height (25) and width (100 m) of the FSRU/LNG carrier combination in relation to each emission source will be input to OCD.

### 3.3.2 Near-Wake (Cavity) and Far-Wake Impacts using AERMOD-PRIME

The United States Coast Guard (USCG) will designate a safety and security zone around the FSRU. The zone will provide a buffer between the FSRU and any vessels not associated with FSRU operations. However the USCG has not yet established the size or shape of the safety and security zone. For air modeling purposes, the area within the safety and security zone's perimeter is excluded from modeling because public vessels will likely not be allowed access within the zone. Determination of the safety and security zone size and shape will also accommodate the FSRU's ability to move based on prevailing wave/tide and, to a lesser extent, weather conditions (i.e., weathervane). Therefore, the safety and security zone may encompass a fixed area centered on the YMS, an area centered on the FSRU, or a distance from the stern of the FSRU. The FSRU will be equipped with a radar system to detect vessel traffic, and any unauthorized vessels entering the safety and security zone will be contacted via radio and directed to leave the area. Therefore, the safety and security zone would be treated analogous to a shore-based facility's "within the fence line" area.

Until a determination is made by USCG, Broadwater has chosen to use a 500-yard safety and security zone distance from the stern of the FSRU. At and beyond the safety and security zone boundary, ambient air quality concentrations determined by AERMOD-PRIME are likely influenced by the wake region of the FSRU structure. This distance is based on similar zones for LNG facilities and prior zones established in Long Island Sound. Until determined by the USCG, however, the 500-yard may or may not be appropriate for an FSRU located in Long Island Sound.

For AERMOD-PRIME, the FSRU/LNG carrier combination is treated as two, two-tiered structures situated side by side. The width ultimately evaluated in the modeling is the width of the FSRU/LNG carrier combination. The height of the first tier of the FSRU is 25 meters, which is the height from the water line to the top of the trunk deck. The second tier of the FSRU is used to model the accommodation area located aft on the FSRU. The accommodation area rises approximately 20 meters above the trunk deck. Similarly, the LNG carrier alongside the FSRU is a two-tier structure. Typical dimensions for a conventional LNG carrier of 140,000 $m^3$ cargo capacity were used. However, the LNG carrier is not as tall as or as long as the FSRU; the height of Tier 1 (height of the main deck above the water line) is 15 meters; Tier 2 (the accommodation area) on the LNG carrier is a 15 meter tall structure on top of tier 1 located aft on the vessel. The Building Profile Input Program (BPIP)-PRIME processes these data to calculate projected structure dimensions by wind angle for input to AERMOD-PRIME.

## 3.4 Meteorological Data

### 3.4.1 OCD

Meteorological data are input into OCD in two categories: overland and overwater. Meteorological data parameters are required on an hourly basis. The mandatory model inputs include:

- • Wind direction (overland only);
- • Wind speed (overland only);
- • Ambient air temperature (overland and overwater);
- • Pasquill stability class (overland only);
- • Mixing height (overland and overwater);
- • Relative humidity (overwater only); and
- • Surface water temperature (overwater only).

The optional model inputs include:

- • Horizontal turbulence intensity (overland and overwater);
- • Vertical turbulence intensity (overland and overwater);
- • Wind direction (overwater only);
- • Wind speed (overwater only);
- • Vertical wind direction shear (overwater only); and
- • Vertical potential temperature gradient (overwater only).

For this analysis, the meteorological data input into OCD included all mandatory parameters. The optional parameters 'overwater wind direction' and 'overwater wind speed' are based on data collected by data buoys in Long Island Sound to the maximum extent they are available. All other optional parameters are calculated by model algorithms.

In the OCD model, overwater observations of wind direction and wind speed are assumed to apply to both over water and land areas. If overwater wind speed and wind direction are not available, OCD procedures prescribe that hourly overland values be used. If overwater measurements of wind direction and wind speed are available, then the only overland meteorological data inputs used in the OCD model are overland stability class, overland ambient temperature, and overland mixing height.

A review was conducted of all available overland, coastal, and overwater meteorological data from stations in the Project vicinity. Beginning in 1994, weather data was collected at Avery Point/Ledge Light in Connecticut at the far eastern portion of Long Island Sound along the Connecticut coastline, approximately 40 miles to the northeast of the proposed FSRU location. For the data period 1994 through late 2002, no other weather data collection stations were identified that could reasonably be considered "in-Sound" sites.

Two new overwater stations began operation in 2003. The University of Connecticut began collecting data in 2003 from two data buoys established as part of a marine monitoring network called "MY Sound"; one of the two buoys is located in the central portion of Long Island Sound (the central Sound buoy), approximately 10 miles (16 km) east of the proposed location of the FSRU, while the other buoy is in the far western end of the Sound (the western Sound buoy), approximately 35 miles (56 km) southwest of the proposed FSRU location. The Western Sound buoy, however, is located in a narrower area of the Sound, ; consequently, measurements taken at this station are likely to contain slightly more land influence. Therefore, representative overwater meteorological surface data to be used in OCD will be based on hourly data collected at the central Sound buoy (Buoy 44039). The period of record to be used in modeling is December 9, 2004, through December 8, 2005.

A 2 ½-year (2003 through mid-2005) wind rose from the central Sound buoy is shown on Figure 3-1. The highest frequency wind direction is from the south-west, which would place the FSRU facing southwest and emission sources farthest from the New York shore. The second highest frequency wind direction is from due north, which would place the FSRU south of the YMS and facing north. This latter situation would place the FSRU emission points closest to the New York shore.

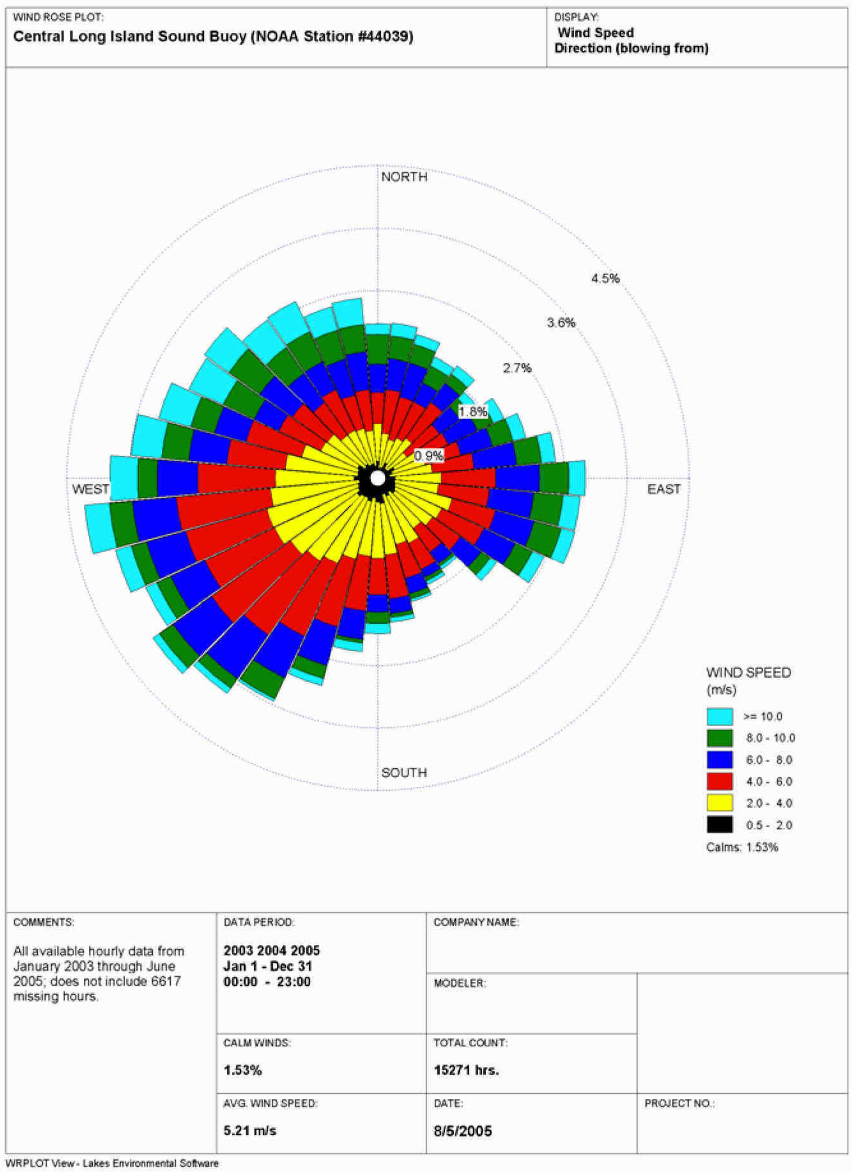


**Figure 3-1 Two and one-half year Wind Rose for Buoy 44039**

The central Sound buoy is a remote 8-foot-diameter, buoy-mounted station in the middle of Long Island Sound. It contains sensors for obtaining meteorological, water quality, and wave data. Data is transmitted from the buoy to a ground station via satellite. The station is operated by the University of Connecticut's Department of Marine Services and is part of the National Oceanic and Atmospheric Administration's (NOAA's) National Data Buoy Center (NDBC).

The western Sound buoy (Buoy 44040) is located approximately 35 miles (56 km) southwest of the proposed FSRU location. It is located at the western end of the Sound, where the width of the Sound is narrowed substantially. Meteorological measurements taken at this location tend to reflect a larger land influence for south, north, or west wind directions than observed in the central Sound. This station also is operated by the University of Connecticut.

The Ledge Light weather station (Station LDLC3) is a station in Long Island Sound located approximately 40 miles (64 km) northeast of the proposed FSRU location. This station is an overwater station approximately 0.5 mile (0.8 km) south of the mouth of the Thames River. This station is fairly distant from the Central Sound station and may not represent mid-Sound conditions. This station also is operated by the University of Connecticut.

The Bridgeport, Connecticut, Sikorsky Memorial Airport (Station 94702) is located on a peninsula that projects slightly out from the coast into Long Island Sound. The airport is approximately 15 miles (24 km) west-northwest of the proposed FSRU location.

Representative overland meteorological surface data to be used in OCD is based on hourly data collected at the Islip-MacArthur Airport (Station 04781) from December 9, 2004, through December 8, 2005. Islip-MacArthur Airport is located approximately 7.5 miles (12 km) inland from the north shore of Long Island. The station is operated by the National Weather Service (NWS).

Upper air (radiosonde) data is used to calculate mixing height for use in OCD and for determination of profiles in AERMOD-PRIME. Overland and overwater meteorological mixing heights to be used in OCD are based on twice-daily radiosonde data collected at Brookhaven (Upton), New York from December 9, 2004, through December 8, 2005. The Brookhaven National Laboratory (BNL) is approximately 15 miles (24 km) south of the proposed FSRU location and approximately 7 miles (11 km) inland from the south shore of Long Island Sound. Radiosonde data and Islip surface data are processed using the EPA's Mixing Height program to determine twice-daily mixing heights.

A literature search was performed to identify studies and research papers describing the mixing height over Long Island Sound. Personnel at BNL (Mr. Victor Cassella, meteorologist) and at the University of Connecticut, Department of Marine Sciences (Dr. Frank Bohlen, director of the My Sound project), were also contacted to inquire about the availability of data/studies/research on mixing height over Long Island Sound. This search resulted in no applicable studies to aid in the determination of mixing height over the Sound or to aid in the interpretation of NWS Upton, New York, upper air data with respect to mixing height over the Sound. In conducting the research, attempts also were made to determine whether mixing height studies had been conducted prior to licensing of the Shoreham Nuclear Power Plant (a site located along the north shore of Long Island near the proposed FSRU location); however, staff at BNL indicated that, to their knowledge, measurements of mixing height were not made (Cassella 2005).

Due to the proximity of the upper air station at BNL to the Sound and the dominant amount of water surface area in the general region compared to land surface area, it is likely that the Upton radiosonde data reflects a significant marine influence. Therefore, the temperature profile measured by the radiosonde during its ascent would be a reasonable representation of the overwater temperature profile and mixing height.

The period from December 9, 2004, to December 8, 2005, was chosen for analysis of meteorological data observations because this period contains the most complete data record for the central Sound buoy. The availability of hourly surface water temperature was used as the limiting factor in data selection because this data is considered important in the calculation of overwater stability (MMS 1989). In the absence of direct information on overwater stability, the OCD model estimates the Monin-Obukhov length from hourly values of overwater ambient air temperature, overwater relative humidity, overwater wind speed, and surface water temperature. The calculation of overwater stability is very sensitive to the difference between air and water temperatures. When this difference is close to zero, a 1-degree error in either temperature can cause the calculated stability to change from stable to unstable. For this reason, the OCD User's Guide (MMS 1989) recommends that temperature observations be input directly to the model only if the measurements are taken at the same place and time (e.g., on an automated buoy).

The proximity of the central Sound buoy to the proposed FSRU location makes this station an ideal source of surface meteorological data. Although NDBC's Buoy Station 44025, which is located in the Atlantic Ocean approximately 40 miles south of Islip, New York has a longer period of record than the in-Sound data buoys, the data from Buoy 44025 is not considered representative of conditions within Long Island sound because of the more open ocean conditions at Buoy 44025, and water temperatures measured outside of the Sound certainly would be expected to differ from measurements taken within the Sound.

The central Sound buoy for the proposed meteorological data period was subject to one long-term data outage due to removal of the buoy from the Sound for maintenance and sensor upgrade. Raw data availability hours for which a complete data record is available (i.e., no values are missing) for the data period is shown in

Table 3-3. For the remaining hours, data is missing in one or more of the data fields.

**Table 3-3 Raw Data Recovery for Buoy 44039**

| Data Period | Total Hours | Data Hours (Air T, Winds, RH) | Data Hours (water temp) | Percent Recovery (Air T, Winds, RH) | Percent Recovery (water T) |
|---|---|---|---|---|---|
| 1st quarter (Dec 9-Mar 9) | 2190 | 2139 | 2139 | 97.7 | 97.7 |
| 2nd quarter (Mar 10 – June 8) | 2190 | 2190 | 2190 | 100 | 100 |
| 3rd quarter (June 9 – Sept 8) | 2190 | 2031 | 2031 | 92.7 | 92.7 |
| 4th quarter (Sept 9 – Dec 8) | 2190 | 1484 | 1437 | 67.8 | 65.6 |
| 12 month | 8760 | 7844 | 7797 | 89.5 | 89.0 |

To account for long periods (i.e., greater than 6 hours) in the central Sound buoy data when required data are unavailable, set procedures were followed for data replacement. For missing air and/or water surface temperatures at the central Sound buoy, a substitute air/water temperature data pair will be taken from buoy 44040. The calculation of overwater stability is sensitive to the air/water temperature difference; therefore, maintaining the air and water temperature relationship in substitute data is important.

The Bridgeport, Connecticut, Sikorsky Memorial Airport meteorological station is located less than 1 mile inland and is on a short peninsula that extends slightly out from the coast. Measurements at this site are considered representative of conditions at a coastal site; however, its location on a short peninsula and proximity to the proposed FSRU location make this station the best suited for filling in wind direction and speed data missing from the central Sound station.

It is anticipated that using these missing data completion procedures will result in no remaining missing data. However, if wind speed or wind direction is not available then OCD will automatically use the overland wind direction from Islip-MacArthur Airport. OCD will also calculate overwater wind speed based on overland wind speed data from the Islip-MacArthur data as described in the OCD User's Guide; the calculation is based on the empirical relation developed by Hsu and shown in the OCD User's Guide (MMS 1997):

$$U_{sea}=3*u_{land}^{2/3}$$

Meteorological data processing for OCD involves the following steps after the missing data has been filled in:

- • Processing twice-daily radiosonde data from BNL using the EPA's Mixing Height program. Input data for this program consists of the radiosonde data for the period obtained from the NOAA/NCDC Forecast Systems Laboratory (FSL) Radiosonde Archive and hourly Islip-MacArthur Airport surface data. The output from this processor is the twice-daily (morning and afternoon) mixing heights.

- • Processing the hourly Islip-MacArthur Airport surface data with the twice-daily mixing height data using PCRAMMET in accordance with EPA Guidance to provide the specific overland data format required for OCD.

- • Formatting the hourly overwater data file based on the Central Sound buoy to match the input requirement of OCD.

- • In accordance with OCD model guidance, the minimum overland wind speeds input into the model are not limited to 1 m per second (m/s). OCD accepts wind speeds from 0 to 1 m/s for overwater and overland wind speeds.

The locations of meteorological stations are shown on Figure 3-2.

### 3.4.2 AERMOD-PRIME

The AERMET meteorological preprocessing program is used to prepare the meteorological data for AERMOD-PRIME. AERMET requires an upper air sounding data file and a surface-based meteorological observation file. The basic function of AERMET is to process the two input files into formatted files containing calculated parameters required to run AERMOD-PRIME. AERMET consists of a three-stage process: extraction/quality checking the raw data files, merging the surface and upper air data into a single file, and reading the merged file followed by using site-specific values for parameters that characterize the land surface to prepare the formatted surface and profile files.

The data period selected for sounding data from Brookhaven (Upton) New York, and surface data from Islip, New York, is December 9, 2004, through December 8, 2005. In order to use the Islip, New York, surface data, a conversion from the ISH format supplied by NCDC into a format compatible with AERMET is necessary. A conversion program called "NCDC_CNV" is available to convert the ISH format to the SAMSON format (Lee 2005).

In AERMET stage 3 processing, site-specific values for parameters that characterize the land surface (surface albedo, Bowen ration, and surface roughness length) of the surface meteorological measurement site are required. Tables 4-2a through 4-3 in the AERMET User's Guide contains values for use in AERMET. Values were chosen based on varying the parameters seasonally but not by wind direction sector. Based on the land use analysis (discussed in Section 3.6), the urban land-use category is appropriate for this study.

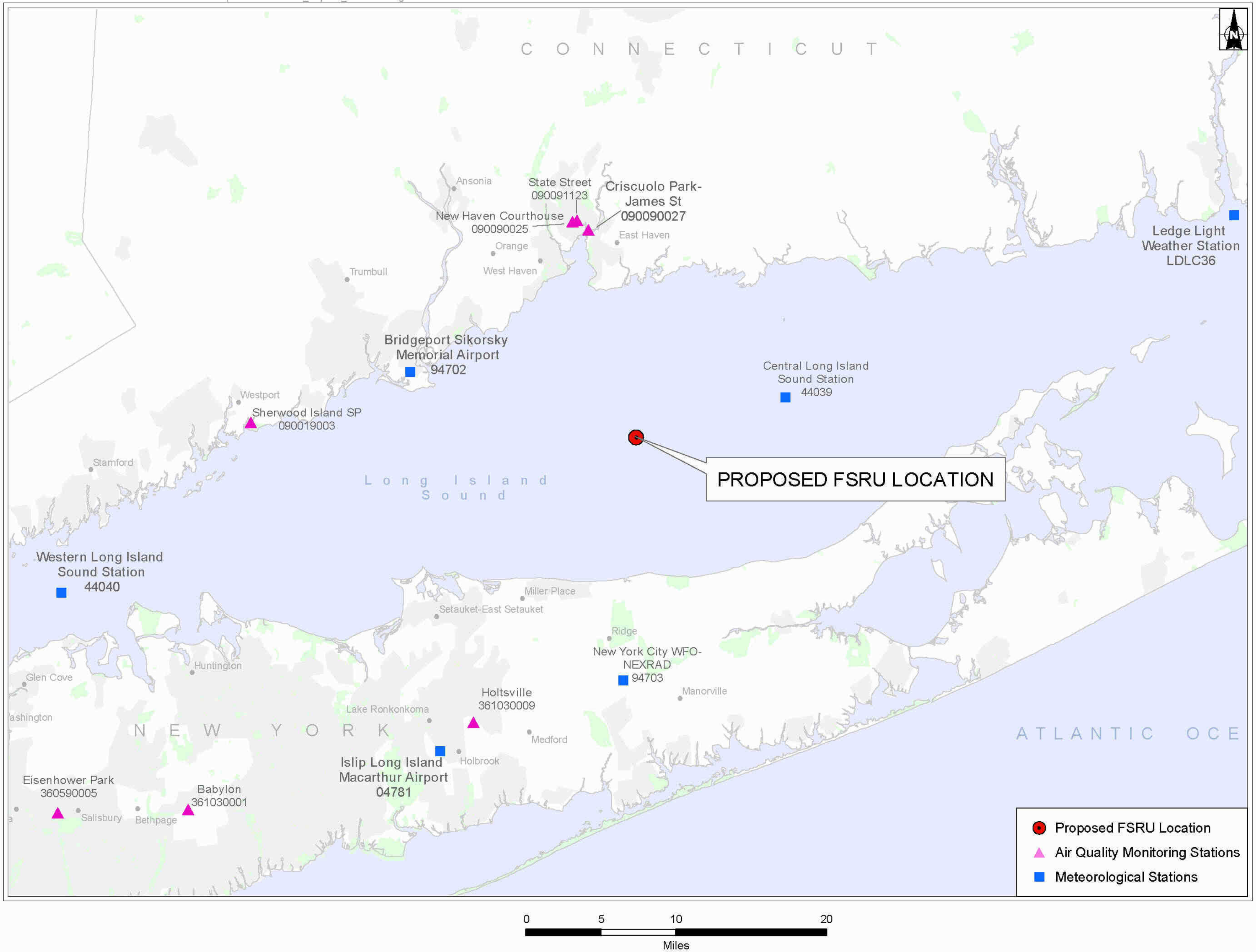


Figure 3-2 Air Monitoring Stations and Meteorological Stations in the Broadwater Project Area

### 3.4.3 CSVP

A two-year (2003 and 2004) set of meteorological data was used for the CSVP analysis, comprised of visibility and present weather observations from Bridgeport Sikorsky Memorial airport merged with wind speed and direction, temperature and dew point/relative humidity from buoy 44039. The CSVP analysis used a longer period of data in order to evaluate as many of the hourly variations in the meteorological parameters as available in recent data. The data support a visual simulation study for the Project environmental resource report filing with the FERC.

## 3.5 Receptors

Each model requires a specific set of receptors to evaluate ambient air quality impacts at the various distances from the FSRU. Receptors located at the boundary of the safety and security zone surrounding the FSRU (i.e., the closest publicly accessible location to the facility) and near-by but outside the safety and security zone were used in AERMOD-PRIME for downwash/cavity impacts in the wake region. OCD receptors at distances extending off-site up to a distance no greater than 50 km were used for evaluating far-field impacts.

Receptor data includes location (x, y coordinates), height above ground, local ground level, and ground-level elevation above the water surface.

### 3.5.1 OCD Receptors

Receptors input to OCD were established as follows:

- On a 2-km by 2-km Cartesian grid system centered on the FSRU with 100-meter spacing in the x and y direction between the grid points. Locations within an assumed 500-yard safety and security zone around the FSRU are excluded. As discussed in Section 3.3.2, to date, the USCG has not defined a specific safety and security zone for the Project. However, for the purposes of air quality modeling and to assess potential impacts, a representative safety and security zone was assumed. Following establishment of a defined safety and security zone by the USCG, Broadwater will update the modeling as necessary to represent anticipated conditions.

- Extending out from the boundary of the Cartesian receptor grid described above, a radial (i.e., polar) receptor grid system was established with receptors located on radial arms at 10-degree compass direction intervals centered on the FSRU. On each radial, receptors were placed at 100-m intervals between 1.5 km and 2.5 km; from 2.5 km to 5 km, receptors were placed at 500-m intervals.

- A large-scale receptor grid covering an area measuring 20 km by 20 km and centered on the FSRU was used to evaluate transport to shore, with receptors located 3.4 km and 4.1 km apart in the east-west and north-south directions, respectively. This grid is established using the procedures within OCD after running the MAKEGEO routine within OCD.

The shape of the coastline is required as input to OCD. This shape is generated from digitized data already incorporated into the OCD model. OCD contains a support program called MAKEGEO that prepares the coastline data. This program requires input of latitude and longitude to define corners of the project area and a grid square spacing. The latitudes defining the north-south extent are 40.8 degrees and 41.5 degrees North latitude. The longitudes defining the east-west extent are 72.5 degrees and 73.3 degrees West longitude. OCD accounts for local terrain in calculation of pollutant concentrations at each receptor.

### 3.5.2 AERMOD-PRIME Receptors

Receptors for AERMOD-PRIME were located along the safety and security zone boundary and arranged in a Cartesian grid outside the safety and security zone perimeter. As discussed in Section 3.3.2 and similar to the approach for OCD modeling, a 500-yard safety and security zone is assumed.

The focus of the AERMOD-PRIME analysis is on close-in air quality impacts at the assumed safety and security zone boundary and in the near-water area beyond the assumed boundary distance. These receptor locations would most likely be located in the near- and far-wake regions if downwash were to occur. Receptor spacing along the potential safety zone boundary is 25 meters lateral distance separation. Receptor spacing in a Cartesian grid established outside of the assumed safety zone boundary is 35 meters in the east-west and north-south directions; this spacing results in a maximum lateral spacing of 50 meters diagonally between receptor locations. The grid extends a minimum distance of 750 meters in the east-west and north-south directions to a maximum distance of 1,330 meters in the northeast/southwest and northwest/southeast directions beyond the assumed safety and security zone boundary.

### 3.5.3 CSVP

Receptor locations are not used in the CSVP analysis procedure.

## 3.6 Land Use

The surface roughness length for the overland meteorological data in OCD is estimated from an examination of vegetation and other obstacles to wind flow within a 3-km radius of the anemometer site (Islip-MacArthur Airport) according to Auer (Auer 1978). Table 3-4 lists typical surface roughness lengths for various types of environments. A composite value for the site is obtained by weighting the value for each type of ground cover according to its fraction of area coverage. Table 3-5 lists the land uses within the 3-km radius and the corresponding ground cover types. The OCD model uses the logarithm of the surface roughness length.

**Table 3-4 Typical Surface Roughness Lengths for Various Ground Covers**

| Ground Cover | Surface Roughness Length (m) |
|---|---|
| Water Surface | 0.00001 - 0.004 |
| Snow Surface | 0.0005 - 0.001 |
| Fallow Field or Low Grass | 0.01 - 0.03 |
| High Grass | 0.03 - 0.10 |
| Desert, Sand Dunes | 0.05 - 0.10 |
| Flat Rural, Few Trees | 0.003 - 0.03 |
| Rural, Rolling Terrain, Few trees | 0.01 - 0.15 |
| Woods | 1.00 |
| Suburban | 0.5 - 1.5 |
| Urban | 1.5 - 4.0 |
| Dense Vegetation Cover | 1/8 of the average canopy height |

Reference: MMS 1989, Table 3-8.

**Table 3-5 Land Use within 3 Kilometers of Islip-MacArthur Airport**

| Land Use Description | Ground Cover Type | Fraction of Area |
|---|---|---|
| Commercial and Services | Suburban | 13.5 |
| Deciduous Forest Land | Heavily Wooded | 12.38 |
| Strip Mines, Quarries, Gravel Pits | Minimal Vegetation | 0.54 |
| Residential | Suburban | 48.71 |
| Transitional Areas | Grass, Weeds | 2.04 |
| Transportation and Utilities | Flat Rural, Few Trees | 22.87 |

Source: E & E 2005.

## 3.7 Miscellaneous Model Options

The following options were used during OCD model runs: stack-tip downwash, buoyancy-induced dispersion, and terrain adjustments. The gradual plume rise option was not used during OCD model runs. Following recommendations of EPA, the OCD User's Guide advises model users not to select the gradual plume rise option since it has been found to occasionally produce large over predictions close to stack(s) (MMS 1989, 1997).

In accordance with recommendations in the OCD User's Guide, the minimum "miss distance" is 10 meters. In complex terrain situations, OCD assumes the plume stays the "miss distance" above the ground surface.

In AERMOD-PRIME, the non-regulatory default option must be selected in order to assume use of flat terrain. This is appropriate given that the receptor grid is located entirely over a water surface.

## 3.8 Analysis of Model Output

### 3.8.1 OCD and AERMOD-PRIME

OCD model results estimate impacts outside of the wake region over water and over land. AERMOD-PRIME results estimate downwash effects in the near- and far-wake regions in close proximity to the FSRU location.

A comparison of OCD and AERMOD-PRIME model output to the SILs presented in Table 2-1 is performed first.

If all modeled maximum concentrations for each pollutant and averaging period are less than the applicable SIL, then no further modeling analysis is required. If one or more modeled maximum concentrations are above the applicable SIL, then prior to comparing modeled air quality concentrations to the NAAQS, total ambient air quality impacts must be calculated. Procedures outlined in NYSDEC Air Guide 26 and Air Guide 36 prescribe methods to determine whether other large nearby sources need to be included in a cumulative modeling study. Development of the cumulative source inventory is guided by procedures outlined in Air Guide 36. If no other large sources need to be included in a cumulative analysis, then total air quality impacts can be determined by adding air pollutant background concentrations to the modeled air pollutant concentrations. Representative air pollutant background monitoring concentrations were identified through a review of existing air quality monitoring data collected at monitoring stations located in New York State and Connecticut (NYSDEC 2004, 2003; EPA 2005b, 2004b, 2003b). Air monitoring in New York State is conducted by NYSDEC (Babylon and Eisenhower Park sites) and Suffolk County (Holtsville site). Air monitoring in Connecticut is conducted by the Connecticut Department of Environmental Protection (CTDEP).

The locations of air quality monitoring stations are shown on Figure 3-2.

Air pollutant background monitoring concentrations for receptors in New York State were based on values from the following data sets:

- • CO, $NO_2$, and $SO_2$: 2002-2004 calendar year data from Holtsville, New York (Station 361030009); and

- • $PM_{2.5}$, and $PM_{10}$ 2002-2004 calendar year data from Babylon, New York, and Eisenhower Park, New York, respectively.

A summary of the proposed air pollutant background data is presented in Table 3-6.

**Table 3-6 Air Pollutant Background Concentrations**

| Pollutant | Averaging Period | Type | Value | Data Source |
|---|---|---|---|---|
| CO | 1-hr | 2nd Highest | 3.7 ppm | Holtsville, New York (Station 361030009) – CY 2002 |
| | 8-hr | 2nd Highest | 1.9 ppm | Holtsville, New York (Station 361030009) – CY 2002 |
| $NO_2$ | Annual | - | 0.017 ppm | Holtsville, NY (Station 361030009) – CY 2002 |
| $PM_{2.5}$ | 24-hr | 98th Percentile | 34.6 $\mu g/m^3$ | Babylon, NY – Average of CY 2002 through 2004 |
| | Annual | - | 11.5 $\mu g/m^3$ | Babylon, NY Average of CY 2002 through 2004 |
| $PM_{10}$ | 24-hr | 2nd Highest | 47$\mu g/m^3$ | Eisenhower Park, NY – CY 2003 |
| | Annual | - | 18 $\mu g/m^3$ | Eisenhower Park, NY – CY 2003 |
| $SO_2$ | 3-hr | 2nd Highest | 0.065 ppm | Holtsville, NY – CY 2004 |
| | 24-hr | 2nd Highest | 0.033 ppm | Holtsville, NY – CY 2004 |
| | Annual | - | 0.007 ppm | Holtsville, NY – CY 2004 |

Sources: EPA 2003b, 2004b, 2005b.

Key:

CY = Calendar Year.

### 3.8.2 CSVP

Four parameters calculated by the CSVP model are key factors to determine whether a visible plume forms given the plume characteristics and ambient weather conditions. If any of these four parameters are non-zero for one or more hours of the meteorological data record, then visible plume formation is possible. These parameters are:

- Condensation temperature of the exhaust, degrees Kelvin (ºK);
- Re-evaporation temperature of the exhaust (ºK);
- Moisture weight fraction at start of condensation; and
- Moisture weight fraction at end of condensation.

If plume formation is indicated and the plume dimension analysis is performed, a tabular summary of plume dimensions is prepared for the range of conditions under which a plume is shown to form. The largest of the plume dimensions would be submitted for use in the visual simulation study.

CSVP results will be checked by manually using a psychrometric chart for ambient temperatures of: 0 ºF, 25 ºF, 40 ºF, 59 ºF, 85 ºF, 90 ºF, 95 ºF, and 100 ºF at an ambient relative humidity level of 60%. A straight line between the exhaust condition and the ambient condition is drawn on the chart. If the line does not cross the saturation curve and the CSVP model results indicated that a plume would not form, the CSVP results are then verified as valid.

# 4 Reporting of Results

The ambient air quality impact analysis is summarized in a report. The report includes emission parameters and building dimensions in tabular format and a discussion of how the meteorological data were prepared. A comparison of the maximum modeled concentrations of each pollutant to the applicable SIL is also shown. If needed based on the results of the SIL comparison, tables showing the maximum modeled concentration added to applicable background concentrations are developed. All OCD and AERMOD-PRIME model input and output files are provided on CD-ROM. Plot plans showing the location of the proposed facilities and appropriate dimension/size information are provided.

CSVP (visible plume) model results are incorporated into the Broadwater visual impact study report supplement to the Coastal Zone portion of the FERC application.

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# A Responses to NYSDEC and EPA comments on Broadwater Air Modeling Protocol



PUBLIC

BW002399

**Responses to NYSDEC and EPA Comments on Broadwater Air Modeling Protocol**

**NYSDEC – November 7, 2005**

Comment regarding applicability of PSD regulations: It is Broadwater's understanding that EPA Region II, along with other EPA regional offices involved in the permitting of offshore LNG facilities, is participating in working group discussions with EPA Headquarters on this subject. To date, no indication of where the EPA is with respect to reaching a conclusion on this matter has been received by Broadwater.

Comment 1: Section 1.3 should reflect the fact that although the 8 hour ozone standard replace the 1 hour NAAQS as of 6/15/05, the non-attainment provisions of the current versions of Parts 200, 201 and 231-2 are still in effect until officially modified. Also, the 11/01/05 Federal Register notice of the proposed rule to implement the fine particle NAAQS should be reviewed to determine applicability of the New Source Review Provisions to the facility.

Response: The January 2006 revised protocol has been revised to address these two topics. Please refer to Section 1.3.1.

Comment 2: Sections 2.2, 2.8 and 3.8 note that the cumulative impact analysis, if necessary, will include the modeling of other nearby sources for the PSD increments while the NAAQS analysis will rely on monitoring data to determine standards compliance. As noted in item 3 of my 6/16/05 letter, a cumulative impacts analysis for NAAQS will also be necessary per PSD requirements and DEC's Air Guides 26 and 36 if the project has significant impacts.

Response: The text in these sections of the protocol has been revised to include a discussion of the cumulative impacts analysis procedures.

Comment 3: Sections 2.4 and 3.3 no longer reference the ISC-PRIME model as requested, but do not reflect our previous comment 5 that the ISC3 model downwash approach be used to determine impacts in the building wake area beyond the approach in OCD, which is not current with respect to the downwash effects. However, DEC understands that the AERMOD model will be officially noticed in the very near future (the Federal Register notice has been signed by the EPA Administrator) and Broadwater may choose to propose the use of the AERMOD exclusively to address the cavity and wake effects.

Response: The January 2006 protocol has been revised to address use of AERMOD-PRIME for downwash/cavity/wake effects evaluation.

Comment 4: Please explain why there is a difference in the PM2.5 versus PM10 hourly emissions for the emergency generators in Table 3-1 which does not appear in Table 4 of Appendix B.

Response: The difference in the $PM_{10}$ and $PM_{2.5}$ rates is related to the units used in each table and significant digits presented after rounding. In Table 3-1, the short-term rates for $PM_{2.5}$ and $PM_{10}$ are shown in grams/second, while in Table 4 in Appendix B they are shown in lb/hr; when using just one decimal place in Table 4 in Appendix B, they both round to the same number.

Comment 5: In Section 3.1.3, all potential combinations of load, fuel and ambient conditions should be analyzed, not just those practicable, unless a permit limit is anticipated for certain conditions. A list of such scenarios should be provided.

Response: A permit limit is not anticipated for certain conditions. The word 'practicable' has been removed from the text. The load and ambient temperature ranges to be evaluated for short-term emission rate determination are shown in the text and cover the operating conditions expected on the FSRU.

Comment 6: As noted in Section 3.3.2, the 'safety zone' where the public access will be precluded is still to be determined and this will determine the status of ambient air receptors to be modeled.

Response: The final determination of the safety and security zone distance by the U.S. Coast Guard is likely to remain unknown for a significant amount of time. The process of determining at what distance to located the safety and security zone around the FSRU considers many factors. For purposes of modeling to get a sense of nearby impacts, a 500-yard distance was selected based on safety and security zone distances proposed for other offshore LNG projects.

Note: There was no Comment 7 in the November 7, 2005 comment letter.

Comment 8: The most significant modeling issue which remains unresolved is the proposed meteorological data. Based on the information presented, it is our position that the data does not meet EPA and DEC requirements and is not acceptable for use, as it stands. This determination is based on a few factors. First, as noted in our and EPA's previous comments, EPA's modeling guidance requires five years of NWS or, at a minimum, one year of complete onsite data. This recommendation presupposes that the meteorological data is essentially complete before any data substitution is made for model applications. The Meteorological Monitoring Guidance document referenced in EPA's June 29, 2005 comments specifies a minimum of 90% data recovery of each variable on an annual basis prior to data filling. We agree that NOAA's NDBC station 44039 in central Long Island sound can be deemed representative of the proposed facility's location. However, data presented in Table 3-3 clearly indicates less than adequate data recovery for not only any of the three calendar years, but for any consecutive 12 month period. Even after short interval data interpolation, the data recovery percentages in Table 3-4 are below the required minimum.

The situation is further complicated by the fact that the required water and ambient temperatures, and relative humidity for use in the OCD model should come from the same location due to sensitivity of instrumentation and the over water stability determination scheme, as noted in the protocol. As such, any substitution of data must demonstrate essentially the same conditions as at the preferred site. To that end, we do agree that data from Bridgeport properly represents these conditions, at least for the temperature and humidity. Of the remaining data locations, the Western station 44040 can serve to be the site for wind data substitution, once the minimum 90% data recovery is achieved at the main site (# 44039).

Thus, we conclude that, at this time, there is inadequate meteorological data for the proper use of the OCD model. Broadwater should consider augmenting the data capture capabilities of the University of Connecticut at the buoy since it appears that data transmission failures were the main cause of the limited data capture. Of course, Broadwater can initiate it's own data gathering program. The only other alternative which is allowed by the Modeling Guidelines is to limit the modeling to the screening level. However, we are unaware of any demonstrated "worst case" modeling inputs for the OCD model. Lastly, if the buoy data is further pursued for application, we request information on the instrumentation specifications and data averaging to assure these meet the requirements of the Meteorological Monitoring guidance.

Response: Meteorological data recovery from buoys in general appears, based on some research into this issue, a bit less reliable than from land-based stations. Data transmission and lack of ready access to the data buoy for repair purposes contributes to a lower data recovery rate. Recognizing that the data period initially evaluated for the modeling study did not meet EPA or DEC minimum raw data recovery requirements, it was felt that the rather uniform conditions found over large water bodies would allow for flexibility in raw data recovery at one station if a secondary station located in the same water body could be used for data substitution. Subsequent to the initial data set proposed, sufficient time elapsed that more data became available from buoy 44039, and it was found that data logger files were periodically downloaded from the buoy during routine maintenance visits on a quasi-monthly basis. Thus, a thorough evaluation to find the best data set (in terms of raw data capture) was made of the data from buoy 44039 for the period September 1, 2002, through December 8, 2005. From this evaluation, a 1-year data set extending from December 9, 2004, through December 8, 2005, was selected. This data set is much better in terms of data recovery, reaching over 90% recovery for the December 9, 2004, through August 31, 2005, time period. For September through November 2005, data recovery is below 90% due to the buoy being out of the water for installation of various sensor upgrade packages. In December 2005, data recovery was again well over 90%. The annual data recovery for the December 9, 2004, through December 8, 2005, period is 89.5%. Two scenarios are proposed in order to complete the data set for use in modeling. As discussed in the comment, for limited data substitution, the Western Sound data can be used for air and water temperature and dew point/relative humidity, and Bridgeport Sikorsky Airport data can be used for wind speed and direction. It is also proposed that this method be used to fill in the missing data period. Alternatively, a data set from a different year from buoy 44039, meeting EPA and DEC minimum requirements, can be substituted for the missing data period (September through November 2005).

Comment 9: With respect to the proposed missing data substitution scheme, we had previously noted that equating the water and ambient temperatures results in neutral stability class, but seems unrealistic and has not been demonstrated to result in conservative impacts. Thus, items 1 and 2 of page 3-13 should be revisited. Furthermore, as noted above, we recommend the use of the water based site (such as station 44040) for concurrent water and temperature and humidity data while the Bridgeport data can be used for wind speed and direction data filling if it determined more representative. This data substitution will be adequate once the minimum 90 % data capture is met at the main station site.

Response: The January 2006 protocol has been revised to reflect this approach.

Comment 10: For the onshore data sites, please provide further information on data availability and adequacy at the Brookhaven National Lab sites noted in table 4 of Appendix C of the FERC Resource Report #9.

Response: The evaluation of these data sets is still in progress.

Comment 11: It should be assured that the receptors at the boundary of the "safety zone" be resolved to a lateral distance interval corresponding to a ten degree radial interval within the Cartisian grid. Furthermore, any terrain features at the land boundaries should be resolved to within 1km interval to identify potential high impacts.

Response: Receptors will be placed according to these recommendations. Currently, receptors will be placed at 25 meter intervals along the safety zone boundary. This lateral distance results in a less than 10 degree resolution.

Comment 12: As requested in item 12 of our 6/16/05 comments, for impacts on Long Island the regional background data, in addition to CO, should come from New York monitor sites.

Response: The protocol text has been updated to reflect this comment.

Final comment (unnumbered): During Broadwater's presentation, you noted that a plume visibility assessment will be conducted for the FERC review process. We would recommend additional modeling analysis also address the consequences of a potential accidental release of hazardous and toxic contaminants and of $PM_{2.5}$ emissions.

Response: The January 2006 protocol has been revised to include the visible plume assessment procedure. $PM_{2.5}$ emissions have been quantified and will be included in the OCD and AERMOD-PRIME modeling analyses. The FERC Resource Report document will contain a section discussing the accidental release of LNG. The FSRU will not contain substances in quantities that are subject to risk management plan (RMP) provisions of the Clean Air Act; the SCR units onboard the FSRU will use aqueous ammonia solution.

**NYSDEC – June 16, 2005**

Comment 1: The protocol should provide some more detail on the emissions and stack parameters in order to better define all required and appropriate analyses, including the possible consideration of a PSD monitoring waiver, the limitations on short term simultaneous operations, the modeling for the diesel fuel use, and the need for a net air quality benefit analysis resulting from EPA's 4/05/05 $PM_{2.5}$ non-attainment guidance policy. Further information is also requested on the auxiliary equipment listed on page 1-4, the shut down and startup conditions for the turbines, and the scenarios of equipment operations.

Response: Section 3 of the revised protocol discusses the stack emissions in more detail. Tables 3-1 and 3-2 provide data on emission rates and stack parameters proposed for modeling.

Comment 2: A visibility analysis for other than Class I areas might be necessary per the "additional analysis" requirements of the PSD regulations if similar sensitive areas are locations on Long Island or Connecticut. A search of such parks or "vistas" should be made.

Response: An update of this has not been included in the protocol pending determination from the EPA regarding the applicability of PSD. However, as part of the Coastal Zone requirements, a visual resource assessment study is being prepared that has a similar requirement to identify locally sensitive visual resource sites on Long Island and Connecticut. The study is identifying and locating visually sensitive resources based on several data sources, including local governments, county planning offices, a "windshield" survey by a land use planning expert, and the results of a survey mailed to local individuals and groups. The results of the survey have not been compiled yet; however, solely based on the search conducted to date, 50 visually sensitive sites have been identified for the visual/aesthetic study. This list of sites, when updated with the results of the survey, will serve as the basis for determining which sites to evaluate under the "additional analysis" requirements of the PSD regulations if the EPA determines that PSD review is required for the project.

Comment 3: A cumulative impacts analysis for PSD increment and NAAQS per PSD requirements and DEC's Air Guides 26 and 36 will be necessary if the project has significant impacts. Although the details of identifying the sources to be modeled can await the determination of the impact area, the protocol should provide the methodologies which will be used per DEC's Air Guide 36 to determine the set of NAAQS and PSD sources. In addition, the baseline area in all of Long Island has been triggered for all three increment consuming pollutant and need not be analyzed in a supplemental submission.

Response: We will provide an addendum to the protocol addressing the methodologies to be used if the EPA determines that PSD is applicable to the project.

Comment 4: Table 2-4 should reflect the $PM_{10}$ increments of 17 and 30 μg/m3 which have long since replaced the TSP values listed.

Response: The table has been updated to reflect this change.

Comment 5: For the calculation of structure downwash effects, the ISC-PRIME model is no longer supported by EPA since the AERMOD model incorporates the PRIME algorithm. However, DEC does not allow the use of AERMOD until it is officially noticed as the replacement for ISC3. Thus, the models of choice currently for downwash effects are ISC3 for wake and SCREEN3 for cavity effects.

Response: The protocol has been revised to include use of SCREEN3 for cavity effects. Since SCREEN3 will be run to evaluate cavity effects, wake effects would be evaluated also. The OCD's wake/downwash algorithm will also be used to determine whether that algorithm gives results significantly different than SCREEN3. OCD's algorithm is based on tracer/wind tunnel tests for offshore platforms.

Comment 6: A series of model runs are planned to account for the changing orientation of the structures which might influence the stack emissions. This is especially important for the short term impacts. Thus, please provide the time frame and wind sectors over which this orientation might change significantly such that a different set of structure dimensions will need to be modeled.

Response: Please see revised approach discussed on page 3-5.

Comment 7: Before receptors in the cavity zone or elsewhere can be dismissed as "within the fence line area", Broadwater must provide further assurance that the public will not have access to these areas.

Response: Broadwater has proposed a 500-yard safety and security zone; however, the final size of the safety and security zone is determined by the U.S. Coast Guard. Please see Section 3.3.2 for a discussion of the considerations involved in establishing the safety and security zone.

Comment 8: A potential major concern we have with the use of the proposed meteorological data base is the limited data recovery of 46% of all of the required parameters. The EPA Modeling Guidelines and associated Meteorological Monitoring guidance documents presuppose and require the availability of 90% existing data basis such as from NWS, similar to the requirements for on-site representative data gathering. Please provide details on the percent recovery of each required parameter, as well as any "seasonal" and yearly percentages of these. Furthermore, provide an estimate of the level of completeness which will be achieved by substituting the data from the Western Long Island Sound station. In addition, the proposed substitution of air or water temperatures for the corresponding missing parameter (i.e. assuming a zero temperature difference) is not acceptable, unless a showing can be made that it would lead to conservative estimates throughout the modeling analysis.

Response: The discussion concerning meteorological data in Section 3.4.1 of the revised protocol provides additional information to address the comment.

Comment 9: As much of the available onshore meteorological data as allowed by the OCD model should be used in calculating impacts on Long Island and Connecticut. Although Bridgeport is representative of coastline meteorology on the sound, meteorological data from Long Island (such as Brookhaven's private monitoring data at Shoreham or Mac Arthur airport data) should be further investigated for used when determining impacts on Long Island. As such, the corresponding required land-use values should also be used. Also, provide details on how the over water wind speed will be calculated from the onshore values.

Response: Please see the discussion in Sections 3.4 (Meteorological Data) and 3.6 (Land Use) of the revised protocol.

Comment 10: Please correct the referenced McElroy-Pooler to the Pasquill -Gifford curves noted on page 3-10 as the former apply for an urban setting.

Response: This has been corrected.

Comment 11: Prior to any modeling, any deviations from the default OCD settings noted on page 3-11 should be approved by DEC and EPA.

Response: Any deviations from default settings will be submitted for DEC and EPA approval.

Comment 12: For impacts on Long Island, we would suggest the use of regional background levels from the New York monitor sites discussed.

Response: Please see the revised discussion of background air quality levels in Section 3.8 of the revised protocol.

Comment 13: We would recommend that other modeling assessments such as for potential $PM_{2.5}$ impacts and visible plumes during the Environmental Impact Assessment phase should be shared with our staff for review.

Response: A protocol for the visible plume analysis that will be incorporated into the visual assessment under Coastal Zone Consistency Policy No. 8 has been incorporated into the revised protocol. As mentioned in the presentation on October 20, 2005, the analysis will utilize the Combustion Source Visible Plume model.

**EPA – June 29, 2005**

Comment 1: The protocol should provide better information on the data capture statistics for the meteorological stations used, especially the buoy data. Use of the parameters needs more explanation.

Response: Please see response to DEC Comment 8.

Comment 2: Over water mixing height needs further discussion in the modeling protocol.

Response: The discussion of the overwater mixing height has been revised. Please see Section 3.4 of the revised protocol.

Comment 3: EPA Region 2 states that concurrence from the EPA Office of Air Quality Planning and Standards would be needed to exclude the 500 yard safety zone from the evaluation of impacts. Region 2 will pursue this with OAQPS if this is Broadwater's final proposal.

Response: The U.S. Coast Guard sets the final safety and security zone requirements for the FSRU. Broadwater has held discussions with the U.S. Coast Guard on the safety and security zone requirement and has discussed a 500-yard zone; however, the U.S. Coast Guard has not made a final determination on this matter.

Comment 4: EPA states that AERMOD-PRIME is the better alternative to use to evaluate impacts due to downwash.

Response: At the time the comment was received, DEC indicated that until AERMOD is officially designated in the Federal Register as final, DEC will not accept use of AERMOD-PRIME. Subsequently, AERMOD-PRIME has been noticed as final in the Federal Register; thus, the revised protocol reflects use of AERMOD-PRIME for downwash evaluation.

Comment 5: Under applicable requirements, note that Suffolk County is nonattainment for $PM_{2.5}$. Nonattainment permit requirements need to be addressed.

Response: The $PM_{2.5}$ nonattainment designation information has been added to Section 1.3.1 of the revised protocol.

Comment 6: Revise table 2-4 to show that $PM_{10}$ is the PSD increment pollutant, not TSP.

Response: This change has been made.

Comment 7: Clarify whether turbines will be simple or combined cycle. Verify how they will be modeled.

Response: The turbines will be equipped with non-fired heat recovery units in the exhaust stream to recover waste heat. The heat recovered will be used to provide additional heat input to the regasification process, and it will also be used for ship system requirements (such as comfort heating, potable hot water heating, etc.). The gas turbines will be modeled as simple cycle units with exhaust gas temperatures lowered to reflect the heat removed by the non-fired heat recovery units.

Comment 8: A preconstruction monitoring waiver request must be submitted prior to the application. EPA recommends that if existing monitoring data is proposed, it should be representative of Long Island impacts.

Response: The discussion of existing monitoring data is included in Section 3.8 of the January 2006 protocol. The closest available New York state monitoring stations representing conditions on Long Island are discussed. The stations include Holtsville, Babylon, and Eisenhower Park.

Comment 9: An Environmental Justice analysis should be included in the application.

Response: The Environmental Justice and Permitting guidelines indicate that an environmental justice analysis should be applied in the context of a new major permit decision, significant modification or renewal of a major permit. At this time, EPA is in the process of determining whether certain emissions (e.g., LNG carrier emissions) should be included in the facility total. This decision will ultimately determine whether the permit application for the Broadwater project is treated as a major new permit, or as a New York State facility (i.e., Minor) permit. If the project is a major new permit, then environmental justice analysis procedures, as outlined in the EPA's Interim Environmental Justice Policy, will be addressed.

# B Emission Calculations Workbook

**ATTACHMENT A - TABLE OF CONTENTS**

**Table 1**
**SUMMARY OF SOURCES**

| Source Description | Fuel | Rating | Rating Units | Annual Hours of Operation (hr/yr) | Annual Operating Conditions | Annual Operating Conditions Units |
|---|---|---|---|---|---|---|
| Turbine 1 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 2 | nat gas | 264 | MMBtu/hr | 8,760 | 2,312,640 | MMBtu/hr |
| Turbine 3 (Backup) | diesel | 264 | MMBtu/hr | 500 | 132,000 | MMBtu/hr |
| Process Heater 1 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 2 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 3 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 4 | nat gas | 247 | MMBtu/hr | 8,760 | 2,061 | MMcf/yr |
| Process Heater 5 (Standby) | nat gas | 1.8 | MMBtu/hr | 8,760 | 15 | MMcf/yr |
| Fire Pump Engine 1 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Fire Pump Engine 2 | diesel | 15.1 | MMBtu/hr | 100 | 1,510 | MMBtu/yr |
| Emergency Generator 1 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 2 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| Emergency Generator 3 | diesel | 22.8 | MMBtu/hr | 100 | 2,280 | MMBtu/yr |
| LNG Carrier Unloading | HFO | - | - | - | - | - |

Key:

HFO = Heavy fuel oil (also known as residual oil or bunker fuel)

Notes:

1. Rating for turbines based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
2. Rating for Process Heaters 1-4 based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
3. Rating for Process Heaters 5 based the operation of 24 pilots operating at 75,000 Btu/hr while heater is standby mode. (Ref. 6).
4. Rating for fire pump engines and emergency generators based on data provided by Shell (Ref. 2).
5. Annual hours of operation of Turbines 1-2 and all process heaters based on continuous operation.
6. Annual operation value for Turbine 3, fire pumps, & emergency generators used by USEPA to estimate potential emissions for emergency equipment.

**Table 2**
**SUMMARY OF STACK PARAMETERS**

| Source Description | Stack Height Above Water Level (m) | Stack Exit Inside Diameter (m) | Deviation of Stack Angle (deg) | Base Elevation Above Water Level (m) | Stack Gas Temp. (K) | Stack Gas Exit Velocity (m/s) | Stack Gas Exit Flowrate (acm/s) |
|---|---|---|---|---|---|---|---|
| Turbine 1 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 2 | 45 | 3.96 | 0 | 25 | 523 | 10.0 | 123 |
| Turbine 3 (Backup) | 45 | 3.96 | 0 | 25 | 523 | 10.3 | 127 |
| Process Heater 1 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 2 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 3 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 4 | 45 | 4.57 | 0 | 25 | 450 | 3.4 | 56 |
| Process Heater 5 (Standby) | 45 | 4.57 | 0 | 25 | 450 | 0.025 | 0.41 |
| Fire Pump Engine 1 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Fire Pump Engine 2 | 40 | 0.46 | 0 | 25 | 716 | 26.8 | 4.45 |
| Emergency Generator 1 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 2 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |
| Emergency Generator 3 | 40 | 0.61 | 0 | 25 | 710 | 23.2 | 6.77 |

Notes:

1. Stack heights, stack exit diameters, and stack angles for turbines and process heaters from Shell (Ref. 1, Table 1).
2. Stack heights and stack exit diameters of fire pump engines, emergency generators, and LNG carrier are strictly estimates.
3. Base elevation for all FSRU equipment based on Trunk Deck height above sea level (Ref. 9).
4. Stack angles of fire pump engines, emergency generators, and LNG carrier assumed equal to data for turbines and process heaters.
5. Stack temperature and flowrate for turbines estimated by calculating effects of waste heat recovery unit (WHRU) on data provided by Shell for operation at 60 F and 100% Load (Ref. 7).
6. Stack temperature and flowrate for Process Heaters 1-4 based on data provided by Shell for operation at 60 F and 100% Load (Ref. 1, Table 2a).
7. Stack temperature and flowrate for process heaters based on data in Table 4 (Load @ 0.73%).
8. Stack temperature and flowrate for fire pump engines based on 50% load for Caterpillar 3608 (Ref 5).
9. Stack temperature and flowrate for emergency generators based on 80% load for Caterpillar 3608 (Ref 5).
10. Stack velocity for all sources calculated from stack exit diameter and stack exit flowrate.

## Table 3
## SUMMARY OF EMISSION RATES FOR MODELING

| Source Description | 1-Hour to 8-Hour Periods | | | | | 24-Hour Periods | | | Annual | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NO_x$ Emission Rate (g/s) | $PM_{2.5}$ Emission Rate (g/s) | $PM_{10}$ Emission Rate (g/s) | $SO_2$ Emission Rate (g/s) | $NH_3$ Emission Rate (g/s) |
| Turbine 1 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 2 | 0.769 | 0.220 | 0.220 | 0.021 | 0.510 | 0.220 | 0.220 | 0.021 | 0.326 | 0.220 | 0.220 | 0.0213 | 0.510 |
| Turbine 3 (Backup) | 0.110 | 0.399 | 0.399 | 0.050 | 0.568 | 0.399 | 0.399 | 0.050 | 0.334 | 0.023 | 0.023 | 0.0028 | 0.032 |
| Process Heater 1 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 2 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 3 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 4 | 0.481 | 0.225 | 0.225 | 0.018 | 0.213 | 0.225 | 0.225 | 0.018 | 0.145 | 0.225 | 0.225 | 0.0178 | 0.213 |
| Process Heater 5 (Standby) | 0.013 | 0.0016 | 0.0016 | 0.00013 | 0 | 0.0016 | 0.0016 | 0.00013 | 0.010 | 0.0016 | 0.0016 | 0.00013 | 0 |
| Fire Pump Engine 1 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Fire Pump Engine 2 | 3.61 | 0.106 | 0.109 | 0.0029 | 0 | 0.106 | 0.109 | 0.0029 | 0.070 | 0.00121 | 0.00124 | 0.00003 | 0 |
| Emergency Generator 1 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 2 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |
| Emergency Generator 3 | 5.46 | 0.160 | 0.165 | 0.0043 | 0 | 0.160 | 0.165 | 0.0043 | 0.105 | 0.00182 | 0.00188 | 0.00005 | 0 |

Notes:

1. Annual emission rates for Turbines 1-2 and Process Heaters 1-4 based on 50 startups and 50 shutdowns each year per unit.
2. CO and NOx emission rates for Turbines 1-2 based on information provided by Shell for normal operation and by GE for startup/shutdown conditions (see Tables 4 and 6).
3. NH3 emission rates for Turbines 1-3 based on information provided by Shell for normal operation (see Table 4). Emissions assumed to be constant during startup and shutdown.
4. PM2.5, PM10, and SO2 emission rates for Turbines 1-2 based on equipment rating and AP-42 emission factors for natural gas turbines (see Tables 1 and 7). Emissions assumed to be constant during startup and shutdown.
5. Air pollutant (except NOx and NH3) emission rates for Turbine 3 based on equipment rating and AP-42 emission factors for diesel turbines (see Tables 1 and 7). NOx emissions for Turbine 3 are based on estimate control of SCR at 80%.
6. NOx emission rates for Turbine 3 based on a NOx concentration of 64 ppmvd @ 15%O2 (see Table 4). This concentration reflects NOx limit in 6 NYCRR 227-2 (NOx RACT) for emissions for diesel-fired combined cycle turbines.
7. CO and NOx emission rates for Process Heaters 1-4 based on information provided by Shell for normal operation and startup/shutdown conditions (see Tables 4, 5 and 6).
8. NH3 emission rates for Process Heaters 1-4 based on information provided by Shell for normal operation (see Table 4). Emissions assumed to be constant during startup and shutdown.
9. PM2.5, PM10, and SO2 emission rates for Process Heaters 1-4 based on equipment rating and AP-42 emission factors (see Tables 1 and 8).
10. CO and NOx emission rates for Process Heater 5 extrapolated from data provided for Shell for normal operation and uncontrolled conditions (no SCR) to 1.8 MMBtu/hr (0.73% Load) (see Table 4).
11. NH3 emission rate for Process Heater 5 is 0 lb/hr based on assumption that SCR is not operational.
12. PM2.5, PM10, and SO2 emission rates for Process Heater 5 based on equipment rating and AP-42 emission factors (see Tables 1 and 8).
13. All air pollutant emission rates for fire pump engines and emergency generators based on equipment rating and AP-42 emission factors (see Tables 1 and 9).

**Table 4**
**SUMMARY OF MAXIMUM HOURLY EMISSION RATES**

| Source Description | Maximum Hourly Emission Rate (lb/hr) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ | VOC | $NH_3$ | $CO_2$ |
| Turbine 1 | 6.1 | 2.6 | 1.7 | 1.7 | 0.17 | 1.1 | 4.1 | 37,501 |
| Turbine 2 | 6.1 | 2.6 | 1.7 | 1.7 | 0.17 | 1.1 | 4.1 | 37,501 |
| Turbine 3 (Backup) | 0.87 | 46.5 | 3.2 | 3.2 | 0.40 | 0.11 | 4.5 | - |
| Process Heater 1 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 2 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 3 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 4 | 3.8 | 1.2 | 1.8 | 1.8 | 0.14 | 0.5 | 1.7 | 28,229 |
| Process Heater 5 (Standby) | 0.10 | 0.078 | 0.013 | 0.013 | 0.0010 | 0.003 | 0 | 206 |
| Fire Pump Engine 1 | 29 | 48 | 0.84 | 0.87 | 0.023 | 1.2 | 0 | 2,492 |
| Fire Pump Engine 2 | 29 | 48 | 0.84 | 0.87 | 0.023 | 1.2 | 0 | 2,492 |
| Emergency Generator 1 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |
| Emergency Generator 2 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |
| Emergency Generator 3 | 43 | 73 | 1.3 | 1.3 | 0.034 | 1.9 | 0 | 3,762 |

**Table 5**
**SUMMARY OF ANNUAL POTENTIAL-TO-EMIT**

| Source Description | Annual Emissions (tpy) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CO | $NO_x$ | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ | VOC | $NH_3$ | $CO_2$ |
| Turbine 1 | 15 | 11.3 | 8 | 8 | 0.7 | 5 | 18 | 164,255 |
| Turbine 2 | 15 | 11.3 | 8 | 8 | 0.7 | 5 | 18 | 164,255 |
| Turbine 3 (Backup) | 0.2 | 11.6 | 0.8 | 0.8 | 0.1 | 0.03 | 1.1 | - |
| **Subtotal Gas Turbines** | **29.7** | **34.3** | **16.1** | **16.1** | **1.6** | **9.4** | **36.6** | **328,509** |
| Process Heater 1 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 2 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 3 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 4 | 12 | 5.1 | 8 | 8 | 0.6 | 2 | 7 | 123,641 |
| Process Heater 5 (Standby) | 0.4 | 0.3 | 0.06 | 0.06 | 0.005 | 0.02 | 0 | 901 |
| **Subtotal Process Heaters** | **49.3** | **20.5** | **31.4** | **31.4** | **2.5** | **8.4** | **29.6** | **495,466** |
| Fire Pump Engine 1 | 1 | 2 | 0.0 | 0.0 | 0.001 | 0.1 | 0 | 125 |
| Fire Pump Engine 2 | 1 | 2 | 0.0 | 0.0 | 0.001 | 0.1 | 0 | 125 |
| Emergency Generator 1 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| Emergency Generator 2 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| Emergency Generator 3 | 2 | 4 | 0.1 | 0.1 | 0.002 | 0.1 | 0 | 188 |
| **Subtotal-FSRU Sources** | **88** | **71** | **48** | **48** | **4** | **18** | **66** | **824,788** |
| **LNG Carrier Unloading** | **2** | **29** | **10** | **10** | **222** | **0** | **0** | **13,032** |
| **TOTAL** | **90** | **99** | **58** | **58** | **226** | **19** | **66** | **837,820** |

**Table 6**
**SUMMARY OF STACK PARAMETERS FOR TURBINES AND PROCESS HEATERS**

| Source Description | Ambient Temp & Load | Fuel Flow (MMBtu/hr) | Exhaust Gas Temp. (F) | Actual Exhaust Gas Flowrate (acfm) | Normalized Exhaust Gas Flowrate[2] (dscfm) | Stack Gas Parameters [Wet Basis] (% vol) | | Stack Gas Parameters [Dry Basis] (% vol) | Air Pollutant Gas Concentrations | | | | | Air Pollutant Concentrations (ppmvd) | | | | Air Pollutant Concentrations[4] (lb/dscf) | | | | Air Pollutant Rates (lb/hr) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $O_2$ | $H_2O$ | $O_2$ | CO | $NO_x$ | VOC[3] | $NH_3$ | Units | CO | $NO_x$ | VOC[3] | $NH_3$ | CO | $NO_x$ | VOC[3] | $NH_3$ | CO | $NO_x$ | VOC[3] | $NH_3$ |
| Turbine (Natural Gas) | 0 F & 100% Load | 282.1 | 876 | 410,822 | 152,563 | 14.1 | 6.07 | 14.98 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 10.0 | 3.64E-07 | 2.99E-07 | 1.25E-07 | 4.42E-07 | 3.3 | 2.7 | 1.1 | 4.1 |
| | 0 F & 75% Load | 243.8 | 915 | 352,435 | 126,864 | 13.8 | 6.28 | 14.77 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.2 | 2.6 | 3.1 | 10.4 | 3.77E-07 | 3.10E-07 | 1.29E-07 | 4.58E-07 | 2.9 | 2.4 | 1.0 | 3.5 |
| | 0 F & 50% Load | 182.3 | 884 | 285,191 | 105,664 | 14.5 | 5.69 | 15.39 | 5 | 2.5 | 5 | 10 | ppmvd @ 15% $O_2$ | 4.7 | 2.3 | 4.7 | 9.3 | 3.39E-07 | 2.79E-07 | 1.94E-07 | 4.12E-07 | 2.2 | 1.8 | 1.2 | 2.6 |
| | 60 F & 100% Load | 264.0 | 977 | 398,084 | 135,714 | 13.61 | 7.23 | 14.68 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.6 | 3.2 | 10.5 | 3.83E-07 | 3.15E-07 | 1.31E-07 | 4.65E-07 | 3.1 | 2.6 | 1.1 | 3.8 |
| | 60 F & 75% Load | 215.8 | 954 | 338,337 | 117,603 | 13.99 | 6.90 | 15.03 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 9.9 | 3.61E-07 | 2.97E-07 | 1.24E-07 | 4.39E-07 | 2.5 | 2.1 | 0.9 | 3.1 |
| | 60 F & 50% Load | 174.8 | 1005 | 279,529 | 93,696 | 13.89 | 6.99 | 14.93 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.1 | 2.5 | 3.0 | 10.1 | 3.67E-07 | 3.02E-07 | 1.26E-07 | 4.46E-07 | 2.1 | 1.7 | 0.7 | 2.5 |
| | 100 F & 100% Load | 222.8 | 1020 | 354,071 | 113,917 | 13.20 | 9.82 | 14.64 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.7 | 3.2 | 10.6 | 3.85E-07 | 3.16E-07 | 1.32E-07 | 4.68E-07 | 2.6 | 2.2 | 0.9 | 3.2 |
| | 100 F & 75% Load | 184.4 | 1010 | 304,751 | 98,989 | 13.51 | 9.56 | 14.94 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.0 | 2.5 | 3.0 | 10.1 | 3.67E-07 | 3.01E-07 | 1.26E-07 | 4.45E-07 | 2.2 | 1.8 | 0.7 | 2.6 |
| | 100 F & 50% Load | 153.8 | 1085 | 256,107 | 78,939 | 13.23 | 9.80 | 14.66 | 5 | 2.5 | 3 | 10 | ppmvd @ 15% $O_2$ | 5.3 | 2.6 | 3.2 | 10.6 | 3.84E-07 | 3.15E-07 | 1.32E-07 | 4.66E-07 | 1.8 | 1.5 | 0.6 | 2.2 |
| Turbine (Diesel) | 0 F & 100% Load | 282.1 | 876 | 424,039 | 160,941 | 14.1 | 4 | 14.66 | | | | 10 | ppmvd @ 15% $O_2$ | | | | 10.6 | | | | 4.67E-07 | | | | 4.5 |
| Process Heater | 60 F & 50% Load | 123.5 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 10 | 2.5 | 3 | 10 | ppmvd @ 3% $O_2$ | 10.0 | 2.5 | 3.0 | 10.0 | 7.27E-07 | 2.98E-07 | 1.25E-07 | 4.41E-07 | 1.4 | 0.6 | 0.2 | 0.8 |
| | 60 F & 0.73% Load | 1.8 | 350 | 860 | 465 | 2.48 | 17 | 2.99 | 50 | 23.3 | 3 | 10 | ppmvd @ 3% $O_3$ | 50.0 | 23.3 | 3.0 | 10.0 | 3.63E-06 | 2.78E-06 | 1.25E-07 | 4.41E-07 | 0.10 | 0.078 | 0.003 | 0.0 |
| | 60 F & 100% Load | 247 | 350 | 117,768 | 63,717 | 2.48 | 17 | 2.99 | 10 | 2.5 | 3 | 10 | ppmvd @ 3% $O_2$ | 10.0 | 2.5 | 3.0 | 10.0 | 7.27E-07 | 2.98E-07 | 1.25E-07 | 4.41E-07 | 2.8 | 1.1 | 0.5 | 1.7 |

Notes:

1. Except for Process Heater @ 0.73% Load and Tubine (Diesel), following data from Ref. 1, Table 2a: Fuel Flow, Exhaust Gas Temp, Actual Gas Flowrate, Stack Gas Parameters [wet], air polluant gas concentrations (ppmvd corrected to 15%02 or 3%O2).
2. Based on dry conditions with with standard temperature ($68^o$ F) and pressure (29.92 in Hg).
3. VOC include total hydrocarbons except methane and ethane.
4. Based on stack pressure of 1 atm (29.92 mmHg).
5. For Turbine (Diesel), dry standard flowrate derived from flowrate with natural gas at 0 F and 100% load and F factors contained in EPA Method 19. Moisture content assumed to be 4%. Actual flowrate derived from dry standard flowrate and moisture content. Exit temperature and O2 content assumed equal to those with natural gas at 0 F and 100% load.
6. For Process Heater @ 0.73% Load, actual gas flowrate extrapolated from 100% load data and air pollutant concentrations assumed based on uncontrolled emission data.

**Table 7**
**SUMMARY OF STACK PARAMETERS FOR PROCESS HEATERS DURING STARTUP AND SHUTDOWN**

| Source Description | Ambient Temp & Load | Duration (min) | Exhaust Gas Temp. (F) | Actual Exhaust Gas Flowrate (acfm) | Normalized Exhaust Gas Flowrate[2] (dscfm) | Stack Gas Parameters [Wet Basis] (% vol) | | Stack Gas Parameters [Dry Basis] (% vol) | Air Pollutant Gas Concentrations | | | Air Pollutant Concentrations (ppmvd) | | Air Pollutant Concentrations[4] (lb/dscf) | | Emissions (lb) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $O_2$ | $H_2O$ | $O_2$ | CO | $NO_x$ | Units | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ |
| Process Heater | Startup | 15 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 50 | 23.3 | ppmvd @ 3% $O_2$ | 50.0 | 23.3 | 3.63E-06 | 2.78E-06 | 1.7 | 1.3 |
| | Shutdown | 15 | 350 | 58,884 | 31,858 | 2.48 | 17 | 2.99 | 50 | 23.3 | ppmvd @ 3% $O_2$ | 50.0 | 23.3 | 3.63E-06 | 2.78E-06 | 1.7 | 1.3 |

Notes:

1. Following data from Ref. 1, Tables 3b and 4b : Fuel Flow, Exhaust Gas Temp, Actual Gas Flowrate, Stack Gas Parameters [wet], air polluant gas concentrations (ppmvd corrected to 15%02 or 3%O2).

2. Based on dry conditions with with standard temperature (68° F) and pressure (29.92 in Hg).
3. VOC include total hydrocarbons except methane and ethane.
4. Based on stack pressure of 1 atm (29.92 mmHg).

**Table 8**
**CO AND NOx EMISSION RATES FOR TURBINES AND PROCESS HEATERS BASED ON STARTUP AND SHUTDOWN**

| Source Description | Ambient Temp & Load | Normal Operation Air Pollutant Rates[1] (lb/hr) | | Startup Emissions[2] (lb) | | Duration of Startup[3] (min) | Shutdown Emissions[2] (lb) | | Duration of Shutdown[3] (min) | Anticipated No. of Annual Startup / Shutdown[4] (#/yr) | 1-Hour Average CO Rate During Startup (lb/hr) | 8-Hour Average CO Rate During Startup (lb/hr) | 1-Hour Average CO Rate During Shutdown (lb/hr) | 8-Hour Average CO Rate During Shutdown (lb/hr) | Annual Average NOx Rate with Startups and Shutdown (lb/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CO | $NO_x$ | CO | $NO_x$ | | CO | $NO_x$ | | | | | | | |
| Turbine | 0 F & 100% Load | 3.3 | 2.7 | 3.0 | 2.6 | 10 | 2.0 | 1.7 | 8 | - | 5.8 | 3.6 | 4.9 | 3.5 | - |
| | 60 F & 100% Load | 3.1 | 2.6 | 3.5 | 2.6 | 10 | 2.23 | 1.96 | 8 | 50 | 6.1 | 3.5 | 4.9 | 3.3 | 2.6 |
| | 100 F & 100% Load | 2.6 | 2.2 | 2.5 | 2.0 | 10 | 1.88 | 1.55 | 8 | - | 4.7 | 2.9 | 4.2 | 2.8 | - |
| Process Heater | 60 F & 100% Load | 2.8 | 1.1 | 1.74 | 1.3 | 15 | 1.7 | 1.3 | 15 | 50 | 3.8 | 2.9 | 3.8 | 2.9 | 1.2 |

Notes:

1. Emission results from Table 4.
2. Emission data from Ref. 8.
3. Turbine data from Ref. 8; process heater data from Ref. 1, Tables 3b and 4b.
4. Number of startups and shutdowns is strictly an estimate.

**Table 9**
**EMISSION FACTORS FOR TURBINES**

| Pollutant | Emission Factors[1,3,4,5,6] | |
|---|---|---|
| | **Natural Gas (lb/MMBtu)** | **Diesel (lb/MMBtu)** |
| $NO_x$ | see Note 2 | 0.176 |
| VOC | see Note 2 | 0.00041 |
| CO | see Note 2 | 0.0033 |
| $SO_2$ | 0.00064 | 0.0015 |
| $PM_{2.5}$ | 0.0066 | 0.012 |
| $PM_{10}$ | 0.0066 | 0.012 |
| $CO_2$ (see note 6) | 37,501.1 | - |

Notes:

1. Except, where noted, emission factors from AP-42, Section 3.1 (Ref 12).
2. Manufacturers emission rate data used instead of AP-42.
3. $NO_x$ emission factor for diesel incorporates estimated SCR control of 80% in uncontrolled factor obtained from AP-42.
4. $SO_2$ emission factor for natural gas based on sulfur content of 0.00068% (5 mg/$m^3$).
5. $SO_2$ emission factor for diesel is based on sulfur content of 15 ppm.
6. See reference 14 - $CO_2$ emission factor for natural gas fired turbine in lb/hr taken from GE spec sheet for 59F/100% load LM2500+DLE

**Table 10**
**EMISSION FACTORS FOR PROCESS HEATERS**

| Pollutant | Emission Factor ($lb/10^6\ ft^3$) |
|---|---|
| $SO_2$ | 0.6 |
| $PM_{2.5}$ | 7.6 |
| $PM_{10}$ | 7.6 |
| $CO_2$ | 120,000.00 |

Notes:
1. Emission factors from AP-42, Section 1.4 (Ref. 12).

**Table 11**
**EMISSION FACTORS FOR FIRE PUMP ENGINES AND EMERGENCY GENERATORS**

| Pollutant | Emission Factors for Diesel Engines >600 hp (lb/MMBtu) | (lb/hp-hr) |
|---|---|---|
| $NO_x$ | 3.2 | 0.024 |
| VOC | 0.082 | 0.00064 |
| CO | 1.9 | 0.0055 |
| $SO_2$ | 0.0015 | 0.00809 |
| $PM_{2.5}$ | 0.0556 | 0.00056 |
| $PM_{10}$ | 0.0573 | 0.00057 |
| $CO_2$ | 165 | 1.16 |

Notes:
1. Emission factors from AP-42, Section 3.4 (Ref 12).
2. $SO_2$ emission factor based on sulfur content of 15 ppm.

**Table 12**
**EMISSION FACTORS FOR LNG CARRIER**

| Pollutant | Sulfur Content of Fuel (wgt %) | Emission Factor (g/kW-hr) | Emission Factor (g/kW-hr) | Emission Factor (lb/MMBtu) |
|---|---|---|---|---|
| | | Steam Turbine | Slow Speed Diesel | Gas Turbine |
| | | Heavy Fuel Oil | Heavy Fuel Oil | LNG |
| $NO_x$ | - | 2.1 | 19.67 | 0.32 |
| VOC | - | 0.03 | 0.6 | 0.0021 |
| CO | - | 0.12 | 1.59 | 0.082 |
| $SO_2$ | 2.67 | 16.3 | 11.63 | 0.00064 |
| | 4.5 | 27.5 | na | not applicable |
| $PM_{2.5}$ | - | 0.75 | 1.64 | 0.0066 |
| $PM_{10}$ | - | 0.75 | 1.64 | 0.0066 |
| $CO_2$ | - | 956 | 682 | 110.0 |

Notes:

1. All emission factors for steam turbines, except for $SO_2$ with fuel sulfur content of 4.5%, from Ref. 13, Table D.9.

2. $SO_2$ emission factor for 4.5% sulfur fuel based on fuel consumption of 305 g/kW-hr (Ref.11, Table 2.8) and sulfur content of fuel.

3. All emission factors for slow speed diesel from Ref.13. Table D.9

4. Heavy Fuel Oil is same as Residual Oil.

5. All emission factors for gas turbines from AP-42, Section 3.1 (uncontrolled emissions); assume sulfur content of natural gas of 6.8 ppm.

Table 13

**SUMMARY OF EMISSION RATES FOR LNG CARRIERS OF VARIOUS CARGO CAPACITY AND LOADING RATE WHILE AT THE FSRU**

| | | | |
|---|---|---|---|
| Daily Natural Gas Delivery | 1 | bcf/day | Estimated average daily natural gas delivery rate. |
| | 21,095 | Mg/day | Calculated from ideal gas law using standard temperature and pressure. |
| Annual LNG Delivery Rate by Mass | 7,700,000 | metric tons/yr | Maximum annual LNG delivery to FSRU |
| | 7,700,051 | Mg/yr | |
| LNG Density | 470 | kg/m$^3$ | Design data from RR13 |
| LNG Annual Delivery Rate by Volume | 16,383,086 | m$^3$/yr | Calculated from Annual LNG Delivery Rate by Mass and LNG Density |

| Vessel | Vessel Size | LNG Loading | Annual Vessel Dockings | Vessel Duration at FSRU | | Power Supplied by Engines[1] | | Fuel Use by Vessel at FSRU[2,3] | Maximum Hourly Emissions[4] (lb/hr) | | | | | | Maximum Hourly Emissions with No Loading[5] (lb/hr) | | Average Hourly Emission Over 24-Hour Period[6] (lb/hr) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | (m$^3$) | (m$^3$/hr) | (#/yr) | LNG Loading (hr) | No Loading (hr) | LNG Pumps (kW) | Other Equip. (kW) | (tons) | $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) |
| **Existing** | | | | | | | | | | | | | | | | | | |
| Conventional LNGC | 125,000 | 10,000 | 132 | 12.5 | 8 | 4,500 | 1,900 | 32 | 30 | 0.4 | 1.7 | 13,489 | 230 | 11 | 115 | 3.1 | 158 | 7 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 132 | 9.6 | 8 | 5,750 | 1,900 | 30 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 224 | 6 |
| Steam turbine propulsion | | 15,000 | 132 | 8.3 | 8 | 6,650 | 1,900 | 29 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 218 | 6 |
| Conventional LNGC | 140,000 | 10,000 | 118 | 14.0 | 8 | 4,500 | 1,900 | 35 | 30 | 0.4 | 1.7 | 13,489 | 387 | 11 | 115 | 3.1 | 264 | 7 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 118 | 10.8 | 8 | 5,750 | 1,900 | 33 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 246 | 7 |
| Steam turbine propulsion | | 15,000 | 118 | 9.3 | 8 | 6,650 | 1,900 | 32 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 240 | 7 |
| Conventional LNGC | 160,000 | 10,000 | 103 | 16.0 | 8 | 4,500 | 1,900 | 40 | 30 | 0.4 | 1.7 | 13,489 | 387 | 11 | 115 | 3.1 | 297 | 8 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 103 | 12.3 | 8 | 5,750 | 1,900 | 37 | 35 | 0.5 | 2.0 | 16,123 | 463 | 13 | 115 | 3.1 | 276 | 8 |
| Steam turbine propulsion | | 15,000 | 103 | 10.7 | 8 | 6,650 | 1,900 | 36 | 40 | 0.6 | 2.3 | 18,020 | 517 | 14 | 115 | 3.1 | 268 | 7 |
| **Vessels On-Order (in-service about 2008)** | | | | | | | | | | | | | | | | | | |
| New Design LNGC | 160,000 | 10,000 | 103 | 16.0 | 8 | 4,500 | 2,700 | 29 | 312 | 9.5 | 25.2 | 10,825 | 185 | 26 | 69 | 9.8 | 146 | 21 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 103 | 12.3 | 8 | 5,750 | 2,700 | 27 | 366 | 11.2 | 29.6 | 12,705 | 217 | 31 | 69 | 9.8 | 134 | 19 |
| Slow Speed Diesel | | 15,000 | 103 | 10.7 | 8 | 6,650 | 2,700 | 26 | 405 | 12.4 | 32.8 | 14,058 | 240 | 34 | 69 | 9.8 | 130 | 18 |
| New Large LNGC | 215,000 | 10,000 | 77 | 21.5 | 8 | 4,500 | 3,000 | 40 | 325 | 9.9 | 26.3 | 11,276 | 192 | 27 | 77 | 10.8 | 180 | 25 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 77 | 16.5 | 8 | 5,750 | 3,000 | 36 | 379 | 11.6 | 30.7 | 13,156 | 224 | 32 | 77 | 10.8 | 179 | 25 |
| Slow Speed Diesel | | 15,000 | 77 | 14.3 | 8 | 6,650 | 3,000 | 35 | 418 | 12.8 | 33.8 | 14,509 | 247 | 35 | 77 | 10.8 | 173 | 24 |
| **Concept Vessels (in-service beyond 2010)** | | | | | | | | | | | | | | | | | | |
| New Very Large LNGC | 250,000 | 10,000 | 66 | 25.0 | 8 | 4,500 | 3,200 | 47 | 334 | 10.2 | 27.0 | 11,577 | 197 | 28 | 82 | 11.6 | 197 | 28 |
| Heavy Fuel Oil (2.7%S) | | 13,000 | 66 | 19.2 | 8 | 5,750 | 3,200 | 42 | 388 | 11.8 | 31.4 | 13,457 | 229 | 32 | 82 | 11.6 | 200 | 28 |
| Slow Speed Diesel(7) | | 15,000 | 66 | 16.7 | 8 | 6,650 | 3,200 | 41 | 427 | 13.0 | 34.5 | 14,810 | 253 | 36 | 82 | 11.6 | 200 | 28 |
| New Very Large LNGC | 250,000 | 10,000 | 66 | 25.0 | 8 | 4,500 | 2,300 | n/a | 20 | 0.13 | 5.0 | 6,732 | 0.04 | 0.40 | 0.01 | 0.14 | 0.04 | 0.40 |
| LNG fuel only | | 13,000 | 66 | 19.2 | 8 | 5,750 | 2,300 | n/a | 23 | 0.15 | 5.9 | 7,970 | 0.05 | 0.48 | 0.01 | 0.14 | 0.04 | 0.41 |
| Gas Turbine Propulsion[8,9] | | 15,000 | 66 | 16.7 | 8 | 6,650 | 2,300 | n/a | 26 | 0.17 | 6.6 | 8,861 | 0.05 | 0.53 | 0.01 | 0.14 | 0.04 | 0.41 |

| Vessel | Annual Emissions - LNG Loading (tpy) | | | | | | Annual Emissions - No Loading (tpy) | | | | | | Annual Emissions - Total (tpy) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) | $NO_x$ | VOC | CO | $CO_2$ | $SO_2$ | $PM_{10}$ ($PM_{2.5}$) |
| **Existing** | | | | | | | | | | | | | | | | | | |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,128 | 190 | 9 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 29 | 0.4 | 1.7 | 13,242 | 226 | 10 |
| Heavy Fuel Oil (2.7%S) | 22 | 0.3 | 1.3 | 10,232 | 174 | 8 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 27 | 0.4 | 1.5 | 12,346 | 210 | 10 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,911 | 169 | 8 | 5 | 0.1 | 0.3 | 2,114 | 36 | 1.7 | 26 | 0.4 | 1.5 | 12,025 | 205 | 9 |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,142 | 190 | 9 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 29 | 0.4 | 1.6 | 13,032 | 222 | 10 |
| Heavy Fuel Oil (2.7%S) | 23 | 0.3 | 1.3 | 10,244 | 175 | 8 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 27 | 0.4 | 1.5 | 12,134 | 207 | 10 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,923 | 169 | 8 | 4 | 0.1 | 0.2 | 1,890 | 32 | 1.5 | 26 | 0.4 | 1.5 | 11,813 | 201 | 9 |
| Conventional LNGC | 24 | 0.3 | 1.4 | 11,115 | 189 | 9 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 28 | 0.4 | 1.6 | 12,764 | 217 | 10 |
| Heavy Fuel Oil (2.7%S) | 22 | 0.3 | 1.3 | 10,220 | 174 | 8 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 26 | 0.4 | 1.5 | 11,869 | 202 | 9 |
| Steam turbine propulsion | 22 | 0.3 | 1.2 | 9,899 | 169 | 8 | 4 | 0.1 | 0.2 | 1,650 | 28 | 1.3 | 25 | 0.4 | 1.4 | 11,549 | 197 | 9 |
| **Vessels On-Order (in-service about 2008)** | | | | | | | | | | | | | | | | | | |
| New Design LNGC | 257 | 7.8 | 20.8 | 8,920 | 152 | 21 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 306 | 9.3 | 24.7 | 10,593 | 181 | 25 |
| Heavy Fuel Oil (2.7%S) | 232 | 7.1 | 18.8 | 8,053 | 137 | 19 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 280 | 8.6 | 22.7 | 9,725 | 166 | 23 |
| Slow Speed Diesel | 223 | 6.8 | 18.0 | 7,723 | 132 | 19 | 48 | 1.5 | 3.9 | 1,673 | 29 | 4.0 | 271 | 8.3 | 21.9 | 9,395 | 160 | 23 |
| New Large LNGC | 269 | 8.2 | 21.8 | 9,334 | 159 | 22 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 309 | 9.4 | 25.0 | 10,723 | 183 | 26 |
| Heavy Fuel Oil (2.7%S) | 242 | 7.4 | 19.5 | 8,377 | 143 | 20 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 282 | 8.6 | 22.8 | 9,766 | 167 | 23 |
| Slow Speed Diesel | 231 | 7.0 | 18.7 | 8,007 | 137 | 19 | 40 | 1.2 | 3.2 | 1,389 | 24 | 3.3 | 271 | 8.3 | 21.9 | 9,396 | 160 | 23 |
| **Concept Vessels (in-service beyond 2010)** | | | | | | | | | | | | | | | | | | |
| New Very Large LNGC | 275 | 8.4 | 22.3 | 9,551 | 163 | 23 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 312 | 9.5 | 25.2 | 10,821 | 185 | 26 |
| Heavy Fuel Oil (2.7%S) | 246 | 7.5 | 19.9 | 8,540 | 146 | 21 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 283 | 8.6 | 22.9 | 9,810 | 167 | 24 |
| Slow Speed Diesel(7) | 235 | 7.2 | 19.0 | 8,145 | 139 | 20 | 37 | 1.1 | 3.0 | 1,270 | 22 | 3.1 | 272 | 8.3 | 22.0 | 9,416 | 161 | 23 |
| New Very Large LNGC | 16 | 0.11 | 4 | 5,554 | 0.03 | 0.33 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 18 | 0.12 | 4.6 | 6,155 | 0.04 | 0.37 |
| LNG fuel only | 15 | 0.10 | 4 | 5,058 | 0.03 | 0.30 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 16 | 0.11 | 4.2 | 5,659 | 0.03 | 0.34 |
| Gas Turbine Propulsion[8,9] | 14 | 0.09 | 4 | 4,873 | 0.03 | 0.29 | 1.7 | 0.01 | 0.4 | 601 | 0.003 | 0.036 | 16 | 0.10 | 4.1 | 5,474 | 0.03 | 0.33 |

Notes:

1. Based on data supplied in Ref 4. LNG Pumps operate only during "LNG Loading". Other Equip. operates during "LNG Loading" and "No Loading"
2. Steam Turbine fuel use based on engine flow rate of 305 g/kW-hr (Ref. 11, Table 2.8). Steady operation while unloading is consistent with "at sea" operations.
3. Slow speed diesel fuel use based on fuel flow rate of 195 g/kW-hr (Ref. 11, Table 2.8). Steady operation while unloading is consistent with "at sea" operations.
4. Maximum hourly emission rate based on operation of vessel auxiliary engines needed to power LNG Pumps and Other Equipment.
5. Maximum hourly emission rate based on operation of vessel auxiliary engines needed to power only Other Equipment.
6. Weighted values based on emissions during Loading and No Loading periods.
7. New Very Large LNGC vessel assumed to use slow speed diesel on HFO only. Vessel will have a LNG reliquefaction plant on-board, no boil off gas available for propulsion.
8. New Very Large LNGC vessel assumed to use gas turbine capable of 22MW generation. No vessels of this type under design yet; specifications speculative only. No reliquefaction plant used.
9. Fuel rate of gas turbines estimated at 9,000 Btu/kW-hr.

**Table 14**
**REFERENCES**

| No. | Description |
|---|---|
| 1 | Spreadsheet: *Emission Sources Parameters 22Jul05.xls* (29-Jul-05 E-Mail from David Carpenter to Sandra Barnett). |
| 2 | Spreadsheet: *Diesel Engine NOX_CO Calc.xls* (29-Jul-05 E-Mail from David Carpenter to Sandra Barnett). |
| 3 | *Broadwater, RR13 Phase - Flare Height Study, 312383-SAI-CAL-601* (Saipem America, Inc., 02-Aug-05). |
| 4 | *13-Jul-05 E-Mail from David Carpenter to Paul Van Kerkhove* (Subject: Broadwater - LNG Transfer from Carriers to FSRU) |
| 5 | *Caterpillar 3608.pdf: "Gen Set Performance Data"* (RR13 Part B, 3-Aug-05). |
| 6 | 16-Aug-05 Telephone Contact Report with OPFI (Contact Report_08_16_2005 OPFI.doc) |
| 7 | WFRU Calculations.doc (Internal E & E document) |
| 8 | *GE LM2500+ Graphs: NOx and CO Emissions During Start-up and Shutdown* (provided to GE to E & E in six pdf files on 15-Aug-2005) |
| 9 | *Broadwater, RR13 Phase - Topsides Section View Fore Area, 312383-SAI-DWG-403.03 Rev. 0* (Saipem America, Inc., 02-Aug-05). |
| 10 | LNG Carrier Aux Equip Calculations.doc (Internal E & E document) |
| 11 | *Quantification of Emissions from Ships Associated with Ship Movements Between Ports in the European Community* (Entec, 2002) |
| 12 | *AP-42: Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (USEPA) |
| 13 | *The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory* (Starcrest, 2003) |
| 14 | GE Estimated Average Engine Performance, run 06/01/05, time 3:49:01 pm, version 3.3.2, LM2500 standard DLE |

# C

# OCD Model Input and Output Files Overwater and Overland Meteorological Data Files

# D AERMOD-PRIME Model Input and Output Files



PUBLIC

BW002426

E

# Plot Plan of FSRU

Critical Energy Infrastructure Information has been removed from the Public Volume and is contained in the Critical Energy Infrastructure Information Volume.

F

# Manufacturer's Emission Specification Sheets for FSRU Combustion Emission Sources: GE LM2500 Gas Turbines

**Estimated Average Engine Performance NOT FOR GUARANTEE**

*GE Energy*

Performance By: **Lee Johnson**
Project Info: **Shell Broadwater**

Engine: **LM2500 Standard DLE**
Deck Info: **GE166B - 7qd.scp**
Generator: **167ER 60Hz, 13.8kV, 0.85PF (10807)**
Fuel: **Gas Fuel #10-1, 19000 Btu/lb,LHV**

Date: **06/01/2005**
Time: **3:49:01 PM**
Version: **3.3.2**

| **Case #** | **100** | **101** | **102** | **103** | **104** |
|---|---|---|---|---|---|
| **Ambient Conditions** | | | | | |
| Dry Bulb, °F | 59.0 | 85.0 | 90.0 | 95.0 | 100.4 |
| Wet Bulb, °F | 51.5 | 74.0 | 78.3 | 82.7 | 87.4 |
| RH, % | 60.0 | 60.0 | 60.0 | 60.0 | 60.0 |
| Altitude, ft | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| Ambient Pressure, psia | 14.670 | 14.669 | 14.669 | 14.669 | 14.669 |
| **Engine Inlet** | | | | | |
| Comp Inlet Temp, °F | 59.0 | 85.0 | 90.0 | 95.0 | 100.4 |
| RH, % | 60.0 | 60.0 | 60.0 | 60.0 | 60.0 |
| Conditioning | NONE | NONE | NONE | NONE | NONE |
| Tons or kBtu/hr | 0 | 0 | 0 | 0 | 0 |
| **Pressure Losses** | | | | | |
| Inlet Loss, inH20 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Exhaust Loss, inH20 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 |
| **kW, Gen Terms** | **21675** | **19967** | **19629** | **19212** | **18716** |
| **Est. Btu/kW-hr, LHV** | **9622** | **9794** | **9838** | **9900** | **9983** |
| **Guar. Btu/kW-hr, LHV** | **9920** | **10097** | **10142** | **10206** | **10291** |
| **Fuel Flow** | | | | | |
| MMBtu/hr, LHV | 208.6 | 195.6 | 193.1 | 190.2 | 186.8 |
| lb/hr | 10977 | 10293 | 10164 | 10011 | 9833 |
| **NOx Control** | **DLE** | **DLE** | **DLE** | **DLE** | **DLE** |
| **Control Parameters** | | | | | |
| HP Speed, RPM | 3600 | 3600 | 3600 | 3600 | 3600 |
| PT Speed, RPM | 9447 | 9415 | 9431 | 9436 | 9444 |
| PS3 - CDP, psia | 257.6 | 243.5 | 240.7 | 237.2 | 233.1 |
| T3CRF - CDT, °F | 845 | 861 | 864 | 866 | 869 |
| T48IN, °R | 1970 | 1970 | 1970 | 1970 | 1970 |
| T48IN, °F | 1510 | 1510 | 1510 | 1510 | 1510 |
| **Exhaust Parameters** | | | | | |
| Temperature, °F | 1001.2 | 1017.9 | 1021.6 | 1026.1 | 1031.6 |
| lb/sec | 148.4 | 140.3 | 138.6 | 136.6 | 134.2 |
| lb/hr | 534083 | 505030 | 499086 | 491795 | 483104 |
| Energy, Btu/s- ref 0 °R | 55369 | 53386 | 53016 | 52543 | 51988 |
| Cp, Btu/lb-R | 0.2762 | 0.2789 | 0.2797 | 0.2806 | 0.2817 |
| **Emissions (NOT FOR USE IN ENVIRONMENTAL PERMITS)** | | | | | |
| NOx ppmvd Ref 15% O2 | 25 | 25 | 25 | 25 | 25 |
| NOx as NO2, lb/hr | 21 | 20 | 20 | 19 | 19 |
| CO ppmvd Ref 15% O2 | 25 | 25 | 25 | 25 | 25 |
| CO, lb/hr | 12.82 | 12.02 | 11.87 | 11.69 | 11.48 |
| CO2, lb/hr | 37501.07 | 33988.15 | 33257.34 | 32547.54 | 31767.94 |
| HC ppmvd Ref 15% O2 | 15 | 15 | 15 | 15 | 15 |
| HC, lb/hr | 4.39 | 4.12 | 4.07 | 4.01 | 3.94 |

PUBLIC

**Estimated Average Engine Performance NOT FOR GUARANTEE**

***GE Energy***

Performance By: **Lee Johnson**
Project Info: **Shell Broadwater**

Engine: **LM2500 Standard DLE**
Deck Info: **GE166B - 7qd.scp**
Generator: **167ER 60Hz, 13.8kV, 0.85PF (10807)**
Fuel: **Gas Fuel #10-1, 19000 Btu/lb,LHV**

Date: **06/01/2005**
Time: **3:49:01 PM**
Version: **3.3.2**

| | | | | | |
|---|---|---|---|---|---|
| SOX as SO2, lb/hr | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Exh Wght % Wet (NOT FOR USE IN ENVIRONMENTAL PERMITS)** | | | | | |
| AR | 1.2536 | 1.2425 | 1.2392 | 1.2353 | 1.2305 |
| N2 | 73.6838 | 73.0314 | 72.8363 | 72.6114 | 72.3306 |
| O2 | 15.3201 | 15.1808 | 15.1265 | 15.0611 | 14.9752 |
| CO2 | 5.1942 | 5.1509 | 5.1469 | 5.1442 | 5.1439 |
| H20 | 4.5423 | 5.3886 | 5.6453 | 5.9420 | 6.3139 |
| SO2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CO | 0.0024 | 0.0024 | 0.0024 | 0.0024 | 0.0024 |
| HC | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| NOX | 0.0027 | 0.0027 | 0.0027 | 0.0027 | 0.0027 |
| **Exh Mole % Dry (NOT FOR USE IN ENVIRONMENTAL PERMITS)** | | | | | |
| AR | 0.9630 | 0.9630 | 0.9631 | 0.9631 | 0.9633 |
| N2 | 80.7156 | 80.7170 | 80.7222 | 80.7293 | 80.7398 |
| O2 | 14.6926 | 14.6893 | 14.6769 | 14.6601 | 14.6350 |
| CO2 | 3.6219 | 3.6239 | 3.6310 | 3.6406 | 3.6550 |
| H20 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| SO2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CO | 0.0026 | 0.0026 | 0.0026 | 0.0026 | 0.0027 |
| HC | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0016 |
| NOX | 0.0026 | 0.0026 | 0.0026 | 0.0026 | 0.0027 |
| **Exh Mole % Wet (NOT FOR USE IN ENVIRONMENTAL PERMITS)** | | | | | |
| AR | 0.8938 | 0.8814 | 0.8777 | 0.8734 | 0.8681 |
| N2 | 74.9187 | 73.8752 | 73.5649 | 73.2085 | 72.7649 |
| O2 | 13.6374 | 13.4442 | 13.3756 | 13.2943 | 13.1894 |
| CO2 | 3.3618 | 3.3167 | 3.3090 | 3.3015 | 3.2940 |
| H20 | 7.1819 | 8.4763 | 8.8665 | 9.3161 | 9.8772 |
| SO2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CO | 0.0024 | 0.0024 | 0.0024 | 0.0024 | 0.0024 |
| HC | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| NOX | 0.0024 | 0.0024 | 0.0024 | 0.0024 | 0.0024 |

| **Aero Energy Fuel Number** | **0-1 (GEDEF)** | |
|---|---|---|
| | **Volume %** | **Weight %** |
| Hydrogen | 0.0000 | 0.0000 |
| Methane | 84.5000 | 71.8447 |
| Ethane | 5.5800 | 8.8924 |
| Ethylene | 0.0000 | 0.0000 |
| Propane | 2.0500 | 4.7909 |
| Propylene | 0.0000 | 0.0000 |
| Butane | 0.7800 | 2.4027 |
| Butylene | 0.0000 | 0.0000 |
| Butadiene | 0.0000 | 0.0000 |
| Pentane | 0.1800 | 0.6883 |
| Cyclopentane | 0.0000 | 0.0000 |
| Hexane | 0.1700 | 0.7764 |
| Heptane | 0.0000 | 0.0000 |
| Carbon Monoxide | 0.0000 | 0.0000 |
| Carbon Dioxide | 0.6700 | 1.5628 |
| Nitrogen | 5.9300 | 8.8044 |
| Water Vapor | 0.0000 | 0.0000 |
| Oxygen | 0.1400 | 0.2374 |
| Hydrogen Sulfide | 0.0000 | 0.0000 |
| Ammonia | 0.0000 | 0.0000 |

| | |
|---|---|
| Btu/lb, LHV | 19000 |
| Btu/scf, LHV | 946 |
| Btu/scf, HHV | 1047 |
| Btu/lb, HHV | 20996 |
| Fuel Temp, °F | 77.0 |
| NOx Scalar | 0.998 |
| Specific Gravity | 0.65 |

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**Estimated Average Engine Performance NOT FOR GUARANTEE**

*GE Energy*

Performance By: **Lee Johnson**
Project Info: **Shell Broadwater**

Engine: **LM2500 Standard DLE**
Deck Info: **GE166B - 7qd.scp**
Generator: **167ER 60Hz, 13.8kV, 0.85PF (10807)**
Fuel: **Gas Fuel #10-1, 19000 Btu/lb,LHV**

Date: **06/01/2005**
Time: **3:49:01 PM**
Version: **3.3.2**

| | | | | | |
|---|---|---|---|---|---|
| **Engine Exhaust** | | | | | |
| Exhaust MW | 28.5 | 28.3 | 28.3 | 28.2 | 28.2 |
| Exhaust Flow, ACFM | 321113 | 308688 | 306293 | 303262 | 299681 |
| Exhaust Flow, SCFM | 112336 | 106771 | 105677 | 104317 | 102699 |
| Exhaust Flow, Btu/lb | 373 | 381 | 382 | 385 | 387 |
| Exhaust Flow, Calories/s | 13952985 | 13453209 | 13360101 | 13240944 | 13100875 |
| | | | | | |
| Inlet Flow Wet, pps | 146.5 | 138.6 | 137.0 | 135.0 | 132.6 |
| Inlet Flow Dry, pps | 145.6 | 136.4 | 134.5 | 132.1 | 129.2 |
| | | | | | |
| Shaft HP | 29845 | 27521 | 27062 | 26495 | 25820 |
| | | | | | |
| **Generator Information** | | | | | |
| Capacity kW | 34663 | 30576 | 29721 | 28840 | 27856 |
| Efficiency | 0.974 | 0.973 | 0.973 | 0.972 | 0.972 |
| Inlet Temp, °F | 59.0 | 85.0 | 90.0 | 95.0 | 100.4 |
| Gear Box Loss | N/A | N/A | N/A | N/A | N/A |
| | | | | | |
| Burner Mode | ABC | ABC | ABC | ABC | ABC |
| | | | | | |
| **8th Stage Bleed** | | | | | |
| Flow, pps | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pressure, psia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Temperature, °R | 0 | 0 | 0 | 0 | 0 |
| | | | | | |
| **CDP Bleed** | | | | | |
| Flow, pps | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pressure, psia | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | | | |
| **Est. Gas Pressure at Baseplate, psia** | **333.3** | **314.5** | **310.8** | **306.3** | **301.0** |
| | | | | | |
| **CardPack** | **7qd** | **7qd** | **7qd** | **7qd** | **7qd** |
| | | | | | |
| **NSI** | **0** | **0** | **0** | **0** | **0** |
| **NSI** | **0** | **0** | **0** | **0** | **0** |
| **NSI** | **0** | **0** | **0** | **0** | **0** |

**Estimated Average Engine Performance NOT FOR GUARANTEE**

***GE Energy***

Performance By: **Lee Johnson**
Project Info: **Shell Broadwater**

| | | | |
|---|---|---|---|
| Engine: | **LM2500 Standard DLE** | | |
| Deck Info: | **GE166B - 7qd.scp** | Date: | **06/01/2005** |
| Generator: | **167ER 60Hz, 13.8kV, 0.85PF (10807)** | Time: | **3:49:01 PM** |
| Fuel: | **Gas Fuel #10-1, 19000 Btu/lb,LHV** | Version: | **3.3.2** |

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