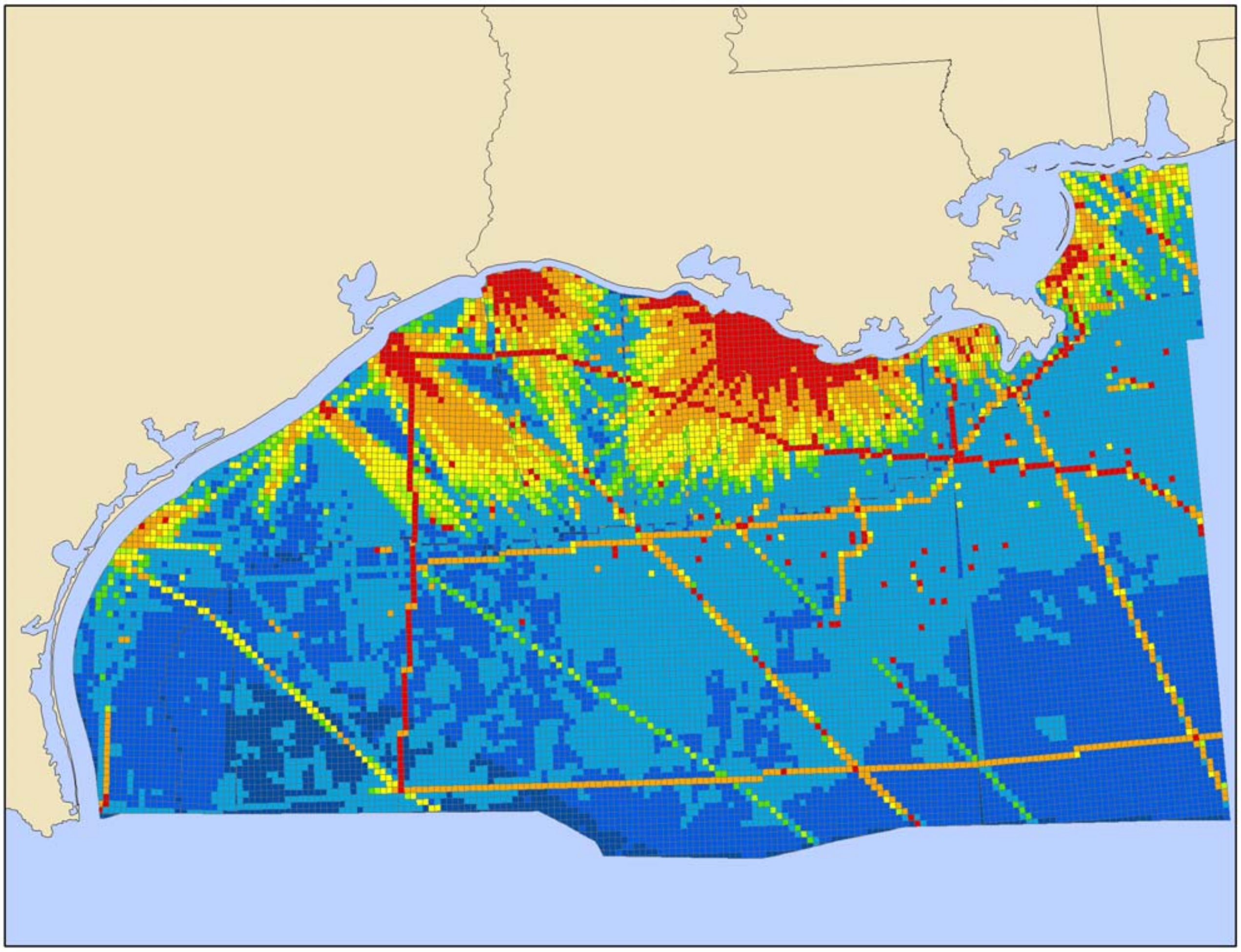
OCS Study
MMS 2007-067

Year 2005 Gulfwide Emission Inventory Study



U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

OCS Study
MMS 2007-067

Year 2005 Gulfwide Emission Inventory Study

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EQUATION UNIT DEFINITIONS

Unit	**Definition**
avg	average
bbl	barrel
Btu	British thermal unit
°F	degrees Fahrenheit
ft	feet
ft^3	cubic feet
gal	gallon
g	gram
hp	horsepower
hr	hour
kW	kilowatt
kWh	kilowatt-hour
Lb	pound
m^2	meter squared
MMBtu	million British thermal units
Mscf	thousand standard cubic feet
MMscf	million standard cubic feet
MMSCFD	million standard cubic feet per day
ppm	parts per million
ppmv	parts per million volume
psig	pressure per square inch gauge
°R	degrees rankine
scf	standard cubic feet
sec	second
tpy	tons per year
µmol	micromole
wt	weight

1. EXECUTIVE SUMMARY

The Minerals Management Service (MMS) is responsible for assessing the potential impacts of air pollutant emissions from offshore oil and gas exploration, development, and production sources in the Outer Continental Shelf (OCS). This responsibility is driven by the OCS Lands Act, which directs the MMS to regulate OCS emission sources to assure that they do not significantly affect onshore air quality. The MMS air quality regulations are contained in 30 CFR 250.302 through 304. In particular, MMS is responsible for determining if any facility which is used for exploration, development, and production of oil, gas, or sulfur from the Gulf of Mexico OCS influence the attainment (or nonattainment) status of onshore areas in Louisiana, Texas, Mississippi, Alabama, and Florida. This responsibility was mandated by the 1990 Clean Air Act Amendments (CAAA). In addition, the CAA requires MMS to coordinate air pollution control activities with the State regulatory agencies. Thus, there will be a continuing need for emission inventories and modeling with the implementation of the 8-hour ozone standard. To assess the emissions of offshore oil and gas platforms and their associated emissions, the MMS conducted some limited emission inventories in the Gulf of Mexico OCS in the 1980s. In 1991 the MMS initiated the Gulf of Mexico Air Quality Study; in 1999 the MMS initiated the Gulfwide Emission Inventory Study for the Regional Haze and Ozone Modeling Effort; and in 2001 the MMS initiated the Data Quality Control and Emissions Inventories of OCS Oil and Gas Production Activities in the Breton Area of the Gulf of Mexico.

The MMS' Gulf of Mexico Outer Continental Shelf Regional office sponsored this project, the *Year 2005 Gulfwide Emission Inventory Study* (MMS Contract No. M04PC00010), which builds upon these studies with the goal of developing a base year 2005 air pollution emissions inventory for all OCS oil and gas production-related sources in the Gulf of Mexico, including non-platform sources. Pollutants covered in this inventory are the criteria pollutants—carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter-10 (PM_{10}), $PM_{2.5}$, and volatile organic compounds (VOC); as well as greenhouse gases—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

To develop the inventory, the 2005 Gulfwide Offshore Activities Data System (GOADS-2005) was created, which was used to collect monthly activity data from platform sources. The activity data were combined with the most recent emission factors published by the EPA, and Emission Inventory Improvement Program (EIIP) emission estimation methods to develop a comprehensive criteria pollutant and greenhouse gas emissions inventory. Non-platform emission estimates were developed for sources such as the Louisiana Offshore Oil Platform (LOOP), commercial marine vessels, and helicopters. Ultimately, State agencies and Regional Planning Organizations will use this information to perform modeling for ozone and regional haze for use in their State Implementation Plans (SIPs).

When reviewing the results of the *Year 2005 Gulfwide Emission Inventory Study*, it is important to keep in mind the widespread damage in the Gulf of Mexico caused by Hurricanes Katrina and Rita, which impacted the inventory results for September through December. The inventory results indicate that OCS oil and gas production platform and non-platform sources emit the majority of criteria pollutants and greenhouse gases in the Gulf of Mexico on the OCS. The OCS oil and gas production platform and non-platform sources account for 93% of total CO emissions (with numerous non-OCS oil and gas production sources accounting for the remainder), 72% of NO_x emissions, 76% of PM emissions, 73% of SO_2 emissions, and 70% of VOC emissions. Oil and gas production platforms account for the majority of the CO and VOC emissions. Non-platform OCS oil and gas production sources such as support vessels and drilling vessels emit the majority of the estimated NO_x, PM, and SO_2 emissions. For greenhouse gases, platform sources account for almost all of the CH_4 emissions. Commercial marine vessels and support vessels are the top-emitting non-OCS oil and gas production sources in the inventory for both criteria pollutants and greenhouse gases.

2. INTRODUCTION

2.1 BACKGROUND

Measurements of ozone concentrations in onshore areas of Texas and Louisiana periodically exceed the national standard for eight-hour ozone in nonattainment areas, with the Beaumont-Port Arthur, Texas, and Baton Rouge, Louisiana, areas classified as marginal, and the Houston-Galveston-Brazoria, Texas, area classified as moderate. Shoreline and inland locations in Texas and Louisiana, as well as Mississippi, Alabama, and Florida, could potentially be influenced by emission sources in the Gulf of Mexico. The Minerals Management Service (MMS) is responsible for determining if air pollutant emissions from Outer Continental Shelf (OCS) oil and natural gas platforms and other sources in the Gulf of Mexico influence the ozone attainment and nonattainment status of onshore areas. Ozone forms in the presence of sunlight from the reaction of volatile organic compounds (VOC) and oxides of nitrogen (NO_x).

The Clean Air Act Amendments of 1990 (CAAA Title VIII, Sec 801(b)) specifically mandate that MMS conduct a research study to assess the potential for onshore impacts of certain types of air pollutant emissions from offshore oil and gas exploration, development, and production in regions of the Gulf of Mexico. This mandate grew out of concerns regarding the cumulative onshore impacts of air pollutant emissions from more than 3,000 offshore facilities in the central and western Gulf of Mexico. MMS launched a series of studies, beginning in the 1980s, to assess the emissions of offshore oil and gas platforms and their associated emissions. In 1991 the MMS sponsored a regional ozone modeling effort conducted by the U.S. Environmental Protection Agency (EPA) using the Regional Oxidant Model (ROM). The *Gulf of Mexico Air Quality Study* (GMAQS) was initiated that same year, and activity data for a Gulfwide emissions inventory were collected for a one-year period in 1991-92 (U.S. DOI, MMS 1995).

The MMS sponsored two more recent air quality emission inventory projects. Through an Office of Management and Budget-approved Information Collection Request, MMS required affected platform operators to collect activity data used in both studies. One study affected only platforms within 100 kilometers (km) of the Breton National Wilderness Area in the Gulf of Mexico. As part of its program to collect activity data, a Visual Basic program was developed, known as the Breton Offshore Activities Data System (BOADS), for platform operators to submit activity data on a monthly basis. An Oracle database management system (DBMS) was created to develop the emissions estimates (Billings and Wilson 2004).

The 2000 *Gulfwide Emission Inventory for Regional Haze and Ozone Modeling Effort* Study built upon the previous MMS studies with the goal of developing criteria pollutant and greenhouse gas emission inventories for all oil and gas production-related sources in the entire Gulf of Mexico OCS. The Gulfwide Offshore Activities Data System (GOADS) was developed from the BOADS Visual Basic program; it was modified to request activity data for additional emission sources. The emission estimation procedures in the Breton Oracle DBMS were also expanded (Wilson et al. 2004a).

The MMS has undertaken the *Year 2005 Gulfwide Emission Inventory Study* to continue past assessments of the potential impacts of emissions from oil and gas exploration, development, and production in the OCS region of the Gulf of Mexico. The overall goal of the study was to assess the effects that OCS development has on ozone concentrations in the onshore areas of Texas and Louisiana that are designated by the EPA as nonattainment for eight-hour average ozone. **When reviewing the results of the *Year 2005 Gulfwide Emission Inventory Study*, it is important to keep in mind the widespread damage in the Gulf of Mexico caused by Hurricanes Katrina and Rita, which impacted the inventory results for September through December.**

2.2 SCOPE AND PURPOSE OF THIS PROJECT

Through an Office of Management and Budget-approved Information Collection Request, MMS required affected platform operators to collect and submit the activity data needed to develop air pollutant emissions estimates from platform activities. The activity data were collected based on MMS NTL No. 2004-G17, “Production Activities Information Collection and Reporting for Calculations of Air Emissions in the Western Gulf of Mexico.”

The MMS developed and distributed a Visual Basic program for platform operators to use to collect and submit activity data on a monthly basis. The program, known as the GOADS, was used by operators to submit activity data for a number of production platform emission sources. Operators used the GOADS software to collect activity data for amine units, boilers/heaters/burners, diesel engines, drilling equipment, fugitives, combustion flares, glycol dehydrators, loading operations, losses from flashing, mud degassing, natural gas engines and turbines, pneumatic pumps, pressure/level controllers, storage tanks, and cold vents.

These activity data were used to calculate carbon monoxide (CO), NO_x, sulfur dioxide (SO_2), particulate matter-10 (PM_{10}), $PM_{2.5}$, and VOC emissions estimates; as well as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The Gulfwide Oracle DBMS calculates and archives the activity data and the resulting emissions estimates. Database users can query by pollutant, month, equipment type, platform, etc.

2.3 STUDY OBJECTIVES

The objectives of this study are:

- To review, modify, and provide support services for GOADS-2005 and the 2005 Gulfwide Oracle DBMS.

- To collect, describe, quality check, quality assure, and archive activity data from all platform and non-platform sources on the OCS that emit air pollutants over the course of one (1) calendar year (2005). Activity data from platform sources were collected using GOADS-2005.

- To calculate and archive a calendar year 2005 total emissions inventory using the most current AP-42 emission factors and the 2005 Gulfwide DBMS for all specified platform and non-platform sources, and to compare the emissions inventory with previously collected emissions data.

2.4 REPORT ORGANIZATION

Following this introduction, the *Year 2005 Gulfwide Emission Inventory Study* report is organized as follows:

- Section 3 discusses how the platform activity data were collected and compiled.
- Section 4 summarizes the quality assurance/quality control (QA/QC) procedures that were implemented after receipt of the files to prepare the data for use in developing emissions calculations. The approach used to fill in data gaps in the platform data is also discussed in Section 4.
- Section 5 presents calculation methods for each piece of platform equipment. These calculation routines are performed in the Oracle DBMS.
- Section 6 presents calculation methods for non-platform sources.
- Section 7 presents diurnal emissions curves developed for all source categories covered in the inventory.
- Section 8 summarizes the resulting emission estimates by equipment type, source category, and pollutant. The limitations associated with the data and the emission estimates are also noted in Section 8, and the results are compared with the 2000 *Gulfwide Emission Inventory for Regional Haze and Ozone Modeling Effort* Study.
- Section 9 presents references cited throughout the report.

3. DATA COLLECTION

3.1 INTRODUCTION

To develop a base year 2005 inventory of criteria pollutant and greenhouse gas emissions for all OCS oil and gas production-related sources in the Gulf of Mexico, MMS collected activity data from platform operators during the year 2005. On September 10, 2004, MMS published NTL 2004-G17 to introduce the "Production Activities Information Collection and Reporting for Calculations of Air Emissions in the Western Gulf" and inform operators about the mandatory data collection, and a meeting to learn more about the data request. Affected operators are lessees and operators of federal oil, gas, and sulfur leases in the Gulf of Mexico OCS region.

This section of the report outlines the steps that MMS and Eastern Research Group, Inc. (ERG) took to collect the data, including modifying the data collection software, meeting with and training platform operators, and answering questions about data collection. Activity data were collected over one calendar year (2005) and were used to calculate and archive emissions data using the most current emission factors and calculation methods.

3.2 IMPROVEMENT OF THE GOADS DATA COLLECTION SOFTWARE

The GOADS data collection software that was used to collect base year 2000 platform activity data was revised for this study to address several issues uncovered during its use for preparing the 2000 inventory. The new version, GOADS-2005, was improved to make the program operate faster and more efficiently. The MMS and ERG staff worked closely with members of the Offshore Operators Committee (OOC) to identify and implement these improvements.

The Oracle Gulfwide database was also re-engineered to streamline data processing. The underlying database format of GOADS was changed to be like the Oracle database format to prevent potential data quality problems arising from data reformatting and conversion. However, this database redesign did not affect the user screens. The user-interface of the revised GOADS-2005 data collection software maintained the same look-and-feel of the original GOADS interface in order to reduce operator retraining. However, many internal modifications were made in an effort to improve efficiency and enhance data quality.

The previous structure of GOADS used a data organization that resulted in duplicate entry of all platform and equipment data each month. This structure increased data volume, data entry, and processing time. It also increased the likelihood of data entry errors. The revised GOADS-2005 was changed such that platform and equipment descriptions were entered into the system only once instead of monthly. Furthermore, a data import feature was added and the platform-equipment lists from the 2000 inventory were made available to minimize the effort of re-entering this static information for the 2005 inventory. Thus, the monthly data entry requirements were reduced to just those dynamic platform and equipment activity data elements that changed on a month-to-month basis.

Other modifications were made to streamline and standardize data entry— extraneous control equipment data elements were removed; extraneous QC error messages were removed; the inputs for describing the destination of air emissions were simplified by reducing the number of data elements and standardizing them across all equipment types; and volume vented and flared activity data entry were simplified. Another time-saving feature that was added to the software was the ability to flag inactive platforms or equipment as “No Emissions to Report” by checking a single box. Other features were added to provide a print screen function/review of data entered, and provide access file import and export features.

3.3 WORKING WITH USERS

A workshop was held in New Orleans on October 13, 2004, to discuss and explain the 2005 Gulfwide study information collection and reporting procedures, the pollutants to be covered, and the reasons the 2005 Gulfwide study was undertaken. The “User’s Guide for the 2005 Gulfwide Offshore Activities Data System (GOADS-2005)” (Wilson et al. 2004b) was the primary source of information for operators. The guide was provided at the workshop, and made available to all users via the MMS web site, where it could be downloaded and printed. The guide contains instructions on installation, starting and exiting GOADS, creating and editing data, quality control, and saving and backing up files. For details on the GOADS-2005 program, refer to the User’s Guide, which can be found at:
http://www.gomr.mms.gov/PI/PDFImages/ESPIS/2/3006.pdf.

An on-line GOADS-2005 Frequently Asked Questions (FAQ) forum (the GOADS-2005 listserv) was established for platform operators to directly submit questions and receive responses related to technical and software issues encountered from the ERG and MMS inventory development team. This forum was linked to the main MMS web site. For example, the listserv forum directed users how to get 2000 static data import files to automatically populate the descriptive data elements for their 2005 inventory and thereby reduce the amount of data entry.

The ERG also provided FAQ lists that were linked to the MMS web site that addressed 64 various technical questions ranging from policy issues for reporting to numerical estimation methods. ERG also provided one-on-one telephone and email support for numerous operators to resolve software usage questions.

3.4 GOADS QUALITY ASSURANCE/QUALITY CONTROL

The ERG programmed automatic QA procedures into the software in an effort to minimize the submittal of incomplete and erroneous activity data by the platform operators. ERG requested that operators submit a printout of their Quality Assurance Summary Form along with their monthly activity files. The QA Summary focuses on identification of critical data that the operators need to complete prior to submitting their data to MMS.

The software also automatically runs a series of QC checks on the data when the operator saves it. If the operator leaves a field blank, provides data that are out of range, or enters a value that is not consistent on a month-to-month basis, an error message will appear. The operator can then correct the problem, override the QC check (and provide a comment), or ignore the message and save the changes. When operators entered data that appeared in the QC results or on the QA Summary Form, ERG attempted to reconcile the missing, atypical, or suspect data by reviewing the comments, contacting the operators, or developing surrogate data as described in Section 4 of this report. Surrogate data were developed primarily for the stack parameters requested for the emission release point for each piece of equipment. These parameters are needed for air quality modeling efforts. The surrogates were developed based on industry averages, and through discussions with MMS.

4. QUALITY ASSURANCE/QUALITY CONTROL

4.1 INTRODUCTION

Platform operators submitted data files and QA Summary Forms generated by the GOADS-2005 software. 114 companies submitted data for 1,619 active or inactive platforms (combination of complex ID and structure ID). Included in the submittal were 16,882 structure records (a unique structure record is a combination of complex ID, structure ID, and month). A total of 134 unique data files were provided by 114 companies.

This section summarizes the data received, the steps ERG took to review the GOADS-2005 descriptive and monthly activity data for completeness and accuracy, and the types of errors encountered. Also discussed in this section are the procedures used to correct and gap-fill missing data, including stack parameter data provided by the operators. When operators failed to enter data or entered data that were atypical or suspect, ERG attempted to reconcile the data by reviewing the comments, contacting the operators, or developing surrogate data. For the atypical months of September, October, November, and December, care was taken when surrogate data were applied because of the widespread damage in the Gulf of Mexico by Hurricanes Katrina and Rita. Null or extremely low activity data values were not replaced with averages from the previous months, nor averages from the base year 2000 inventory, nor adjusted in any way. Null values were assumed to be zeros.

4.2 CHECKING FILE INTEGRITY AND MATCHING QA SUMMARY

The MMS sent 134 unique data files to ERG. The first set, received by July, 2006, included 1,579 platforms. The second set, received by April, 2007, included 40 platforms. All electronic data were in the prescribed Microsoft Access database that was created by the GOADS-2005 software. For comparison, 239 unique data files were submitted for the base year 2000 inventory for 2,873 active platforms. Section 8 presents a discussion on the likely reason for the discrepancy in the number of platforms in the 2000 and 2005 inventories.

The ERG checked file integrity to verify that the file submitted could be opened, and that it matched its QA Summary Form (same user, structure, and complex IDs). ERG was able to open and review all of the files provided. Companies were also required to submit a hardcopy of their QA Summary Form. Of the 134 files submitted, 117 were accompanied by a hardcopy of their QA summary results (87%). For the submittals missing hard-copy QA Summary Forms, ERG was able to print the form for review.

4.3 EQUIPMENT SUMMARY CHECKS

Each GOADS-2005 submittal contained templates for up to 36 tables. The majority of these tables cover the descriptive and activity data for specific equipment types (amine units, boilers, etc.). The user-, structure-, and QC tables were appended along with the equipment tables into one composite database. Primary keys (user ID, month, year, complex ID, structure ID, and equipment ID) were retained in all tables to ensure that no duplicate data were added.

4.3.1 User-Level Summary

The first data entry page in GOADS is for user information. The user ID should be the MMS company number assigned by MMS. The user IDs submitted were checked against the MMS master lease and company lists. The official MMS list of companies, leases, and platforms was retrieved from the MMS web site: http://www.gomr.mms.gov/homepg/pubinfo/freeasci/platform/freeplat.html.

The ERG used these master lists to check and correct the lease, company, and platform IDs. Additionally, ERG checked and corrected the locational data (latitude/longitude pairs) for each platform.

4.3.2 Structure-Level Summary

For each survey, the user was required to enter platform-level data that includes location coordinates, sales gas composition, total monthly platform fuel usage, and status (active or inactive for that month). A total of 19,644 records were submitted, and 16,882 were considered active (86%). For comparison, 31,473 active records were submitted for the base year 2000 inventory. The likely reasons for the discrepancy in the number of active records in the 2000 and 2005 inventories is the number of platforms in the inventories, as well as the impacts of Hurricanes Katrina and Rita (which resulted in monthly records flagged as inactive).

4.3.3 Equipment-Level Summary

Equipment descriptive information and activity-level data for 16 different types of equipment can be populated for each platform. A list of all the platform equipment submitted per equipment type was compiled. This composite list includes a total of 262,399 equipment surveys, of which 197,842 were active (75%).

4.4 QA/QC CHECKS

A number of QA/QC steps were performed to identify missing and out-of-range data for each type of equipment. The first step of the QA/QC task consisted of reviewing the sales gas compositions for validity and completeness. The sum of compositions that deviated from 100% were evaluated and corrected. Questionable sales gas compositions were replaced with a default set of compositions.

Another part of the QA/QC task for the GOADS submittals was to identify incorrect and missing equipment descriptive and activity data, and to correct and populate the missing information with surrogates. Six types of data analyses were performed: 1) pre-processing of the data; 2) equipment survey consistency; 3) data range checks; 4) stream analysis between certain equipment; 5) applying surrogate values; and 6) post-processing of surrogates.

4.4.1 Pre-Processing

Three pre-processing steps occurred before the rigorous data analysis could begin. First, the activity status of each survey was confirmed. Second, the reported number of operating hours for each piece of equipment was checked to make sure it did not exceed the maximum number of hours in the month. Third, the reported fuel usage at the equipment level was compared to the maximum capacity of the equipment and the reported fuel usage for the entire platform.

Operators had the opportunity to identify a platform or individual pieces of equipment as being inactive for each month by checking a "No Emissions to Report" checkbox. Otherwise, all platforms and equipment were treated as active. Inactive data are not considered for emissions calculations, so this step is extremely important. For equipment surveys that request hours of operation, platform surveys were labeled as active if any of the equipment the operating hours were greater than zero. Conversely, a platform survey was labeled as inactive if all of the equipment operating hours were zero.

Platform/equipment surveys were also considered active based on a review of the following equipment data if: 1) in the Fugitive equipment table, the component count provided was greater than zero; 2) in the Loading and Losses from Flashing equipment tables the throughputs were greater than zero; or 3) in the Mud Degassing equipment table, the drilling days per month were greater than zero.

For each month, operating hours were to be provided for most types of equipment. A typical error would be to exceed the maximum hours possible for a given month. Similarly, hours of operation may not have been populated. For both of these errors, data were corrected in the same manner by populating with the maximum number of hours possible. The maximum number of hours for months with 31 days (January, March, May, July, August, October, and December) is 744; for months with 30 days (April, June, September, and November), the maximum number of hours is 720. In year 2005, the maximum amount of hours for February (with 28 days) is 672. Two exceptions are also noted due to the implementation of daylight savings: 1) the number of hours possible for March is 743 hours; and 2) the number of hours possible for October is 745 hours.

The last pre-processing step focused on the reported fuel usage. Platform operators provided estimates of total fuel used for each month for the entire platform, and for each boiler/heater/burner, diesel engine, natural gas engine, natural gas turbine, and drilling rig operation. Additionally, operators were asked to provide fuel equipment parameters such as hours operated, fuel usage rate (average and maximum), operating horsepower (average and maximum), and heat input rate.

The average and theoretical maximum fuel usage values for each reported boiler/heater/burner, diesel engine, natural gas engine, and natural gas turbine were calculated by multiplying the hours operated by the average or maximum heat input or fuel usage rate and operating horsepower, and dividing by the fuel heating value.

After correcting the individual equipment fuel usage values, the reported monthly total fuel used for the platform was compared to the sum of the individual pieces of equipment by fuel type. For the most part, the goal of this comparison was to make the two reported totals somewhat consistent. If the sum of reported (or corrected) fuel usage in the equipment tables was greater than the reported platform total, the platform total was revised to equal the equipment sum. If the reported platform total was not populated, it was populated with the equipment sum.

4.4.2 Equipment Survey Consistency

A platform may contain several pieces of equipment that operate year-round, but data parameters may not have been populated for every month. In this situation, the entire platform equipment dataset was examined. For example, 11 of the 12 monthly surveys may be populated for a boiler with the same fuel heating value, while one month, although marked active, may be null or provide a different fuel heating value. The missing or different value was populated to match the other platform equipment surveys if ERG believed a data entry error occurred. Approximately 25% of the monthly equipment records required corrections in this process. However, no attempt was made to supplement missing data during the period of the hurricane impacts, e.g., data averages from other months were not used to replace null values for September through December.

4.4.3 Data Range Checks

After the equipment surveys were checked for survey consistency, the parameters were checked to ensure that they were within an acceptable data range. For example, some operators mistakenly entered incorrect fuel heating values. Natural gas has a fuel heating value on average of 1,050 Btu/scf. However, some equipment surveys had entered 105 Btu/scf as their fuel heating value, or even 19,300, which is the average fuel heating value of diesel fuel (in units of Btu/lb, however). Approximately 15% of the records required corrections in this process.

This type of error would not be detected through the equipment survey consistency step if all the incorrect data were entered the same for each survey. It is believed that some operators did not run the QC check correctly or at all within the GOADS program; this would explain why these incorrect data were not flagged initially. Additionally, there was clear evidence that some databases were not populated with the GOADS software as they contained invalid equipment type codes, mismatching equipment type codes, and database relational integrity errors.

The ranges were checked for the fields listed in Table 4.1. These ranges are based on the relationship between the parameters noted in Table 4.1 (e.g., actual fuel usage rate cannot exceed the reported maximum fuel usage rate), and typical fuel and control device efficiency values.

4.4.4 Stream Analysis Between Certain Equipment

Certain pieces of equipment may not be vented locally, but rather piped downstream to a cold vent or combustion flare. It is important for the downstream exhaust vents to be correctly identified; otherwise the calculations may overestimate emissions. The Amine Unit, Glycol Dehydrator, Loading, Losses from Flashing, Pneumatic Pumps, and Storage Tanks equipment may exhaust gases locally or downstream. If the Vent or Flare ID is populated in these tables,

Table 4.1

Fields and Range Check Values

Field	Range Check
API Specific Gravity	Minimum value: 9 degrees API
Average Liquid Height	Not to exceed outlet height
Flare Efficiency	Between 90 and 99%
Fuel Heating Value	Natural gas: 500 to 1500 Btu/scf Diesel: 18,000 to 22,000 Btu/lb
Fuel Usage Rate	Not to exceed maximum fuel usage rate
Fuel H_2S Content	0 to 5 ppmv
Fuel Sulfur Content	0 to 5 percent
Heat Input Rate	Not to exceed maximum heat input rate
Inner Diameter	Greater than 5 inches
Operating Horsepower	Not to exceed maximum rated horsepower
Stack Angle	Between 0 and 360

then a downstream analysis was performed on the Vent or Flare equipment tables to verify their existence. For Vent or Flare ID's that could not be traced to an existing active vent or flare, the survey was updated as to being vented/flared locally. Approximately 10% of the records required corrections during this process.

4.4.5 Applying Surrogate Values

Surrogate values were used to populate missing stack parameters that are needed for air quality modeling. These parameters are listed in Table 4.2 by equipment type. As shown in Table 4.2, surrogate values could be calculated for exit velocity and exhaust volume flow rate from the submitted data. Other surrogate data were developed from industry averages, and through discussions with MMS.

4.4.6 Post-Processing of Surrogates

After all the missing data have been populated through quality assurance checks and surrogates, two calculations were performed to check the overall quality of the data. The first calculation was for exit velocity; the second was for total fuel usage. Both of these parameters were recalculated using a combination of corrected and originally-submitted activity and descriptive data to yield values consistent with the inter-related, quality assured data parameters.

Table 4.2

Surrogate Stack Parameters Used to Supplement GOADS-2005 Data

Unit	Field	Default Value
Amine Unit	Elevation (above sea level)	50 ft
Amine Unit– ventilation system for acid gas from reboiler	Exit velocity (ft/sec)	Calculated with AMINECalc[a]
Amine Unit– ventilation system for acid gas from reboiler	Exit temperature	110 ^oF
Amine Unit–ventilation system for acid gas from reboiler	Combustion temperature	1832 ^oF
Boiler/heater/burner	Elevation (above sea level)	50 ft
Boiler/heater/burner – exhaust System	Exit temperature	400 ^oF
Boiler/heater/burner – exhaust system	Outlet orientation	0 degrees
Boiler/heater/burner – exhaust system	Outlet diameter	12 inches
Boiler/heater/burner – exhaust system	Exit velocity	Calculated
Diesel Engine	Elevation (above sea level)	50 ft
Diesel Engine	Max rated fuel use	7000 Btu/hp-hr
Diesel Engine	Average fuel use	7000 Btu/hp-hr
Diesel Engine– exhaust system	Outlet height	7 ft above engine
Diesel Engine– exhaust system	Exit velocity	Calculated
Diesel Engine– exhaust system	Exit temperature	900 ^oF
Diesel Engine– exhaust system	Outlet orientation	0 degrees
Diesel Engine– exhaust system	Outlet diameter	12 inches
Combustion Flare	Combustion temperature (excluding upsets)	1832 ^oF
Combustion Flare	Stack orientation	0 degrees
Combustion Flare	Outlet diameter	12 inches
Combustion Flare	Pilot feed rate	2.28 Mscf/day
Combustion Flare	H_2S concentration	3.38 ppm
Glycol Dehydrator	Elevation (above sea level)	50 ft
Glycol Dehydrator– flash tank	Temperature	120 ^oF
Glycol Dehydrator– flash tank	Pressure	60 psig
Glycol Dehydrator– ventilation system	Exit temperature	GLYCalc default (usually 212 ^oF)[b]

Table 4.2

Surrogate Stack Parameters Used to Supplement GOADS-2005 Data (Continued)

Unit	Field	Default Value
Glycol Dehydrator– ventilation system	Outlet orientation	0 degrees
Glycol Dehydrator– ventilation system	Flare feed rate (scf/hr)	Calculated with GLYCalc[b]
Glycol Dehydrator– ventilation system	Combustion temperature	1832 °F
Glycol Dehydrator– ventilation system	Condenser temperature	110 °F (or calculated with GLYCalc)[b]
Glycol Dehydrator– ventilation system	Condenser pressure	14.8 psia
Loading – barge	Elevation (above sea level)	0
Loading – ventilation system	Exit temperature	70 °F
Loading– ventilation system	Outlet orientation	0 degrees
Loading– ventilation system	Outlet diameter	3 in.
Loading– ventilation system	Exit velocity	Calculated
Loading– ventilation system	Flare feed rate	Calculated (use loading exhaust volume flow rate if controlled by flare)
Loading– ventilation system	Combustion temperature	1832 °F
Losses from Flashing– ventilation system	Exhaust volume flow rate	Calculated
Losses from Flashing– ventilation system	Exit velocity	Calculated
Losses from Flashing– ventilation system	Exit temperature	70 °F
Losses from Flashing– ventilation system	Outlet diameter	Use tank vent outlet diameter
Natural Gas Engine	Max rated fuel usage	7500 Btu/hp-hr
Natural Gas Engine	Average fuel usage	7500 Btu/hp-hr
Natural Gas Engine– exhaust system	Exit velocity	Calculated
Natural Gas Engine– exhaust system	Exit temperature	4-cycle rich burn: 1100 °F
Natural Gas Engine– exhaust system	Exit temperature	2-cycle lean burn: 700 °F
Natural Gas Engine– exhaust system	Outlet diameter	12 inches
Natural Gas Turbine	Max rated fuel use	10,000 Btu/hp-hr

Table 4.2

Surrogate Stack Parameters Used to Supplement GOADS Data (Continued)

Unit	Field	Default Value
Natural Gas Turbine	Average fuel use	10,000 Btu/hp-hr
Natural Gas Turbine– exhaust system	Exit velocity	Calculated
Natural Gas Turbine– exhaust system	Outlet diameter	12 inches
Natural Gas Turbine– exhaust system	Exit temperature	1000 ^{o}F
Pneumatic Pumps	Elevation (above sea level)	50 ft
Pneumatic Pumps– ventilation system	Exit velocity	Calculated
Pneumatic Pumps– ventilation system	Exit temperature	70 ^{o}F
Pressure/level Controllers	Elevation (above sea level)	50 ft
Storage Tank – General Information	Roof Height above Shell (ft)	0.0625*(Tank Diameter ÷2), ft
Storage Tank– ventilation system	Exit velocity	Calculated
Storage Tank– ventilation system	Exit temperature	70 ^{o}F
Storage Tank– ventilation system	Outlet orientation	0 degrees
Storage Tank– ventilation system	Flare feed rate	Calculated (or use the calculated storage tank exhaust vol. flow rate)
Cold Vent	Outlet elevation (above sea level)	50 ft
Cold Vent	Outlet diameter	Calculated (average of submitted data)
Cold Vent	Exit temperature	70 ^{o}F
Cold Vent	Outlet orientation	0 degrees

[a] AMINECalc is released by the Gas Technology Institute as part of the AIRCalc Air Emissions Inventory Report Management Software Program (GTI 2001)

[b] GLYCalc is released by the Gas Technology Institute, formerly the Gas Research Institute (GRI) (GTI 2000)

5. DEVELOPMENT OF THE PLATFORM EMISSION INVENTORY

5.1 INTRODUCTION

The goal of this study is to develop criteria pollutant and greenhouse gas emission inventories for all oil and gas production-related sources in the Gulf of Mexico. To achieve this goal, ERG revised the 2000 Gulfwide Oracle Database Management System (DBMS) to create the 2005 Gulfwide Oracle DBMS. The 2005 Gulfwide DBMS imports the activity data provided by platform operators, and applies emission factors and emission estimation algorithms to calculate emissions from platform sources in the Gulf of Mexico. The database calculates emissions of CO, SO_2, NO_x, PM_{10}, $PM_{2.5}$, VOC, CO_2, CH_4, and N_2O, which contribute to regional haze, ozone, or greenhouse gas effects.

The MMS provided surrogates for values such as fuel sulfur content, fuel heating value, fuel density, and control efficiency. These surrogate values are based on industry averages and/or MMS recommended values. For example, the diesel fuel sulfur content is consistent with MMS' “Spreadsheet for Exploration Plans” (http://www.gomr.mms.gov/homepg/regulate/environ/airquality/reporting.html).

Natural gas hydrogen sulfide (H_2S) content = 3.38 ppmv
Diesel fuel sulfur content = 0.4 wt%
Natural gas heating value = 1050 Btu/scf
Diesel fuel heating value = 19,300 Btu/lb
Diesel fuel density = 7.1 lb/gal
Gasoline density = 6.17 lb/gal
Flare efficiency for H_2S = 95%
Vapor recovery/condensor (VR/C) efficiency for total hydrocarbons (THC) and VOCs = 80%
Sulfur recovery (SR) + VR/C efficiency for THC and VOCs = 80%
SR efficiency for THC and VOCs = 0%

5.2 EMISSION ESTIMATION PROCEDURES

For the most part, the emission estimation procedures presented in this section are unchanged from those in the 2000 Gulfwide DBMS (Wilson et al. 2004a), the exception being the PM emission factors for boilers/heaters/burners combusting natural gas, flare-pilots, and natural gas turbines. The PM factors were revised to reflect filterable PM rather than total PM over concern about the accuracy of the PM total emission factors. The following sections present the methods used to calculate criteria pollutant and greenhouse gas emissions from platform sources in the study, and highlight any changes in the emission estimation procedures.

5.2.1 Amine Units

Some platforms produce natural gas containing unacceptable amounts of hydrogen sulfide. While most platform operators pipe the sour gas onshore for sulfur removal, a few remove the sulfur on the platform using the amine process. Various amine solutions are used to absorb H_2S. After the H_2S has been separated out, it is vented, flared, incinerated, or used for feedstock in elemental sulfur production (U.S. DOI, MMS 1995).

Operators were given the option of using the "Model Inputs" tab if requested data were not readily available. CH_4 and VOC emissions are estimated externally using AMINECalc (GTI 2001), and loaded directly into the DBMS. Emissions are adjusted for any control devices that were reported, such as a combustion flare, a vapor recovery system/condenser, or a sulfur recovery unit, and other user-specified control devices. Controlled emissions of VOC are calculated as follows:

$$E_{c,control} = E_{c,unc} \times \sum \frac{100 - Eff_{c,d}}{100\%}$$

where:

$E_{c,control}$ = Controlled VOC emissions (pounds per month)
$E_{c,unc}$ = Uncontrolled VOC emissions (pounds per month)
$Eff_{c,d}$ = Control efficiency of control device d for VOCs (percent)

Devices that are intended to control H_2S emissions, such as sulfur recovery units or combustion flares, will produce emissions of SO_2 as a by-product. If a combustion flare is present, SO_2 emissions are calculated as follows (EIIP 1999, Wilson et al. 2004a).

$$E_{SO_2,control} = E_{H2S}\left(\frac{lb \cdot mol_{H_2S}}{34\,lb_{H_2S}}\right) \times \left(\frac{64\,lb_{SO_2}}{lb \cdot mol_{SO_2}}\right) \times \left(\frac{Eff_{SO_2}}{100}\right)$$

where:

$E_{SO2,\ control}$ = Resulting SO_2 emissions (pounds per month)
E_{H_2S} = Uncontrolled emissions of H_2S (pounds per month)
Eff_{SO2} = Flare efficiency (%)

If a sulfur recovery unit is present, SO_2 emissions are calculated as follows (EIIP 1999, Wilson et al. 2004a):

$$E_{SO_2,control} = E_{H_2S}\left(\frac{lb \cdot mol_{H_2S}}{34\,lb_{H_2S}}\right) \times \left(\frac{64\,lb_{SO_2}}{lb \cdot mol_{SO_2}}\right) \times \left(\frac{Eff_{SO_2}}{100}\right) \times \left(\frac{1\,lb \cdot mol_{SO_2}}{3\,lb \cdot mol_S}\right) \times \left(1 - \frac{\%\,RE}{100}\right)$$

where:

$E_{SO2,\ control}$ = Resulting SO_2 emissions (pounds per month)
E_{H_2S} = Uncontrolled emissions of H_2S (pounds per month)
% RE = Recovery efficiency of the sulfur recovery unit (%)

5.2.2 Boilers/Heaters/Burners

Boilers, heaters, and burners provide process heat and steam for many processes such as electricity generation, glycol dehydrator reboilers, and amine reboiler units (EIIP 1999). To calculate uncontrolled emissions for liquid-fueled engines (waste oil or diesel) based on fuel use, $E_{fu,liq}$:

$$E_{fu,\,liq} = EF_{(lb/10^3\ gal)} \times 10^{-3} \times U_{liq} \div 7.1\,lb/gal$$

To calculate uncontrolled emissions for gas-fueled engines (natural gas, process gas, or waste gas) based on fuel use, $E_{fu,gas}$:

$$E_{fu,gas} = EF_{(lb/MMscf)} \times 10^{-3} \times U_{gas}$$

where:

E = Emissions in pounds per month
EF = Emission factor
U_{liq} = Fuel usage (pounds/month)
U_{gas} = Fuel usage (Mscf/month)

If fuel usage is not provided, it is calculated based on hours operated, max rated or average heat input, and fuel heating value.

The following emission factors are used to estimate emissions. These factors come from *AP-42*, Sections 1.3 and 1.4 (U.S. EPA 2002). All boilers are assumed to be wall-fired boilers (no tangential-fired boilers). Emission factors for No. 6 residual oil were used to estimate emissions from waste-oil-fueled units.

Table 5.1

Emission Factors for Liquid-Fueled Units – Diesel where Max Rated Heat Input ≥ 100 MMBtu/hr

	Emission Factors (lb/10^3 gal)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	0.252	0.252	0.252
VOC	0.2	0.2	0.2
SO_2	157 × S	157 × S	157 × S
NO_x	24	10	10
$PM_{2.5}$	0.25	0.25	0.25
PM_{10}	2.0	2.0	2.0
CO	5	5	5
N_2O	0.11	0.11	0.11
CH_4	0.052	0.052	0.052
CO_2	22,300	22,300	22,300

S = Fuel oil sulfur content (wt%)

Table 5.2

Emission Factors for Liquid-Fueled Units – Diesel where Max Rated Heat Input < 100 MMBtu/hr

	Emission Factors (lb/10^3 gal)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	0.252	0.252	0.252
VOC	0.2	0.2	0.2
SO_2	142 × S	142 × S	142 × S
NO_x	20	20	20
$PM_{2.5}$	0.25	0.25	0.25
PM_{10}	2	2	2
CO	5	5	5
N_2O	0.11	0.11	0.11
CH_4	0.052	0.052	0.052
CO_2	22,300	22,300	22,300

S = Fuel oil sulfur content (wt %)

Table 5.3

Emission Factors for Liquid-Fueled Units – Waste Oil
where Max Rated Heat Input ≥ 100 MMBtu/hr

	Emission Factors (lb/10^3 gal)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	1.28	1.28	1.28
VOC	0.28	0.28	0.28
SO_2	157 × S	157 × S	157 × S
NO_x	47	40	40
$PM_{2.5}$	5.23 × S + 1.73	5.23 × S + 1.73	5.23 × S + 1.73
PM_{10}	9.19 × S + 3.22	9.19 × S + 3.22	9.19 × S + 3.22
CO	5	5	5
N_2O	0.11	0.11	0.11
CH_4	1.00	1.00	1.00
CO_2 (high S)[a]	24,400	24,400	24,400

S = Fuel oil sulfur content (wt%)

[a] As opposed to oil that has been desulfurized

Table 5.4

Emission Factors for Liquid-Fueled Units – Waste Oil
where Max Rated Heat Input < 100 MMBtu/hr

	Emission Factors (lb/10^3 gal)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	1.28	1.28	1.28
VOC	0.28	0.28	0.28
SO_2	157 × S	157 × S	157 × S
NO_x	55	55	55
$PM_{2.5}$	0.37 × S + 0.12	0.37 × S + 0.12	0.37 × S + 0.12
PM_{10}	9.19 × S + 3.22	9.19 × S + 3.22	9.19 × S + 3.22
CO	5	5	5
N_2O	0.11	0.11	0.11
CH_4	1.00	1.0	1.0
CO_2 (high S)[a]	24,400	24,400	24,400

S = Fuel oil sulfur content (wt%)

[a] As opposed to oil that has been desulfurized

Table 5.5

Emission Factors for Gas-Fueled Units – Natural Gas or Process Gas where Max Rated Heat Input ≥ 100 MMBtu/hr

	Emission Factors (lb/MMscf)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	11	11	11
VOC	5.5	5.5	5.5
SO_2	0.6	0.6	0.6
NO_x	280	140	100
PM_{10}[a]	1.9	1.9	1.9
CO	84	84	84
N_2O	2.2	0.64	0.64
CH_4	2.3	2.3	2.3
CO_2	120,000	120,000	120,000

[a] Also represents $PM_{2.5}$

Table 5.6

Emission Factors for Gas-Fueled Units – Natural Gas or Process Gas where Max Rated Heat Input < 100 MMBtu/hr

	Emission Factors (lb/MMscf)		
Pollutant	Uncontrolled	Low NO_x Burner	Flu Gas Recirculation
THC	11	11	11
VOC	5.5	5.5	5.5
SO_2	0.6	0.6	0.6
NO_x	100	50	32
PM_{10}[a]	1.9	1.9	1.9
CO	84	84	84
N_2O	2.2	0.64	0.64
CH_4	2.3	2.3	2.3
CO_2	120,000	120,000	120,000

[a] Also represents $PM_{2.5}$

5.2.3 Diesel and Gasoline Engines

Diesel and gasoline engines are used to run generators, pumps, compressors, and well-drilling equipment. Most of the pollutants emitted from these engines are from the exhaust. Evaporative losses are insignificant in diesel engines due to the low volatility of diesel fuels (U.S. EPA 2002).

If a user-entered value for total fuel used is available, or if it can be estimated from default values then emissions are estimated based upon fuel use. Otherwise, if operating HP and hours operated are both available, then emissions are estimated based upon power output.

To calculate uncontrolled emissions based on fuel use, E_{fu}:

$$E_{fu} = EF_{(lb/MMBtu)} \times 10^{-6} \times U \times \frac{7.1\,lb}{gal} \times H$$

To calculate uncontrolled emissions based on power output, E_{po}:

$$E_{po} = EF_{(g/hp\text{-}hr)} \times HP \times t \times \frac{lb}{453.6g}$$

where:

E = Emissions in pounds per month
EF = Emission factor (units are shown in parentheses)
U = Fuel usage (gallons/month)
H = Fuel heating value (Btu/lb)
HP = Engine horsepower (hp)
t = Engine operating time (hr/month)

The following emission factors are used to estimate emissions. These factors come from *AP-42*, Sections 3.3 and 3.4 (U.S. EPA 2002).

Table 5.7

Emission Factors for Gasoline Engines

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	3.03	9.8
VOC	3.03	9.8
SO_x	0.084	0.268
NO_x	1.63	4.99
PM_{10}[a]	0.1	0.327
CO	62.7	199
CO_2	154.0	489.9

[a] Also represents $PM_{2.5}$

Table 5.8

Emission Factors for Diesel Engines
where Max HP < 600

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	0.36	1.14
VOC	0.33	1.04
SO_x	1.01 × S	3.67 × S
NO_x	4.41	14.1
PM_{10}[a]	0.31	1
CO	0.95	3.03
CO_2	164.0	521.6

[a] Also represents $PM_{2.5}$
S = Fuel oil sulfur content (wt%)

Table 5.9

Emission Factors for Diesel Engines
where Max HP ≥ 600

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	0.09	0.32
VOC	0.08	0.29
SO_x	1.01 × S	3.67 × S
NO_x	3.2	10.9
$PM_{2.5}$[a]	0.056	0.178
PM_{10}	0.057	0.182
CO	0.85	2.5
CH_4	0.008	0.03
CO_2	165.0	526.2

S = Fuel oil sulfur content (wt%)
[a] <3 µm

If the corresponding field is null, a surrogate fuel consumption rate of 7,000 Btu/hp-hr is applied.

5.2.4 Drilling Rigs

Drilling activities associated with an existing facility or from a jack-up rig adjacent to a platform are included because of their emissions associated with gasoline, diesel, and natural gas fuel usage in engines. Total emissions equal the sum of emissions due to gasoline, diesel, and natural gas fuel usage.

For gasoline fuel use, calculate uncontrolled emissions, E_{gas}, as follows (Wilson et al. 2004a):

$$E_{gas} = EF_{(lb/MMBtu)} \times 10^{-6} \times U \times \frac{6.17\,\text{lb}}{\text{gal}} \times \frac{20{,}300\,\text{Btu}}{\text{lb}}$$

where:

E = Emissions in pounds per month
EF = Emission factor (units shown in parentheses)
U = Fuel usage (gallons)

For diesel fuel use, calculate uncontrolled emissions, E_{die}, as follows (Wilson et al. 2004a):

$$E_{die} = EF_{(lb/MMBtu)} \times 10^{-6} \times U \times \frac{7.1\,\text{lb}}{\text{gal}} \times \frac{19{,}300\,\text{Btu}}{\text{lb}}$$

where:

E = Emissions in pounds per month
EF = Emission factor (units shown in parentheses)
U = Fuel usage (gallons)

For natural gas fuel use, calculate uncontrolled emissions, E_{ng}, as follows:

$$E_{ng} = EF_{(lb/MMscf)} \times 10^{-3} \times U$$

where:

E = Emissions in pounds per month
EF = Emission factor (units shown in parentheses)
U = Fuel usage (Mscf)

The following emission factors are used to estimate emissions. These factors come from *AP-42*, Sections 3.2, 3.3 and 3.4 (U.S. EPA 2002). Diesel engines are assumed to be ≥ 600 hp. Natural gas engines are assumed to be 4-cycle and evenly distributed between lean and rich burns (by averaging).

Table 5.10

Emission Factors for Gasoline Fuel Use

Pollutant	EF_{gas} (lb/MMBtu)
THC	3.03
VOC	3.03
SO_x	0.084
NO_x	1.63
PM_{10}[a]	0.1
CO	62.7
CO_2	154

[a] Also represents $PM_{2.5}$

Table 5.11

Emission Factors for Diesel Fuel Use

Pollutant	EF_{die} (lb/MMBtu)
THC	0.09
VOC	0.08
SO_x	$1.01 \times S$
NO_x	3.2
$PM_{2.5}$[a]	0.056
PM_{10}	0.057
CO	0.85
CO_2	165

S = Fuel oil sulfur content (wt%)
[a] <3 µm

Table 5.12

Emission Factors for Natural Gas Fuel Use

Pollutant	EF_{ng} (lb/MMscf)
THC	932.3
VOC	75.3
SO_2	0.6
NO_x	2467.5
PM_{10}[a]	4.9
CO	2127.3
CH_4	755
CO_2	112,200

[a] Also represents $PM_{2.5}$

5.2.5 Combustion Flares

A flare is a burning stack used to dispose of hydrocarbon vapors. Flares can be used to control emissions from storage tanks, loading operations, glycol dehydration units, vent collection system, and amine units. Flares usually operate continuously; however, some are used only for process upsets (U.S. DOI, MMS 1995).

Flare emissions for THC, VOC, NO_x, PM_{10}, and CO are estimated according to the following equation:

$$E_{\text{flare}} = V \times H \times EF_{\text{flare}} \div 1000$$

where:

E_{flare} = Emissions in pounds per month
V = Total volume of gas flared (Mscf) = vol flared (Mscf, including upsets)
H = Flare gas heating value (Btu/scf)
EF_{flare} = Emission factor for flares (lb/MMBtu)

SO_2 emissions are estimated using to the following equation:

$$E_{\text{flare},SO_2} = \left(\frac{\text{Eff}_F\,\%}{100\%}\right) \times \frac{10^{-6}}{\text{ppm}} \times \frac{m_{SO_2}}{379.4\ \text{scf/lb}\cdot\text{mol}} \times 1000 \times \left(V \times C_{H_2S}\right)$$

where:

$E_{\text{flare, SO2}}$= Emissions in pounds per month
$\text{Eff}_F\%$ = The combustion efficiency of the flare (percent)
m_{SO2} = Molecular weight of SO_2 = 64 lb/lb·mol
V = Volume of gas flared (Mscf)
C_{H_2S} = Concentration of H_2S in the flare gas (ppm)

If the user indicates there is a continuous flare pilot, pilot light emissions are estimated as follows:

$$E_{\text{pilot}} = P \times D \times EF_{\text{pilot}} \div 1000$$

where:

E_{pilot} = Pilot emissions in pounds per month
P = Flare feed rate (Mscf/day)
D = Number of days in month
EF_{pilot} = Emission factor for pilot (lb/MMscf)

The following emission factors are used to estimate emissions. The CO, NO_x, and THC emission factors come from *AP-42*, Sections 13.5 and 1.4 (U.S. EPA 2002). The VOC and CH_4 emission factors are derived from the default sales gas composition shown in Table 5.25 of this report based on the weight fraction of the volatile components.

Table 5.13

Emission Factors for Flares[a]

Pollutant	EF (lb/MMBtu)
THC	0.14
VOC	0.006
NO_x	0.068
PM_{10}	0; where flare smoke = none
	0.002; where flare smoke = light
	0.01; where flare smoke = medium
	0.02; where flare smoke = heavy
CO	0.37
CH_4	0.126

[a] Factors are not available for $PM_{2.5}$, N_2O or CO_2

Table 5.14

Emission Factors for Pilots

Pollutant	EF (lb/MMscf)
THC	11
VOC	5.5
NO_x	100
PM_{10}	7.6
SO_2	0.6
CO	84
N_2O	2.2
CH_4	2.3
CO_2	120,000

If the corresponding fields are null, the following surrogate values are applied:

Flare $\text{Smoke}_{\text{default}}$ = None
Pilot Fuel Feed Rate = 2.28 Mscf/day

The emission factors shown in Table 5.13 are assumed to be based on flares operating under stable conditions, with a combustion efficiency of approximately 98%. Based on a comment by a Science Review Board member, ERG investigated the possibility that not all platform flares are actually operating under stable conditions. Emissions of VOC, THC, and CH_4 increase during unstable conditions due to incomplete combustion of the waste stream (TCEQ

2000), while emissions estimates for CO, NO_x, and PM are unchanged due to uncertainty of the impacts. Unstable conditions occur if:

- The heating value of the flared gas is less than 300 Btu/scf for steam or air assisted flaring and the exit velocity is greater than 60 feet per second (fps); or
- The heating value of the flared gas is less than 200 Btu/scf for unassisted flaring and the exit velocity is greater than 60 (fps); or
- The heating value of the flared gas is less than 1000 Btu/scf and the exit velocity is greater than 400 fps.

For flared platform gas, the heating value is generally greater than 1000 Btu/scf, therefore ERG reviewed the flare velocity to insure that it is less than 400 fps. Only one flare had a reported exit gas velocity greater than 400 fps; the emission factors were adjusted to reflect combustion efficiency of 93% (TCEQ 2006).

5.2.6 Fugitives

Fugitive emissions are leaks from sealed surfaces associated with process equipment. Specific fugitive source types include equipment components such as valves, flanges, and connectors (EIIP 1999). Operators were required to delineate the stream type (gas, heavy oil, light oil, or water/oil) and average VOC weight percent of fugitives, and provide an equipment inventory (number of components).

Fugitive THC emissions are estimated according to the following equation:

$$E_{THC} = \sum_{comp} \left(EF_{comp,stream} \times N_{comp} \right) \times D$$

where:

E_{THC} = THC emissions in pounds per month
$EF_{comp,stream}$ = Emission factor unique the type of component and process stream (lb/component-day)
N_{comp} = Count of components of a given type present on the facility. (Note: Null values are treated as zero.)
D = Number of days in month

Fugitive VOC emissions are estimated according to the following equation:

$$E_{VOC} = E_{THC} \times WtFrVOC_{comp,\ stream}$$

where:

E_{VOC} = VOC emissions in pounds per month
E_{THC} = THC emissions in pounds per month
$WtFrVOC_{comp,stream}$ = Weight fraction of VOC unique to the process stream

Fugitive CH_4 emissions are estimated according to the following equation:

$$E_{CH4} = E_{THC} \times WtFrCH_{4\,comp,\,stream}$$

where:

E_{CH4} = CH_4 emissions in pounds per month
E_{THC} = THC emissions in pounds per month
$WtFrCH_{4comp,stream}$ = Weight fraction of CH_4 unique to the process stream

Table 5.15

THC Emission Factors for Oil and Gas Production Operations
(lb/component-day)[a]

Component	Gas	Natural Gas Liquid	Heavy Oil (<20 API Gravity)	Light Oil (≥ 20 API Gravity)	Water/Oil	Oil/Water/ Gas[c]
Connector	1.1E-02	1.1E-02	4.0E-04	1.1E-02	5.8E-03	1.1E-02
Flange	2.1E-02	5.8E-03	2.1E-05	5.8E-03	1.5E-04	2.1E-02
Open-end	1.1E-01	7.4E-02	7.4E-02	7.4E-02	1.3E-02	1.1E-01
Other[b]	4.7E-01	4.0E-01	1.7E-03	4.0E-01	7.4E-01	7.4E-01
Pump	1.3E-01	6.9E-01	6.9E-01	6.9E-01	1.3E-03	1.3E-01
Valve	2.4E-01	1.3E-01	4.4E-04	1.3E-01	5.2E-03	2.4E-01

[a] Source: API 1996
[b] Includes compressor seals, diaphragms, drains, dump arms, hatches, instruments, meters, pressure relief valves, polished rods, and vents
[c] Assumed to be equal to either gas or water/oil, whichever is greater

If a component count is not provided, the following surrogate component counts are used (derived from API 1993, average number of offshore platform components, and percentage of total components by type):

Connectors:	9,194
Valves:	1,713
Open-Ends:	285
Others:	228

If stream type is not provided, emissions are calculated assuming the stream type is light oil. The default values in Table 5.16 are assigned if the average VOC weight percent field is blank.

Table 5.16

Default Speciation Weight Fractions for THC Emissions by Stream Type[a]

THC Fraction	Gas	Natural Gas Liquid	Light Oil (≥ 20 API Gravity)	Heavy Oil (<20 API Gravity)	Water/Oil[b]	Oil/Water/ Gas
CH_4	0.945	0.612	0.612	0.942	0.612	0.612
VOC	0.0137	0.296	0.296	0.030	0.296	0.296

[a] Source: API 1996

[b] Water/oil refers to water streams in oil service with a water content greater than 50% from the point of origin to the point where the water content reaches 99%. For water streams with a water content greater than 99%, the emission rate is considered negligible

5.2.7 Glycol Dehydrators

Glycol dehydrators remove excess water from natural gas streams to prevent the formation of hydrates and corrosion in the pipeline (EIIP 1999). Surrogate VOC glycol dehydrator still column vent emission estimates were calculated based on regression equations from GRI-GLYCalc version 4 (GTI 2000) computer program runs for varying combinations of wet gas pressure and wet gas temperature. Surrogate glycol dehydrator flash tank vent emissions were also calculated based on regression equations from GRI-GLYCalc version 4 computer program runs for varying combinations of flash tank pressure and flash tank temperature. Table 5.17 presents the surrogate gas analysis used in the runs.

The VOC emission rate in pounds per hour is directly proportional to the volume of gas dehydrated if all other variables are held constant. Thus, emission factors from the GRI-GLYCalc runs were developed to express VOC emissions in pounds per hour per million standard cubic feet per day gas (lbs/hr-MMSCFD) processed. For still column vents, VOC emission factors were developed for over 60 combinations of wet gas pressure and temperature. The emission factors range from 0.0126 lb VOC/hr-MMSCFD at a pressure of 1200 psig and temperature of 50° F, to 0.3357 lb VOC/hr-MMSCFD at a pressure of 600 psig and temperature of 130°F.

For glycol dehydrator flash tanks, VOC emission factors were developed for over 120 combinations of wet gas pressure and temperature, and flash tank pressure and temperature. The lowest emission factor is 0.03457 lb VOC/hr-MMSCFD at a wet gas pressure of 1100 psig and temperature of 70°F, and flash tank pressure of 100 psig and temperature of 75°F. The highest emission factor is 0.09282 lb VOC/hr-MMSCFD at a wet gas pressure of 800 psig and temperature of 90°F, and flash tank pressure of 50 psig and temperature of 125°F.

The following assumptions were used to estimate emissions:

- The wet gas is saturated;
- The volume of dry gas was constant at 10 MMSCFD;
- The dry gas water content is 7 lbs water per MMSCF gas;
- The triethylene glycol (TEG) circulation rate is 3 gallons/lb water removed;
- A gas injection pump is used to recirculate the TEG;
- If a flash tank is present, the flash tank is vented to the atmosphere; and
- No stripping gas used.

Table 5.17

Surrogate Gas Analysis for GLYCalc Runs

Component	Mole Percent (%)
H_2S	0.000
Nitrogen	0.100
CO_2	0.800
CH_4	94.500
Ethane	3.330
Propane	0.750
n-Butane	0.150
Iso-Butane	0.150
N-Pentane	0.050
Iso-Pentane	0.050
Iso-Hexanes	0.077
N-Hexane	0.018
Benzene	0.004
Toluene	0.003
Ethylbenzene	0.000
Xylenes	0.001
Trimethylpentane	0.003
Heptanes	0.008
Octanes	0.006
Nonanes	0.000
Decanes +	0.000

5.2.8 Loading Operations

Emissions due to loading operations are generated by the displacement of the vapor space in the receiving cargo hold by liquid product. Loading losses are due to: 1—liquids displacing vapors already residing in the cargo tank, and 2—vapors generated by the liquid being loaded into the cargo tank (EIIP 1999, Boyer and Brodnax 1996). The calculations below assume that ships arrive in uncleaned, ballasted condition and that the previously carried loads were crude oil.

For marine loading of crude petroleum and gasoline, *AP-42* recommends the following equation to calculate THC emissions due to loading of fresh cargo:

$$E_{THC} = \left(0.46 + 1.84 \times (0.44 \times P_{VA} - 0.42) \times \frac{mG}{T_b}\right) \times Q \times \frac{42.0\ \text{gal}}{\text{bbl}} \times 10^{-3}$$

where:

E_{THC} = THC emissions (pounds per month)
P_{VA} = True vapor pressure of the loaded liquid (psia) = $\exp[A - (B/T_{LA})]$
m = Average molecular weight of vapors (lb/lb-mol)
G = Vapor growth factor = 1.02
T_b = Liquid bulk temperature (°R)
Q = The amount transferred (bbl)
A = Empirical constant = 12.82 − 0.9672 × ln(Reid VP)
B = Empirical constant = 7261 − 1216 × ln(Reid VP)
T_{LA} = Daily average liquid surface temperature (°R) = $0.44 \times T_{aa} + (0.56 \times T_b) + (0.0079 \times a \times I)$
T_{aa} = Daily average ambient temperature (°R)
a = Tank paint solar absorptance
I = Daily solar insulation factor ($\text{Btu/ft}^2\cdot\text{day}$) = 1437 $\text{Btu/ft}^2\cdot\text{day}$

Table 5.18

Daily Average Ambient Temperature, T_{aa}

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°F	63	63	65	70	75	82	84	85	84	76	69	61
°R	523	523	525	530	535	542	544	545	544	536	529	521

Source: U.S. DOC, National Climatic Data Center 2006

Table 5.19

Tank Paint Solar Absorptance, a

Paint Color	Solar Absorptance by Paint Color and Condition	
	Paint Condition	
	Good	Poor
Aluminum/Specular	0.39	0.49
Aluminum/Diffuse	0.6	0.68
Grey/Light	0.54	0.63
Grey/Medium	0.68	0.74
Red/Primer	0.89	0.91
White	0.17	0.34

VOC emissions (E_{VOC}, in pounds) are calculated as a percent of THC emissions:

$$E_{VOC} = \text{TankVaporWeightPercentVOC}/100 \times E_{THC}$$

The following surrogates are assigned or estimated if the corresponding fields are null:

Reid Vapor $\text{Pressure}_{default} = 5$
$T_{b,default} = T_{aa} + 6 \times a - 1$
Tank Bulk Liquid $\text{Temp}_{default} = T_{aa}$
Tank VOC Molecular $\text{Weight}_{default} = 50$
Tank Vapor Weight Percent $\text{VOC}_{default} = 85$

5.2.9 Losses from Flashing

Flash gas is a natural gas that is liberated when an oil stream undergoes a pressure drop. Flash gas is associated with high, intermediate, and low pressure separators, heater treaters, surge tanks, accumulators, and fixed roof atmospheric storage tanks. Flash gas emissions are only estimated for gas that is vented to the atmosphere or burned in a flare. No emissions are associated with flash gas that is routed back into the system (e.g., sales gas).

If a pressure drop occurs between vessels, flash gas emissions are estimated using the Vasquez-Beggs correlation equations to estimate tank vapors in standard cubic feet per barrel of oil produced. Operators were asked to report the following parameters for each part of the process:

- API gravity of stored oil;
- Operating pressure (psig) of each vessel and immediately upstream (i.e., separator, heater treater, surge tank, storage tank);

- Operating temperature (°F) of each vessel and immediately upstream;
- Actual throughput of oil for each vessel;
- Disposition of flash gas from each vessel – routed to system (e.g., sales pipeline, gas-lift), vented to atmosphere, or burned in flare; and
- SCF of flash gas per bbl of oil throughput (optional).

Flashing losses of THC, in pounds, are calculated according to the following equation:

$$L_f = \text{GOR} \times \text{Throughput} \times \text{GD}$$

where:

L_f = THC emissions in pounds per month
GOR = Gas-to-oil ratio (scf/bbl) – see discussion below if not provided by operator
Throughput = The actual throughput volume for each vessel for the survey period
GD = Tank vent hydrocarbon gas density (lb/ft^3) = tank mol weight of gas ÷ 379.4

Gas-to-oil ratio, GOR:

$$\text{GOR} = C_1 \times \text{OP}^{C_2} \times \text{CSG} \times e^{\left(\frac{C_3 \times \text{API gravity}}{\text{Vessel temp} + 460}\right)}$$

where:

C_1 = Vasquez-Beggs constant = $\begin{cases} 0.0178; \text{if API gravity} > 30 \\ 0.0362; \text{otherwise} \end{cases}$
OP = Vessel operating pressure (psia)
C_2 = Vasquez-Beggs constant = $\begin{cases} 1.187; \text{if API gravity} > 30 \\ 1.0937; \text{otherwise} \end{cases}$
CSG = Corrected specific gravity of gas (see below)
C_3 = Vasquez-Beggs constant = $\begin{cases} 23.931; \text{if API gravity} > 30 \\ 25.724; \text{otherwise} \end{cases}$

Emissions of CO_2, CH_4, and VOC are estimated using speciation profiles from API publication no. 4638:

$$L_{f,VOC} = L_{f,THC} \times 0.04$$
$$L_{f,CO2} = L_{f,THC} \times 0.02$$
$$L_{f,CH4} = L_{f,THC} \times 0.88$$

If the corresponding field is null, a default API gravity of 37 is applied. A default tank molecular gas weight of 24.994 lbs/lb·mole is also assumed as an industry average.

The following surrogate values are used for the corrected specific gravity of gas (CSG):

API Gravity	Gas Specific Gravity (at 100 psig)
>30	0.93
<30	1.08

5.2.10 Mud Degassing

Hydrocarbon emissions from mud degassing occur when gas that has seeped into the well bore and dissolved or become entrained in the drilling mud is separated from the mud and vented to the atmosphere (EIIP 1999). To estimate mud degassing emissions, operators were asked to provide:

- Number of days that drilling operations occurred; and
- Type of drilling mud used (water-based, synthetic, oil-based).

Emissions were calculated using the equation:

$$E_{THC} = EF_{THC} \times D_{drill}$$

where:

E_{THC} = THC emissions (pounds per month)
EF_{THC} = THC emission factor (lbs/day)
D_{drill} = Number of days in the month that drilling occurred

For water-based and oil-based muds, hydrocarbon emissions are estimated using emission factors provided in the 1977 U.S. EPA report: *Atmospheric Emissions from Offshore Oil and Gas Development and Production:*

Water-based muds:	881.84 lbs THC/day
Oil-based muds:	198.41 lbs THC/day
Synthetic based muds:	198.41 lbs THC day

For synthetic-based muds, no information is available on air emission rates. Synthetic-based muds are used as substitutes for oil-based muds, and may occasionally be used to replace water-based muds. Synthetic muds perform like oil-based muds, but with lower environmental impact and faster biodegradability (U.S. EPA 2000a). No information was found, however, on a possible reduction in THC emissions. Because most emissions are associated with the release of entrained hydrocarbons, and EPA estimates no change in the amount of waste cuttings between synthetic- and oil-based muds (U.S. EPA 2000a), the oil-based mud THC emission factor is used for synthetic-based muds as well.

THC emissions are speciated as follows (U.S. EPA 1977):

Component	Percent Composition by Volume (%)
Methane	83.85
Ethane	5.41
Propane	6.12
Butane	3.21
Pentane	1.40

5.2.11 Natural Gas Engines

Like diesel and gasoline engines, natural gas engines are used to run generators, pumps, compressors, and well-drilling equipment. Most of the pollutants emitted from these engines are from the exhaust (U.S. EPA 2002).

If a user-entered value for total fuel used is available, or if it can be estimated from the default values (below), then emissions are estimated based upon fuel use. Otherwise, if operating horsepower and hours operated are both available, then emissions are estimated based upon power output.

Emissions are calculated based on fuel use as:

$$E_{\mathrm{fu}} = EF_{(\mathrm{lb/MMBtu})} \times H \times U \times 10^{-3}$$

Emissions are calculated based on power output as:

$$E_{\mathrm{po}} = EF_{(\mathrm{g/hp\text{-}hr})} \times HP \times t \times \frac{\mathrm{lb}}{453.6\mathrm{g}}$$

where:

E = Emissions in pounds per month
EF = Emission factor (units are shown in parentheses)
H = Fuel heating value (Btu/scf)
U = Fuel usage (Mscf/month)
HP = Engine horsepower (hp)
t = Engine operating time (hr/month)

Tables 5.20 through 5.23 present the emission factors used to estimate natural gas engine emissions. These factors come from *AP-42*, Section 3.2 (U.S. EPA 2002).

Table 5.20

Emission Factors for Natural Gas Engines where Engine Stroke Cycle = 2-Cycle and Engine Burn Type = Lean

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	1.64	5.6
VOC	0.12	0.41
SO_2	5.88×10^{-4}	2×10^{-3}
NO_x (<90% load)	1.94	6.6
PM_{10}[a]	3.84×10^{-2}	0.13
CO (<90% load)	0.353	1.2
CH_4	1.45	4.9
CO_2	110	374.2

[a] Also represents $PM_{2.5}$

Table 5.21

Emission Factors for Natural Gas Engines where Engine Stroke Cycle = 4-Cycle and Engine Burn Type = Lean

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	1.47	5.00
VOC	0.12	0.41
SO_2	5.88×10^{-4}	2.00×10^{-3}
NO_x (<90% load)	0.85	2.89
PM_{10}[a]	7.71×10^{-5}	2.6×10^{-4}
CO (<90% load)	0.56	1.9
CH_4	1.25	4.25
CO_2	110	374.2

[a] Also represents $PM_{2.5}$

Table 5.22

Emission Factors for Natural Gas Engines
where Engine Stroke Cycle =
4-Cycle and Engine Burn Type = Rich

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	0.36	1.25
VOC	0.03	0.1
SO_2	5.88×10^{-4}	2.00×10^{-3}
NO_x (<90% load	2.27	7.72
PM_{10}[a]	9.5×10^{-3}	0.03
CO (<90 % load)	3.51	11.94
CH_4	0.23	0.78
CO_2	110	374.22

[a] Also represents $PM_{2.5}$

Table 5.23

Emission Factors for Natural Gas Engines
where Engine Burn Type = Clean

Pollutant	EF_{fu} (lb/MMBtu)	EF_{po} (g/hp-hr)
THC	1.47	5.00
VOC	0.12	0.41
SO_2	5.88×10^{-4}	2.00×10^{-3}
NO_x	0.59	2.00
PM_{10}[a]	7.71×10^{-5}	2.6×10^{-4}
CO	0.88	3.00
CH_4	1.25	4.25
CO_2	110	374.22

[a] Also represents $PM_{2.5}$

If the corresponding field is null, a fuel consumption rate of 7,000 Btu/hp-hr is applied.

5.2.12 Natural Gas Turbines

A gas turbine is an internal combustion engine that operates with rotary rather than reciprocating motion. Turbines are primarily used to power compressors rather than generate electricity (Boyer and Brodnax 1996). A turbine’s operating load has a considerable effect on the resulting emission levels. With reduced loads, there are lower thermal efficiencies and more incomplete combustion (U.S. EPA 2002).

If a user-entered value for total fuel used is available, then emissions are estimated based upon fuel use. Otherwise, if operating horsepower and hours operated are both available, then emissions are estimated based upon power output.

To calculate emissions based on fuel use:

$$E_{fu} = EF_{(lb/MMBtu)} \times 10^{-3} \times H \times U$$

To calculate emissions based on power output:

$$E_{po} = EF_{(lb/MMBtu)} \times 10^{-6} \times FU \times HP \times t$$

where:

E = Emissions in pounds per month
EF = Emission factor (units are shown in parentheses)
H = Fuel heating value (Btu/scf)
U = Fuel usage (Mscf/month)
FU = Average fuel usage (Btu/hp-hr)
HP = Turbine horsepower (hp)
t = Turbine operating time (hr/month)

The following emission factors are used to estimate emissions. These factors come from *AP-42* Section 3.1 (U.S. EPA 2002).

Table 5.24

Emission Factors for Natural Gas Turbines

Pollutant	EF (lb/MMBtu)
THC	1.1×10^{-2}
VOC	2.1×10^{-3}
SO_2	$0.94 \times S$
NO_x	0.32
PM_{10}[a]	1.9×10^{-3}
CO	8.2×10^{-2}
N_2O	0.003
CH_4	8.6×10^{-3}
CO_2	110

S= $(C_{H2S}) \times (1.78 \times 10^{-4})$, %S. C_{H2S} = ppm_v H_2S in fuel.
If not available, EF is 3.47×10^{-3} lb/MMBtu
[a] Also represents $PM_{2.5}$

If the corresponding field is null, a fuel consumption rate of 10,000 Btu/hp-hr is applied.

5.2.13 Pneumatic Pumps

A readily-available supply of compressed natural gas is used to power gas actuated pumps. There is no combustion of the gas because the energy is derived from the gas pressure. These pumps include reciprocating pumps such as diaphragm, plunger, and piston pumps. Most gas actuated pumps vent directly to the atmosphere (Boyer and Brodnax 1996).

Operators were asked to provide the following information for pumps that are in natural gas service:

- Manufacturer and model;
- Amount of natural gas consumed in SCF/hr (optional);
- Hours of operation in the reporting period; and
- Whether it is vented to a manifold, a flare, or the atmosphere.

CO_2, CH_4, THC, and VOC emissions (in pounds) for pneumatic pumps are developed using equation 10.4-3, from Chapter 10, “Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processing Operations” (EIIP 1999):

$$E = t \times FU \times (\text{mole weight of gas, lbs/lb-mole}) \times (1 \text{ lb-mole}/379.4 \text{ SCF})$$

where:

E = Emissions in pounds per month
t = Operating time (hr/month)
FU = Fuel usage rate (SCF/hr)

$$\text{Mole weight of gas} = \text{Mole percent of constituent}/100 \times \text{mole weight of constituent/gas MW}$$

To determine the mole percent of each constituent (CH_4, CO_2, THC, and VOC), operators were asked to provide the sales gas composition for their structure. Table 5.25 presents the default gas composition if not provided. Table 5.25 also presents the mole weight for each gas constituent.

If the fuel usage rate is not provided, an average value for each make and model is assigned based on reported manufacturer data, or an average surrogate based on the manufacturer is applied.

Table 5.25

Default Sales Gas Composition

Component	Default Mol%	Mole Weight (lb/lb-mole)
CO_2	0.80	44.010
CH_4	94.50	16.043
C_2	3.33	30.070
C_3	0.75	44.097
i-C_4	0.15	58.124
n-C_4	0.15	58.124
i-C_5	0.05	72.150
n-C_5	0.05	72.150
C_6	0.099	86.177
C_7	0.011	100.272
C_8+	0.007	114.231

5.2.14 Pressure/Level Controllers

Devices that control both pressure and liquid levels on vessels and flow lines are used extensively in production operations. The units are designed to open or close a valve when a preset pressure or liquid level is reached. The valves are automatically actuated by bleeding compressed gas from a diaphragm or piston. The gas is vented to the atmosphere in the process. Most production facilities use natural gas to actuate the controllers. The amount of gas vented is dependent on several factors, including the manufacturer and application (Boyer and Brodnax 1996).

Operators were asked to provide the following information for controllers that are in natural gas service:

- Service type (pressure control vs. level control);
- Manufacturer and model;
- Amount of natural gas consumed in SCF/hr (optional); and
- Hours of operation in the reporting period.

Similar to pneumatic pumps, CO_2, CH_4, THC, and VOC emissions estimates (in pounds) for pressure and level controllers are developed using the following equation (EIIP 1999):

$$E = \text{No. of units} \times t \times FU \times (\text{mole weight of gas, lbs/lb-mole}) \times (1 \text{ lb-mole}/379.4 \text{ SCF})$$

where:

E = Emissions in pounds per month
t = Operating time (hr/month)
FU = Fuel usage rate (SCF/hr)
Mole weight of gas = mole percent of constituent/100 × mole weight of constituent/gas MW

To determine the mole percent of each constituent (CH_4, CO_2, and VOC), operators were asked to provide the sales gas composition for their structure. Table 5.25 presents the default gas composition if not provided. Table 5.25 also presents the mole weight for each gas constituent.

If the fuel usage rate is not provided, an average value for each make and model is assigned based on reported manufacturer data, or an average surrogate based on the manufacturer and service type is applied.

5.2.15 Storage Tanks

The VOC and THC may be lost from storage tanks as a result of flashing, working, and standing losses. This discussion only addresses working and standing losses (L_w and L_s). Flashing losses are estimated separately.

Standing losses result from the expulsion of vapors due to vapor expansion and contraction resulting from temperature and barometric pressure changes. Working losses result from filling and emptying operations (Boyer and Brodnax 1996). These calculations assume that all tanks are fixed roof tanks.

Standing losses of THC in pounds are calculated according to the following equation:

$$L_{s,\,THC} = D \times V_V \times W_V \times K_E \times K_S$$

where:

L_s = Standing losses (lbs/month)
D = Number of days in the month
V_V = Tank vapor space volume (ft^3)
W_V = Stock vapor density (lb/ft^3)
K_E = Calculated vapor space expansion factor (unitless)
K_S = Calculated vented vapor saturation factor (unitless)

Vapor space volume for a horizontal, rectangular tank is calculated as:

$$V_V = \text{Tank Shell Length} \times \text{Tank Shell Width}_1 \times H_{VO}$$

where:

V_V = Vapor space volume (ft^3)
H_{VO} = Vapor space outage (ft) = Tank Shell Height – Tank Average Liquid Height

Vapor space volume for a vertical, rectangular tank is calculated as:

$$V_V = \text{Tank Shell Width}_1 \times \text{Tank Shell Width}_2 \times H_{VO}$$

where:

V_V = Vapor space volume (ft^3)
H_{VO} = Vapor space outage (ft) = Tank Shell Height – Tank Average Liquid Height

Vapor space for a horizontal, cylindrical tank is calculated as:

$$V_v = \frac{\pi \times \text{Tank Shell Diam} \times \text{Tank Shell Length} \times H_{VO}}{4 \times 0.785}$$

where:

V_V = Vapor space volume (ft^3)
H_{VO} = Vapor space outage (ft) = 0.5 × Tank Shell Diameter

Vapor space for a vertical, cylindrical tank is calculated as:

$$V_V = \frac{\pi}{4} \times \text{Tank Shell Diam}^2 \times H_{VO}$$

where:

V_V = Vapor space volume (ft^3)
H_{VO} = Vapor space outage (ft) =

$$\begin{cases} \text{Tank Shell Hgt-Tank Avg Liquid Hgt} + \tfrac{1}{3}\text{Tank Roof Hgt}\text{; if Tank Roof Type} = \text{"cone" or "peaked"} \\ \text{Tank Shell Hgt-Tank Avg Liquid Hgt} + \text{Tank Roof Hgt}\left[\tfrac{1}{2} + \tfrac{1}{6}\left(\dfrac{\text{Tank Roof Hgt}}{\text{Tank Shell Diam}}\right)^2\right]\text{; if Tank Roof Type} = \text{"dome"} \end{cases}$$

TankShell Hgt-TankAvgLiquidHgt; if Tank Roof Type = “Flat”

Stock vapor density is calculated as:

$$W_v = (\text{Tank VOC Molecular Weight} \times P_{VA}) \div (10.731 \times T_{LA})$$

where:

W_V = Stock vapor density (lb/ft^3)
P_{VA} = True vapor pressure (psia) = $\exp[A - (B/T_{LA})]$
A = Empirical constant = $12.82 - 0.9672 \times \ln(\text{ReidVP})$

B = Empirical constant = 7261 − 1216 × ln(ReidVP)
T_{LA} = Daily average liquid surface temperature (°R) = $0.44 \times T_{aa} + (0.56 \times T_b) + (0.0079 \times a \times I)$
T_{aa} = Daily average ambient temperature (°R) (See Table 5.18)
a = Tank paint solar absorptance (See Table 5.19)
T_b = Liquid bulk temperature (°R)
I = Daily solar insulation factor (Btu/ft^2·day) = 1437 Btu/ft^2·day

The vapor space expansion factor is calculated as:

$$K_E = (T_v/T_{LA}) + (P_v - P_b)/(P_a - P_{va})$$

where:

K_E = Vapor space expansion factor
T_v = Daily vapor temperature range (°R) = $0.72 \times T_a + 0.028 \times a \times I$
T_{LA} = Daily average liquid surface temperature (°R)
P_v = Daily pressure range (psia)= $0.50 \times B \times P_{va} \times T_v/T_{LA}^2$
P_b = Breather vent pressure setting range (psig) = Breather vent pressure − breather vent vacuum
P_a = Atmospheric pressure (psia)
P_{va} = Vapor pressure at daily average liquid surface temperature (psia)

The vented vapor saturation factor is calculated as:

$$K_S = 1/(1 + 0.053 \times P_{VA} \times H_{VO})$$

where:

K_S = Vented vapor saturation factor
P_{VA} = Vapor pressure at daily average liquid surface temperature (psia)
H_{VO} = Vapor space outage (ft)

Working losses of THC in pounds are calculated according to the following equation:

$$L_{w,THC} = 0.0010 \times \text{Tank VOC Mol Weight} \times P_{VA} \times \text{Throughput} \times K_P \times K_N$$

where:

L_w = Working losses
P_{VA} = Vapor pressure at daily average liquid surface temperature (psia)
K_P = Working loss product factor (unitless) = 0.75
K_N = Working loss turnover factor (unitless) = $\begin{cases} 1; \text{for } N \le 36 \\ \frac{180+N}{6N}; \text{for } N > 36 \end{cases}$

N = Number of turnovers per month = 5.614 × throughput/V_{LX}

V_{LX} = Tank maximum liquid volume (ft^3)

Tank maximum liquid volume for a horizontal, rectangular tank is calculated as:

$$V_{LX} = \text{Tank Shell Length} \times \text{Tank Shell Width}_1 \times \text{Tank Shell Height}$$

Tank maximum liquid volume for a vertical, rectangular tank is calculated as:

$$V_{LX} = \text{Tank Shell Width}_1 \times \text{Tank Shell Width}_2 \times \text{Tank Shell Height}$$

Tank maximum liquid volume for a horizontal, cylindrical tank is calculated as:

$$V_{LX} = \frac{\pi}{4} \times \text{Tank Shell Diam}^2 \times \text{Tank Shell Length}$$

Tank maximum liquid volume for a vertical, cylindrical tank is calculated as:

$$V_{LX} = \frac{\pi}{4} \times \text{Tank Shell Diam}^2 \times \text{Tank Shell Hgt}$$

where:

V_{LX} = Tank maximum liquid volume (ft^3)

The following surrogates are assigned or estimated if the corresponding fields are null:

Product type = Crude Oil
Paint Color = Grey
Condition = Good
Roof type = Fixed
Roof Shape = Cone
API $\text{Gravity}_{default}$ = 37
Reid $\text{VP}_{default}$ = −1.699 + 0.179 × API Gravity (or 5, if no other information is available)
$T_{b,default} = T_{aa} + 6 \times a - 1$ (or 530º R, if no other information is available)
Breather Vent $\text{Pressure}_{default}$ = 0.03
Breather Vent $\text{Vacuum}_{default}$ = –0.03
Tank Bulk $\text{LiqT}_{default} = T_{aa}$
Tank VOC Mol $\text{Weight}_{default}$ = 50
Tank Vapor Weight Percent $\text{VOC}_{default}$ = 85
Mole $\text{Fraction}_{default}$ = 0.9
Tank Avg Liquid $\text{Hgt}_{default}$ = 0.5 × Tank Shell Hgt

5.2.16 Cold Vents

Production facilities often discharge natural gas to the atmosphere via vents. The discharges can be due to routine or emergency releases. Vents receive exhaust streams from miscellaneous sources, as well as manifold exhaust streams from other equipment on the same platform such as amine units, glycol dehydrators, loading operations, and storage tanks. Emissions from vents are calculated based on the volume of gas vented from miscellaneous equipment (less the volume from the manifold equipment, which are reported with the other equipment), including periods of upset venting in the total, and the chemical composition of the gas.

Vent emissions of VOC are estimated using the following equation:

$$E_{\text{vent, VOC}} = C_{\text{VOC}} \times \frac{10^{-6}}{\text{ppm}} \times \frac{m_{\text{VOC}}}{379.4 \ \text{scf/lb} \cdot \text{mol}} \times 1000 \times V$$

where:

$E_{\text{vent, VOC}}$ = VOC emissions in pounds per month
C_{VOC} = Concentration of VOC in the vent gas (ppmv)
m_{VOC} = Molecular weight of VOC (lb/lb·mol)
V = Volume of gas vented from miscellaneous sources (Mscf)

Vent emissions of H_2S are estimated using the following equation:

$$E_{\text{vent, } H_2S} = \frac{10^{-6}}{\text{ppm}} \times \frac{m_{\text{H2S}}}{379.4 \ \text{scf/lb} \cdot \text{mol}} \times 1000 \times \left(V \times C_{\text{H2S}}\right)$$

where:

$E_{\text{vent, H2S}}$ = H_2S emissions in pounds
C_{H2S} = Concentration of H_2S in the vent gas (ppmv)
m_{H2S} = Molecular weight of H_2S = 34 lb/lb mol
V = Volume of gas vented from miscellaneous sources (Mscf)

Vent emissions of CH_4 are estimated using the following equation:

$$E_{\text{vent, CH4}} = C_{\text{CH4}} \times \frac{10^{-6}}{\text{ppm}} \times \frac{m_{\text{CH4}}}{379.4 \ \text{scf/lb} \cdot \text{mol}} \times 1000 \times V$$

where:

$E_{\text{vent, CH4}}$ = CH_4 emissions in pounds
C_{CH4} = Concentration of CH_4 in the vent gas (ppmv)
M_{CH4} = Molecular weight of CH_4 = 16 lb/lb mol
V = Volume of gas vented from miscellaneous sources (Mscf)

If a flare is used:

$$\text{Event}_{\text{controlled}} = \text{Event} \times \frac{\text{Eff}_{\text{FLARE}}}{100\%}$$

The following surrogates are assigned or estimated if the corresponding fields are null:

VOC concentration = 12,700 ppmv (=1.27 mol %)
H_2S concentration = 3.38 ppmv
CH_4 concentration = 945,000 ppmv (=94.5 mol %)

6. DEVELOPMENT OF THE NON-PLATFORM EMISSIONS INVENTORY

Emission estimates were developed for criteria air pollutants and greenhouse gases for non-platform OCS sources operating in the Gulf of Mexico for the 2005 calendar year. The non-platform sources included in this study are noted below.

Non-platform oil/gas production sources:

- Drilling vessels;
- Pipelaying operations;
- Support helicopters;
- Support vessels; and
- Survey vessels.

Non-platform non-oil/gas production sources:

- Biogenic and geogenic sources;
- Commercial fishing vessels;
- Commercial marine vessels;
- Louisiana Offshore Oil Platform (LOOP);
- Military vessels (Coast Guard/Navy); and
- Vessel lightering.

The ERG developed the Gulfwide non-platform emission estimates based on work previously performed for MMS' *Gulfwide Emission Inventory for the Regional Haze and Ozone Modeling Effort* Study (Wilson et al. 2004a). The biggest change between the two inventories is that in the 2005 inventory, more recent emission factors from the Swedish Environmental Protection Agency were used to develop the emission estimates for marine vessels. The previously-used EPA emission factors were based on a regression analysis performed by EPA on older marine engine test data, as noted in *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data* (U.S. EPA 2000b). The new Swedish emission factors take into account vessel engine speed, fuel type, and mode of operation. The Swedish emission factors were subdivided into at sea, maneuvering, and at-port operating modes. These emission factors were applied to the hours of operation, total vessel horsepower (converted to kW), and load to estimate emissions. Overall, the updated emission factors are twice the value of the EPA factors for hydrocarbons, and between 15% and 70% higher for NO_x. The difference noted with the other criteria and greenhouse gas pollutants is less significant.

Another important change between the 2000 and 2005 inventories is the use of updated, and, in some cases, activity data from new sources that more accurately represent activities in 2005. Initially, data were solicited from the same data sources used to develop the 2000 inventory to ensure that the data files were relatively comparable. For some source categories, however, data that previously had been available to the public were no longer available because of national security concerns. This was apparent with regard to obtaining lightering vessel data from the U.S. Coast Guard. This problem was addressed by obtaining more accurate data directly from the company that provides most all of the lightering escort services. Issues of national security were also noted for the LOOP, which previously provided vessel-specific schedules on their public web site. The 2005 activity data for the LOOP were therefore developed by adjusting the 2000 data to account for the period that the platform was shut down during to the 2005 hurricane season.

The 2005 inventory year was unusual as the Gulf of Mexico was hit by two major hurricanes that disrupted platform activities; sometimes leading to an increase in non-platform activities, such as support vessels and helicopters, where utilization rates during the last quarter were at or above 97%. Alternatively, there was a reduction in certain activities, such as drilling and new pipelaying activities. Drilling rig activities declined by 24%; some of this reduction was due to the hurricanes, but some was also due to an overall decline in the development of new sites in the Gulf of Mexico. Even though few new pipelines were constructed during the last quarter, a large number of pipeline segments needed to be repaired after the hurricanes, such that pipelaying vessel activities remained constant throughout the year.

Enhancements made in the 2005 inventory include improved commercial marine vessel (CMV) activity data derived directly from U.S. Department of Transportation Maritime Administration 2005 vessel movement data. The drilling rig characteristics were obtained for individual vessels identified by MMS as operating in the Federal waters in 2005. Also, Federal Aviation Administration (FAA) helicopter population data were used to supplement the Helicopter Safety Advisory Conference's data, which are believed to be incomplete due to the voluntary membership participation. The offshore support vessel population data were obtained from the Offshore Marine Service Association, which documented a significantly higher vessel population than used in previous inventories. It was also noted that because the offshore support vessel population is leased to operators and oil companies, these vessels can be hired for platform construction and removal activities, such that there was double counting of this source category in previous inventories. For the 2005 inventory the platform construction and removal category was removed as a non-platform source category.

Sufficient data were also compiled to quantify and locate emissions from mud volcanoes; these data were not available when the 2000 Gulfwide inventory was initially developed and represents a new emission source for the 2005 inventory.

6.1 NON-PLATFORM OIL/GAS PRODUCTION RELATED SOURCES

Emission sources included in this group are preliminary drilling operations (exclusive of drilling associated with a platform); construction or removal of pipelines; helicopters and vessels that provide supplies, equipment, and personnel for platforms; and survey vessels that are used to identify oil finds.

6.1.1 Marine Diesel Emission Factors

The same set of emission factors were used for all marine diesel engines, whether they were for drilling operations, pipeline construction, support or survey vessels, fishing boats, CMVs, or military vessels. As noted earlier, these emission factors were obtained from the Swedish Environmental Protection Agency (SEPA 2004) *Methodology for Calculating*

Emissions From Ships: 1. Update of Emission Factors. The 2002 base year factors were chosen because the base factors represent uncontrolled emissions. Also, the 2002 emission factors were broken out into the modes of operation. Unless otherwise noted, the at sea emission factors were used, as the amount of time vessels spend maneuvering or hotelling at sea is relatively small compared to the amount of time spent underway. The emission factors also vary depending upon whether the engine is a low, medium, or high speed engine, and the type of fuel that is being used. Unless otherwise noted, it was assumed that the marine diesel fuel is used (distillate fuel oil #2), with a sulfur content of 0.4%. Vessel-specific assumptions about mode of operation, fuel type, and engine speed are noted in each section below. The emission factors used for this study are presented in Table 6.1. The table also shows the engine speed and fuel type assumptions for each vessel category.

Diesel marine engine emissions were calculated for all vessel categories using the following equation:

$$E = AH \times kW \times LF \times EF \times CF$$

where:

E = Emissions (tons)
AH = Annual hours per mode of operation (underway, maneuvering, hoteling) (hours)
kW = Average vessel kW (totaling individual propulsion engines) (kW)
LF = Engine load factor for specified mode of operation (percent)
EF = Emission factor (g/kWH)
CF = Conversion factor (g = 1.10231 E-6 ton)

6.1.2 Drilling Rigs

Drilling vessels are used for exploratory drilling to supplement the geologic information provided by survey vessels. The drilling rig drills a hole in the ocean floor by turning a drill bit attached to lengths of tubular pipe. Several different types of drill rigs operate in the Gulf of Mexico, including barges, jack-ups, semisubmersibles, submersibles, and drill ships. Drilling rigs vary relative to the water depth where they operate. For example, barges and jack-ups are able to work in water up to 375 feet deep, semisubmersibles and submersibles operate in water with depths of 300 to 2,000 feet, and drill ships operate in waters with depths greater than 2,000 feet.

Table 6.1

Marine Vessel Emission Factors

Vessel Type	**Mode**	**Engine type[a]**	**Load Factor**	**Emission Factors (g/kWh)**									
				NOx	**CO**	**VOC**	**SO_2**	**NH_3**	**PM10**	**PM2.5**	**CO_2**	**CH_4**	**N_2O**
Commercial Fishing Vessels													
Longline Fishing Vessels	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	MSD	0.10	10.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Reef Fishing Vessels	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	MSD	0.10	10.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Shrimp Fishing Vessels	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Vessel Lightering													
Oil Tankers	Maneuvering	SSD	0.10	13.6	1	0.6	1.6	0.003	0.4	0.4	647	0.012	0.031
Escort Vessels	Maneuvering	MSD	0.10	10.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
LOOP													
Tankers	At Sea	SSD	0.55	17.0	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
	Maneuvering	SSD	0.10	13.6	1	0.6	1.6	0.003	0.4	0.4	647	0.012	0.031
Support Vessels	Maneuvering	HSD	0.25	9.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
LOOP Generator	At Sea	HSD	0.50	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
LOOP Pumps	At Sea	HSD	1.00	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Pipelaying Operations													
Pipelaying	Maneuvering	MSD	0.75	10.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Drilling Rigs													
Drill Ship Equipment	At Sea	HSD	0.75	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Jack-up Equipment	At Sea	HSD	0.75	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Semisubmersible Equipment	At Sea	HSD	0.75	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Submersible Equipment	At Sea	HSD	0.75	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Drilling Propulsion	At Sea	HSD	0.15	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Semisubmersible Propulsion	At Sea	HSD	0.15	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Survey Vessels													
Survey Vessels	At Sea	MSD	0.90	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Anchor Handling	At Sea	HSD	0.85	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	HSD	0.10	9.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031

Table 6.1

Vessel Emission Factors (Continued)

Vessel Type	Mode	Engine type[a]	Load Factor	Emission Factors (g/kWh)									
				NOx	CO	VOC	SO_2	NH_3	PM10	PM2.5	CO_2	CH_4	N_2O
Support Vessels													
Supply/Crew Boats	At Sea	HSD	0.85	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	HSD	0.10	9.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Lift Boats	At Sea	HSD	0.85	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	HSD	0.10	9.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Tugs/Towing Boats	At Sea	HSD	0.85	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
	Maneuvering	HSD	0.10	9.6	2.2	0.4	1.8	0.003	0.4	0.4	717	0.008	0.031
Coast Guard Vessels													
Buoy Tenders	At Sea	SSD	0.85	17.0	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Cutters	At Sea	MSD	0.85	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Patrol	At Sea	HSD	0.85	12.0	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Commercial Marine Vessels													
Auto Carriers	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Average/Unknown	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Bulk Materials	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Container Ships	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Cruise Ships	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Ferries	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
General Cargo	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Miscellaneous	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Offshore	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Refrigerated	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Roll On/Roll Off	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031
Tankers	At Sea	SSD	0.80	17	0.5	0.3	1.5	0.003	0.2	0.2	588	0.006	0.031
Tug Boats	At Sea	MSD	0.80	13.2	1.1	0.2	1.6	0.003	0.2	0.2	652	0.004	0.031

[a] SSD = Slow Speed Diesel Engine
MSD = Medium Speed Diesel Engine
HSD = High Speed Diesel Engine

The Operation and Analysis Branch of the Engineering and Operations Division of MMS provided 2005 activity data for drilling rigs by block, which included activity for barges, jack-ups, semisubmersibles, submersibles, and drill ships (Mayes 2006). The drilling rig activity data used in this study are based on the specific blocks where drilling activities took place, the drilling rig name, and the time drilling commenced and concluded. These data were extracted for the period from January 2005 through December 2005.

The drilling rig names in the MMS data were matched to vessel names in the RigZone database (Rigzone Data Center 2006). RigZone is an oil and gas trade service that monitors drilling rigs, and their database includes details concerning the drilling rig propulsion engines, prime engines, mud pumps, and draw works. By matching the MMS drilling rig vessel names to vessel characteristics in the Rigzone database, accurate engine and equipment data were used to estimate emissions. Where RigZone did not include a vessel noted in the MMS data, the RigZone data were averaged by vessel type and used to gap fill missing data. The average engine kW ratings used to gap fill are noted in Table 6.2. The propulsion engines were assumed to operate at 75% as noted in Table 6.1 while the rig is moved to the lease block where drilling activities occur.

Table 6.2

Equipment kW Ratings by Drilling Rig Type

Type	Drill Ships	Jack-Ups	Semi-submersibles	Sub-mersibles
Prime	1,864	1,238	1,517	1,517
Pumps	1,193	1,193	1,193	1,193
Drawworks	2,237	1,491	2,237	2,237
Total	5,294	3,922	4,947	4,947

The kW rating of each rig was applied to the hours that the rig spent at a block, as noted in Table 6.3, to get the vessel kW-hours. These values were applied to the emission and load factors provided in Table 6.1. In selecting the emission factors (SEPA 2004), it was assumed that all rig engines were classified as high-speed diesel engines. It should also be noted that the few drilling rigs with propulsion engines tended to be drill ships which use their thrusters to maintain the vessel's drilling position at the block; these engines tend to operate at relatively low loads to keep the vessel in place.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

In 2005, all drill ships operated 32,256 hours. Average vessel kW of drill ships is 5,294, load factor is 0.75, and the emission factor for NO_x is 12.0 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 32{,}256 \times 5{,}294 \times 0.75 \times 12.0 \times 1.10231 \times 10^{-6}$$
$$E = 1{,}694.11 \text{ tons of } NO_x$$

The drilling operation emissions were spatially allocated to the lease blocks where drilling occurred. Figure 6.1 maps the location of all drilling rigs.

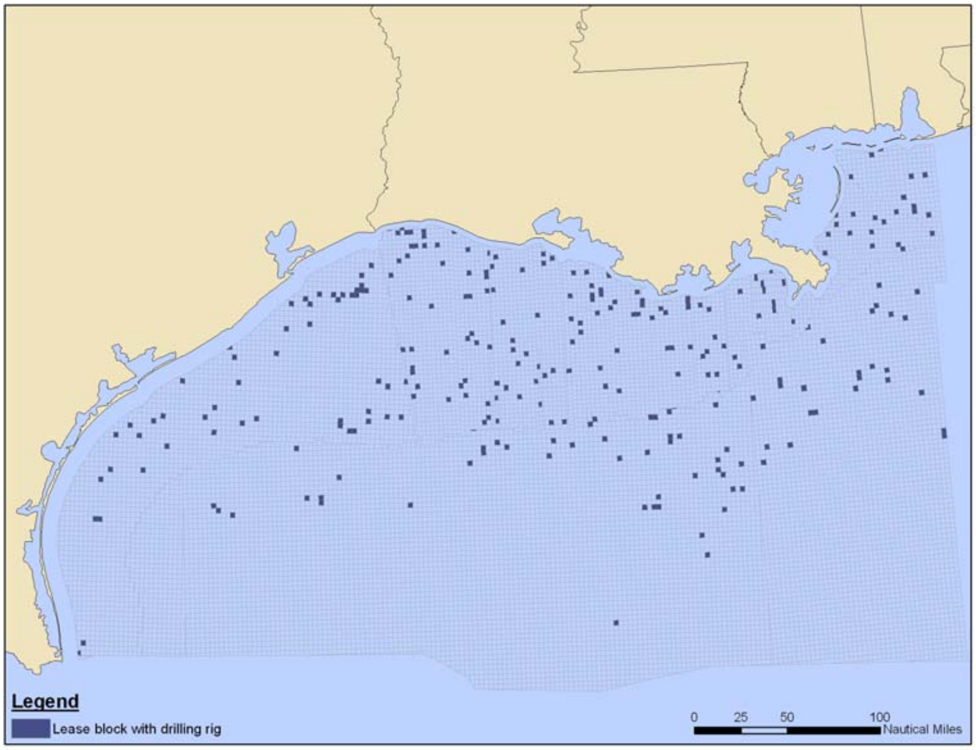

Figure 6.1. Location of drilling operations and MMS lease blocks for 2005.

Table 6.3

Drilling Vessel Activity Data

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
SU	EI	42	*Atwood Richmond*	3/15/2005	4/18/2005	35	840
SU	EI	45	*Atwood Richmond*	12/7/2005	12/31/2005	25	600
SU	HI	199	*Atwood Richmond*	4/20/2005	7/4/2005	76	1,824
SU	WC	21	*Atwood Richmond*	1/5/2005	2/9/2005	36	864
SU	WC	21	*Atwood Richmond*	2/9/2005	3/15/2005	35	840
SS	AT	13	*Cal Dive Uncle John*	4/18/2005	4/21/2005	4	96
SS	AT	13	*Cal Dive Uncle John*	4/23/2005	5/3/2005	11	264
SS	AT	14	*Cal Dive Uncle John*	4/21/2005	4/23/2005	3	72
SS	AT	14	*Cal Dive Uncle John*	5/3/2005	5/5/2005	3	72

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
SS	EB	623	*Diamond Ocean America*	10/25/2005	11/19/2005	26	624
SS	EB	668	*Diamond Ocean America*	4/29/2005	5/26/2005	28	672
SS	EB	715	*Diamond Ocean America*	3/24/2005	4/21/2005	29	696
SS	GC	299	*Diamond Ocean America*	5/28/2005	10/19/2005	145	3,480
SS	GC	473	*Diamond Ocean America*	12/24/2005	12/25/2005	2	48
SS	GC	473	*Diamond Ocean America*	12/25/2005	12/31/2005	7	168
SS	MC	804	*Diamond Ocean America*	4/24/2005	4/29/2005	6	144
SS	MC	804	*Diamond Ocean America*	11/22/2005	12/25/2005	34	816
JU	EC	121	*Diamond Ocean Champion*	10/20/2005	12/20/2005	62	1,488
JU	EC	75	*Diamond Ocean Champion*	6/29/2005	8/18/2005	51	1,224
JU	GA	223	*Diamond Ocean Champion*	8/21/2005	9/14/2005	25	600
JU	ST	164	*Diamond Ocean Champion*	12/20/2005	12/31/2005	12	288
JU	ST	242	*Diamond Ocean Champion*	1/28/2005	4/14/2005	77	1,848
JU	ST	242	*Diamond Ocean Champion*	4/14/2005	6/29/2005	77	1,848
SS	EB	157	*Diamond Ocean Concord*	2/23/2005	4/17/2005	54	1,296
SS	GB	200	*Diamond Ocean Concord*	5/28/2005	9/5/2005	101	2,424
SS	GB	22	*Diamond Ocean Concord*	4/19/2005	4/22/2005	4	96
SS	GB	22	*Diamond Ocean Concord*	4/20/2005	5/29/2005	40	960
SS	GI	106	*Diamond Ocean Concord*	9/6/2005	12/31/2005	117	2,808
SS	AT	272	*Diamond Ocean Confidence*	9/11/2005	9/16/2005	6	144
SS	AT	272	*Diamond Ocean Confidence*	11/15/2005	12/31/2005	47	1,128
SS	GC	826	*Diamond Ocean Confidence*	4/29/2005	5/17/2005	19	456
SS	GC	826	*Diamond Ocean Confidence*	5/24/2005	9/9/2005	109	2,616
SS	GC	826	*Diamond Ocean Confidence*	9/16/2005	11/2/2005	48	1,152
JU	EI	141	*Diamond Ocean Crusader*	4/4/2005	6/17/2005	75	1,800
JU	EI	141	*Diamond Ocean Crusader*	4/5/2005	4/8/2005	4	96
JU	ST	36	*Diamond Ocean Crusader*	1/24/2005	3/31/2005	67	1,608
JU	MP	169	*Diamond Ocean Drake*	6/22/2005	7/29/2005	38	912
JU	MP	95	*Diamond Ocean Drake*	1/27/2005	3/12/2005	45	1,080
JU	MP	95	*Diamond Ocean Drake*	3/12/2005	4/9/2005	29	696
JU	ST	135	*Diamond Ocean Drake*	11/24/2005	12/27/2005	34	816

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	ST	135	*Diamond Ocean Drake*	12/27/2005	12/31/2005	5	120
JU	ST	177	*Diamond Ocean Drake*	10/9/2005	11/24/2005	47	1,128
JU	ST	189	*Diamond Ocean Drake*	8/3/2005	9/8/2005	37	888
JU	VK	20	*Diamond Ocean Drake*	4/16/2005	5/8/2005	23	552
JU	VK	432	*Diamond Ocean Drake*	5/26/2005	6/4/2005	10	240
JU	VK	77	*Diamond Ocean Drake*	6/5/2005	6/21/2005	17	408
JU	VK	80	*Diamond Ocean Drake*	5/8/2005	5/25/2005	18	432
JU	HI	115	*Diamond Ocean King*	5/25/2005	9/30/2005	129	3,096
SS	EB	430	*Diamond Ocean Lexington*	1/30/2005	3/13/2005	43	1,032
SS	GB	302	*Diamond Ocean Lexington*	10/11/2005	12/31/2005	82	1,968
SS	MC	278	*Diamond Ocean Lexington*	3/18/2005	3/31/2005	14	336
SS	MC	278	*Diamond Ocean Lexington*	3/31/2005	4/17/2005	18	432
SS	MC	278	*Diamond Ocean Lexington*	4/17/2005	5/25/2005	39	936
SS	EW	977	*Diamond Ocean New Era*	12/20/2005	12/31/2005	12	288
JU	HI	A553	*Diamond Ocean Nugget*	2/13/2005	4/7/2005	54	1,296
JU	MP	264	*Diamond Ocean Nugget*	5/25/2005	7/17/2005	54	1,296
SS	GC	199	*Diamond Ocean Quest*	2/1/2005	6/12/2005	132	3,168
SS	GC	199	*Diamond Ocean Quest*	10/11/2005	10/11/2005	3	72
SS	GC	199	*Diamond Ocean Quest*	10/13/2005	11/19/2005	38	912
SS	GC	199	*Diamond Ocean Quest*	11/19/2005	12/15/2005	27	648
SS	GC	199	*Diamond Ocean Quest*	12/15/2005	12/24/2005	10	240
SS	MC	161	*Diamond Ocean Quest*	6/15/2005	7/4/2005	20	480
SS	MC	161	*Diamond Ocean Quest*	7/4/2005	7/22/2005	19	456
SS	MC	161	*Diamond Ocean Quest*	7/22/2005	8/25/2005	35	840
SS	MC	204	*Diamond Ocean Quest*	12/24/2005	12/31/2005	8	192
SS	GC	157	*Diamond Ocean Saratoga*	4/25/2005	5/23/2005	29	696
SS	GC	157	*Diamond Ocean Saratoga*	4/26/2005	6/9/2005	45	1,080
SS	GC	157	*Diamond Ocean Saratoga*	4/26/2005	10/14/2005	172	4,128
SS	GC	157	*Diamond Ocean Saratoga*	10/15/2005	11/28/2005	45	1,080
JU	HI	170	*Diamond Ocean Spartan*	3/1/2005	3/17/2005	17	408
JU	HI	A282	*Diamond Ocean Spartan*	3/17/2005	4/5/2005	20	480
JU	SM	102	*Diamond Ocean Spartan*	6/26/2005	7/1/2005	6	144
JU	SM	102	*Diamond Ocean Spartan*	6/30/2005	7/8/2005	9	216
JU	VR	344	*Diamond Ocean Spartan*	12/26/2005	12/31/2005	6	144
JU	SM	107	*Diamond Ocean Spur*	10/26/2005	11/23/2005	29	696

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	WC	498	*Diamond Ocean Spur*	11/23/2005	12/28/2005	36	864
SS	GC	680	*Diamond Ocean Star*	2/14/2005	3/8/2005	23	552
SS	GC	768	*Diamond Ocean Star*	6/22/2005	8/16/2005	56	1,344
SS	GC	768	*Diamond Ocean Star*	8/21/2005	10/14/2005	55	1,320
SS	GC	768	*Diamond Ocean Star*	11/9/2005	11/17/2005	9	216
SS	GC	768	*Diamond Ocean Star*	11/17/2005	12/29/2005	43	1,032
SS	GC	768	*Diamond Ocean Star*	12/29/2005	12/31/2005	3	72
JU	HI	A540	*Diamond Ocean Summit*	11/10/2005	12/7/2005	28	672
JU	MI	617	*Diamond Ocean Summit*	6/23/2005	8/18/2005	57	1,368
JU	GI	99	*Diamond Ocean Titan*	12/21/2005	12/31/2005	11	264
JU	WC	96	*Diamond Ocean Titan*	1/20/2005	9/19/2005	243	5,832
JU	WD	89	*Diamond Ocean Titan*	9/29/2005	10/30/2005	32	768
JU	MP	221	*Diamond Ocean Tower*	10/26/2005	12/31/2005	67	1,608
JU	VK	251	*Diamond Ocean Tower*	1/6/2005	10/26/2005	294	7,056
SS	EB	602	*Diamond Ocean Valiant*	6/29/2005	9/15/2005	79	1,896
SS	EB	646	*Diamond Ocean Valiant*	5/23/2005	6/28/2005	37	888
SS	GB	171	*Diamond Ocean Valiant*	1/27/2005	5/22/2005	116	2,784
SS	GB	668	*Diamond Ocean Victory*	8/25/2005	11/9/2005	77	1,848
SS	GC	155	*Diamond Ocean Victory*	2/23/2005	4/17/2005	54	1,296
SS	MC	687	*Diamond Ocean Victory*	8/9/2005	8/23/2005	15	360
SS	MC	734	*Diamond Ocean Victory*	11/15/2005	11/18/2005	4	96
SS	MC	734	*Diamond Ocean Victory*	11/18/2005	11/26/2005	9	216
SS	MC	734	*Diamond Ocean Victory*	11/26/2005	12/31/2005	36	864
SS	EB	599	*Diamond Ocean Voyager*	5/23/2005	6/28/2005	37	888
SS	EW	784	*Diamond Ocean Voyager*	2/16/2005	3/30/2005	43	1,032
SS	GB	159	*Diamond Ocean Voyager*	12/24/2005	12/31/2005	8	192
SS	MC	711	*Diamond Ocean Voyager*	5/3/2005	5/20/2005	18	432
SS	MC	711	*Diamond Ocean Voyager*	7/13/2005	8/9/2005	28	672
SS	MC	711	*Diamond Ocean Voyager*	8/9/2005	9/1/2005	24	576
SS	MC	711	*Diamond Ocean Voyager*	10/27/2005	12/12/2005	47	1,128
SS	MC	711	*Diamond Ocean Voyager*	12/12/2005	12/20/2005	9	216
SS	MC	837	*Diamond Ocean Voyager*	3/30/2005	3/30/2005	1	24
SS	MC	837	*Diamond Ocean Voyager*	4/22/2005	5/3/2005	12	288
JU	EI	182	*Ensco 60*	1/2/2005	12/31/2005	364	8,736
JU	WC	153	*Ensco 64*	5/30/2005	5/31/2005	2	48
JU	EI	268	*Ensco 69*	6/7/2005	6/26/2005	20	480
JU	EI	76	*Ensco 69*	2/11/2005	6/1/2005	111	2,664
JU	MI	A5	*Ensco 69*	6/30/2005	8/1/2005	33	792
JU	MP	270	*Ensco 74*	7/28/2005	10/18/2005	83	1,992
JU	MP	280	*Ensco 74*	6/28/2005	7/28/2005	31	744
JU	WC	130	*Ensco 74*	10/27/2005	12/31/2005	66	1,584
JU	SM	230	*Ensco 75*	9/4/2005	12/31/2005	119	2,856

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
SS	DC	621	*Ensco 7500*	5/8/2005	5/27/2005	20	480
SS	GC	385	*Ensco 7500*	3/2/2005	4/25/2005	55	1,320
SS	GC	385	*Ensco 7500*	3/4/2005	3/18/2005	15	360
SS	GC	518	*Ensco 7500*	1/18/2005	1/18/2005	1	24
SS	GC	652	*Ensco 7500*	5/27/2005	11/30/2005	188	4,512
SS	GC	652	*Ensco 7500*	11/30/2005	12/21/2005	22	528
SS	MC	299	*Ensco 7500*	3/4/2005	12/14/2005	286	6,864
JU	ST	252	*Ensco 81*	12/3/2005	12/28/2005	26	624
JU	WD	104	*Ensco 81*	11/8/2005	11/11/2005	4	96
JU	WD	104	*Ensco 81*	11/11/2005	12/2/2005	22	528
JU	WC	98	*Ensco 82*	7/25/2005	9/29/2005	67	1,608
JU	BS	41	*Ensco 83*	11/16/2005	11/25/2005	10	240
JU	BS	41	*Ensco 83*	11/25/2005	12/31/2005	37	888
JU	ST	156	*Ensco 83*	6/13/2005	6/16/2005	4	96
JU	ST	156	*Ensco 83*	6/24/2005	7/27/2005	34	816
JU	WD	21	*Ensco 86*	2/22/2005	4/21/2005	59	1,416
JU	WD	21	*Ensco 86*	6/15/2005	7/31/2005	47	1,128
JU	WD	21	*Ensco 86*	7/31/2005	7/31/2005	1	24
JU	EI	320	*Ensco 87*	3/9/2005	4/3/2005	26	624
JU	HI	194	*Ensco 90*	6/17/2005	7/8/2005	22	528
JU	SS	37	*Ensco 93*	5/9/2005	10/9/2005	154	3,696
JU	SS	90	*Ensco 93*	1/30/2005	5/9/2005	100	2,400
JU	EC	328	*GSF Adriatic III*	10/16/2005	11/13/2005	29	696
JU	VR	267	*GSF Adriatic III*	5/2/2005	5/24/2005	23	552
SS	MC	413	*GSF Arctic I*	7/28/2005	9/14/2005	49	1,176
SS	MC	413	*Gsf Arctic I*	11/22/2005	12/31/2005	40	960
DS	WR	206	*GSF C.R. Luigs*	3/17/2005	9/1/2005	169	4,056
DS	WR	206	*GSF C.R. Luigs*	9/1/2005	12/31/2005	122	2,928
SS	MC	755	*GSF Celtic Sea*	1/4/2005	2/26/2005	54	1,296
JU	EC	32	*GSF High Island I*	5/4/2005	6/24/2005	52	1,248
JU	MI	682	*GSF High Island I*	2/16/2005	4/7/2005	51	1,224
JU	MU	782	*GSF High Island I*	4/18/2005	5/2/2005	15	360
JU	VR	217	*GSF High Island I*	2/5/2005	5/3/2005	88	2,112
JU	ST	41	*GSF High Island VIII*	2/11/2005	3/28/2005	46	1,104
JU	WC	18	*GSF Main Pass I*	4/24/2005	11/7/2005	198	4,752
JU	HI	A287	*GSF Main Pass IV*	1/19/2005	3/5/2005	46	1,104
JU	VR	102	*GSF Main Pass IV*	6/9/2005	8/17/2005	70	1,680
JU	GA	227	*Hercules 11*	8/24/2005	9/30/2005	38	912
JU	MI	639	*Hercules 11*	6/29/2005	7/14/2005	16	384
JU	MI	639	*Hercules 11*	7/15/2005	8/3/2005	20	480
JU	MI	687	*Hercules 11*	11/3/2005	12/23/2005	51	1,224
JU	ST	197	*Hercules 11*	1/25/2005	3/1/2005	36	864

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	WC	45	*Hercules 11*	6/2/2005	6/27/2005	26	624
JU	SS	56	*Hercules 15*	8/22/2005	9/28/2005	38	912
JU	SS	92	*Hercules 15*	1/25/2005	2/18/2005	25	600
JU	SS	99	*Hercules 15*	11/29/2005	12/31/2005	33	792
JU	GI	34	*Hercules 20*	5/1/2005	5/29/2005	29	696
JU	PL	5	*Hercules 20*	10/17/2005	11/3/2005	18	432
JU	WD	42	*Hercules 20*	3/10/2005	4/2/2005	24	576
JU	WD	42	*Hercules 20*	4/2/2005	5/1/2005	30	720
JU	ST	47	*Hercules 21*	2/12/2005	3/13/2005	30	720
JU	GA	386	*Hercules 30*	11/20/2005	12/31/2005	42	1,008
JU	WD	42	*Hercules 30*	9/26/2005	10/10/2005	15	360
JU	MO	819	*Hercules Odin Victory*	8/18/2005	9/15/2005	29	696
JU	MO	861	*Hercules Odin Victory*	9/15/2005	10/4/2005	20	480
JU	VK	341	*Hercules Odin Victory*	4/17/2005	6/3/2005	48	1,152
JU	EC	38	*Nabors Dolphin 106*	1/24/2005	2/23/2005	31	744
JU	PL	6	*Nabors Dolphin 106*	4/22/2005	4/28/2005	7	168
JU	WD	35	*Nabors Dolphin 106*	4/8/2005	4/21/2005	14	336
JU	EI	123	*Nabors Pool 53*	8/16/2005	8/28/2005	13	312
JU	MP	64	*Nabors Pool 53*	10/17/2005	10/28/2005	12	288
JU	SS	62	*Nabors Pool 53*	7/25/2005	8/15/2005	22	528
JU	HI	201	*Nabors Pool 54*	5/29/2005	6/16/2005	19	456
JU	HI	A1	*Nabors Pool 54*	5/5/2005	5/28/2005	24	576
JU	HI	A6	*Nabors Pool 54*	2/8/2005	3/6/2005	27	648
SS	GC	320	*Noble Amos Runner*	1/26/2005	7/13/2005	169	4,056
SS	GC	765	*Noble Amos Runner*	9/11/2005	10/14/2005	34	816
SS	GC	765	*Noble Amos Runner*	11/15/2005	12/31/2005	47	1,128
SS	GC	767	*Noble Amos Runner*	7/13/2005	9/11/2005	61	1,464
JU	EC	359	*Noble Eddie Paul*	10/25/2005	11/7/2005	14	336
JU	EC	359	*Noble Eddie Paul*	11/7/2005	11/22/2005	16	384
JU	HI	A546	*Noble Eddie Paul*	7/3/2005	7/27/2005	25	600
JU	SS	296	*Noble Eddie Paul*	2/23/2005	3/11/2005	17	408
SU	EC	79	*Noble Fri Rodli*	9/27/2005	12/23/2005	88	2,112
SU	HI	203	*Noble Fri Rodli*	12/23/2005	12/31/2005	9	216
SU	WD	49	*Noble Fri Rodli*	6/4/2005	10/5/2005	124	2,976
SU	EC	79	*Noble Joe Alford*	6/22/2005	9/23/2005	94	2,256
SU	EC	90	*Noble Joe Alford*	1/1/2005	2/3/2005	34	816
SU	MP	19	*Noble Lester Pettus*	4/17/2005	5/10/2005	24	576
SU	MP	19	*Noble Lester Pettus*	5/10/2005	5/25/2005	16	384
SU	MP	19	*Noble Lester Pettus*	5/25/2005	6/15/2005	22	528
SS	EW	906	*Noble Lorris Bouzigard*	2/16/2005	4/9/2005	53	1,272
SS	EW	915	*Noble Lorris Bouzigard*	4/9/2005	5/8/2005	30	720
SS	GB	244	*Noble Lorris Bouzigard*	7/31/2005	9/30/2005	62	1,488

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
SS	GC	178	*Noble Lorris Bouzigard*	6/15/2005	7/31/2005	47	1,128
SS	MC	400	*Noble Lorris Bouzigard*	5/8/2005	6/10/2005	34	816
SS	VK	992	*Noble Lorris Bouzigard*	10/30/2005	12/2/2005	34	816
SS	GC	282	*Noble Max Smith*	5/25/2005	10/14/2005	143	3,432
SS	GC	518	*Noble Paul Romano*	6/8/2005	8/10/2005	64	1,536
SS	GC	518	*Noble Paul Romano*	8/10/2005	10/14/2005	66	1,584
SS	GC	518	*Noble Paul Romano*	11/20/2005	12/31/2005	42	1,008
SS	EB	602	*Noble Therald Martin*	11/9/2005	12/31/2005	53	1,272
JU	ST	156	*Ocean Summit*	6/13/2005	6/16/2005	4	96
BR	SM	224	*Parker 76-B*	7/11/2005	12/31/2005	174	4,176
JU	WD	117	*Pride Alaska*	12/1/2005	12/31/2005	31	744
JU	SS	98	*Pride Arizona*	4/11/2005	5/31/2005	51	1,224
JU	ST	75	*Pride Arizona*	5/31/2005	11/10/2005	164	3,936
JU	EI	275	*Pride Florida*	7/21/2005	8/30/2005	41	984
JU	SM	15	*Pride Florida*	5/7/2005	5/23/2005	17	408
JU	ST	41	*Pride Georgia*	5/2/2005	6/14/2005	44	1,056
JU	WC	455	*Pride Georgia*	7/15/2005	8/5/2005	22	528
JU	WC	42	*Pride Kansas*	9/14/2005	12/19/2005	97	2,328
JU	BA	366	*Pride Michigan*	7/12/2005	12/2/2005	144	3,456
JU	BA	A19	*Pride Michigan*	3/19/2005	3/28/2005	10	240
JU	BA	A39	*Pride Michigan*	1/9/2005	3/19/2005	70	1,680
JU	EC	111	*Pride Mississippi*	3/29/2005	5/12/2005	45	1,080
JU	EC	122	*Pride Mississippi*	7/16/2005	9/17/2005	64	1,536
JU	EC	206	*Pride Mississippi*	2/24/2005	3/28/2005	33	792
JU	EC	219	*Pride Mississippi*	6/6/2005	6/10/2005	5	120
JU	GA	291	*Pride Mississippi*	12/10/2005	1/2/2006	22	528
JU	VR	179	*Pride Mississippi*	5/13/2005	6/6/2005	25	600
JU	WC	295	*Pride Missouri*	3/14/2005	3/15/2005	2	48
JU	WC	295	*Pride Missouri*	3/29/2005	8/11/2005	136	3,264
JU	WC	494	*Pride Missouri*	2/23/2005	3/14/2005	20	480
JU	PL	15	*Pride New Mexico*	1/21/2005	2/18/2005	29	696
JU	SS	112	*Pride New Mexico*	5/21/2005	7/5/2005	46	1,104
SU	WC	295	*Pride Utah*	10/24/2005	12/31/2005	69	1,656
JU	BA	397	*Pride Wyoming*	12/30/2005	12/31/2005	2	48
JU	BA	490	*Pride Wyoming*	10/21/2005	11/10/2005	21	504
JU	BA	A83	*Pride Wyoming*	10/12/2005	10/19/2005	8	192
JU	EC	194	*Pride Wyoming*	8/7/2005	10/12/2005	67	1,608
JU	GA	A177	*Pride Wyoming*	12/12/2005	12/23/2005	12	288
JU	GA	A203	*Pride Wyoming*	12/23/2005	12/29/2005	7	168
JU	WC	442	*Pride Wyoming*	11/10/2005	11/12/2005	3	72
JU	WC	442	*Pride Wyoming*	11/12/2005	11/23/2005	12	288
JU	WC	442	*Pride Wyoming*	12/3/2005	12/12/2005	10	240

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	SM	195	*Rowan Alaska*	1/3/2005	2/27/2005	56	1,344
JU	VR	311	*Rowan Alaska*	2/28/2005	3/28/2005	29	696
JU	EC	282	*Rowan Anchorage*	1/25/2005	2/18/2005	25	600
JU	EI	154	*Rowan Anchorage*	2/23/2005	3/28/2005	34	816
JU	SM	116	*Rowan Anchorage*	11/23/2005	12/31/2005	39	936
JU	VR	61	*Rowan Anchorage*	9/20/2005	11/21/2005	63	1,512
JU	WC	256	*Rowan Anchorage*	4/26/2005	5/6/2005	11	264
JU	WC	328	*Rowan Anchorage*	3/30/2005	4/25/2005	27	648
JU	WC	444	*Rowan Anchorage*	5/6/2005	6/10/2005	36	864
JU	WC	444	*Rowan Anchorage*	6/10/2005	6/27/2005	18	432
JU	HI	A520	*Rowan Arch Rowan*	2/28/2005	3/22/2005	23	552
JU	HI	A346	*Rowan Bob Keller*	8/30/2005	10/8/2005	40	960
JU	WC	95	*Rowan Bob Keller*	10/10/2005	12/31/2005	83	1,992
JU	SP	87	*Rowan Bob Palmer*	6/26/2005	11/17/2005	145	3,480
JU	SP	87	*Rowan Bob Palmer (Gorilla Rig)*	11/17/2005	12/31/2005	45	1,080
JU	EI	182	*Rowan California*	8/10/2005	12/30/2005	143	3,432
JU	SS	188	*Rowan California*	5/8/2005	6/22/2005	46	1,104
JU	HI	169	*Rowan Cecil Provine*	12/2/2005	12/31/2005	30	720
JU	HI	A343	*Rowan Cecil Provine*	1/1/2005	2/27/2005	58	1,392
JU	MP	178	*Rowan Charles Rowan*	2/20/2005	4/7/2005	47	1,128
JU	ST	254	*Rowan Fort Worth*	4/30/2005	5/24/2005	25	600
JU	ST	254	*Rowan Fort Worth*	5/24/2005	6/12/2005	20	480
JU	PN	891	*Rowan Gilbert Rowe*	9/9/2005	11/16/2005	69	1,656
JU	PN	A9	*Rowan Gilbert Rowe*	11/19/2005	12/31/2005	43	1,032
JU	WC	62	*Rowan Gilbert Rowe*	4/7/2005	9/9/2005	156	3,744
JU	EC	365	*Rowan Gorilla II*	1/11/2005	1/11/2005	1	24
JU	EC	365	*Rowan Gorilla II*	1/11/2005	1/26/2005	16	384
JU	SM	166	*Rowan Gorilla II*	9/18/2005	10/14/2005	27	648
JU	VR	389	*Rowan Gorilla II*	12/13/2005	12/31/2005	19	456
JU	HI	A568	*Rowan Gorilla III*	1/22/2005	3/29/2005	67	1,608
JU	HI	A569	*Rowan Gorilla III*	6/9/2005	8/23/2005	76	1,824
JU	SS	199	*Rowan Gorilla III*	12/21/2005	12/31/2005	11	264
JU	SM	192	*Rowan Gorilla IV*	3/1/2005	4/12/2005	43	1,032
JU	SM	192	*Rowan Gorilla IV*	4/12/2005	5/2/2005	21	504
JU	SM	192	*Rowan Gorilla IV*	5/2/2005	5/9/2005	8	192
JU	EC	2	*Rowan Juneau*	1/24/2005	4/17/2005	84	2,016
JU	WC	174	*Rowan Juneau*	4/17/2005	5/5/2005	19	456
JU	WC	295	*Rowan Juneau*	8/1/2005	12/31/2005	153	3,672
JU	WC	577	*Rowan Juneau*	6/4/2005	7/28/2005	55	1,320
JU	EI	93	*Rowan Louisiana*	2/7/2005	4/21/2005	74	1,776
JU	MU	A113	*Rowan Louisiana*	1/25/2005	2/8/2005	15	360

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	VR	319	*Rowan Louisiana*	4/28/2005	5/14/2005	17	408
JU	VR	338	*Rowan Louisiana*	5/15/2005	8/22/2005	100	2,400
JU	WC	567	*Rowan Middletown*	5/5/2005	8/22/2005	110	2,640
SS	EW	949	*Rowan Midland*	3/16/2005	5/1/2005	47	1,128
SS	EW	989	*Rowan Midland*	5/1/2005	8/1/2005	93	2,232
SS	EW	990	*Rowan Midland*	2/16/2005	3/16/2005	29	696
JU	EI	202	*Rowan New Orleans*	2/5/2005	2/16/2005	12	288
JU	MP	185	*Rowan New Orleans*	5/30/2005	8/29/2005	92	2,208
JU	MP	207	*Rowan New Orleans*	4/18/2005	5/4/2005	17	408
JU	MP	207	*Rowan New Orleans*	5/12/2005	5/30/2005	19	456
JU	EC	315	*Rowan Odessa*	5/1/2005	7/1/2005	62	1,488
JU	VR	302	*Rowan Paris*	1/15/2005	1/29/2005	15	360
JU	ST	168	*Rowan Scooter Yeargain*	2/5/2005	12/31/2005	330	7,920
JU	EC	298	*Rowan Texas*	6/9/2005	8/25/2005	78	1,872
SS	MC	252	*T.O. Cajun Express*	3/18/2005	4/28/2005	42	1,008
SS	MC	299	*T.O. Cajun Express*	3/18/2005	3/18/2005	1	24
SS	MC	299	*T.O. Cajun Express*	4/28/2005	5/13/2005	16	384
SS	MC	728	*T.O. Cajun Express*	2/18/2005	3/17/2005	28	672
SS	MC	772	*T.O. Cajun Express*	1/20/2005	1/20/2005	1	24
SS	MC	961	*T.O. Cajun Express*	5/13/2005	6/27/2005	46	1,104
SS	WR	29	*T.O. Cajun Express*	5/13/2005	7/21/2005	70	1,680
SS	WR	29	*T.O. Cajun Express*	7/21/2005	8/6/2005	17	408
SS	WR	29	*T.O. Cajun Express*	8/6/2005	12/31/2005	148	3,552
SS	AT	398	*T.O. Deepwater Horizon*	6/8/2005	8/23/2005	77	1,848
SS	AT	398	*T.O. Deepwater Horizon*	8/23/2005	11/3/2005	73	1,752
SS	GC	654	*T.O. Deepwater Horizon*	4/8/2005	6/7/2005	61	1,464
SS	MC	82	*T.O. Deepwater Horizon*	11/12/2005	11/28/2005	17	408
SS	MC	82	*T.O. Deepwater Horizon*	11/28/2005	12/31/2005	34	816
DS	AT	305	*T.O. Deepwater Millennium*	2/18/2005	2/24/2005	7	168
DS	AT	305	*T.O. Deepwater Millennium*	5/27/2005	6/15/2005	20	480
DS	AT	349	*T.O. Deepwater Millennium*	2/24/2005	3/3/2005	8	192
DS	AT	349	*T.O. Deepwater Millennium*	6/15/2005	7/7/2005	23	552
DS	DC	621	*T.O. Deepwater Millennium*	9/28/2005	11/9/2005	43	1,032
DS	DC	621	*T.O. Deepwater Millennium*	11/9/2005	11/20/2005	12	288
DS	DC	621	*T.O. Deepwater Millennium*	11/20/2005	12/31/2005	42	1,008

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
DS	GC	652	*T.O. Deepwater Millennium*	3/3/2005	5/18/2005	77	1,848
DS	GC	652	*T.O. Deepwater Millennium*	5/18/2005	5/25/2005	8	192
DS	LL	399	*T.O. Deepwater Millennium*	7/7/2005	8/14/2005	39	936
DS	LL	47	*T.O. Deepwater Millennium*	1/18/2005	2/5/2005	19	456
DS	LL	50	*T.O. Deepwater Millennium*	2/5/2005	2/17/2005	13	312
DS	LL	95	*T.O. Deepwater Millennium*	8/14/2005	9/27/2005	45	1,080
SS	AT	267	*T.O. Deepwater Nautilus*	1/3/2005	6/25/2005	174	4,176
SS	GC	434	*T.O. Deepwater Nautilus*	6/25/2005	10/14/2005	112	2,688
SS	GC	434	*T.O. Deepwater Nautilus*	12/1/2005	12/31/2005	31	744
DS	MC	859	*T.O. Discoverer Deep Seas*	12/26/2005	12/31/2005	6	144
DS	WR	758	*T.O. Discoverer Deep Seas*	4/21/2005	12/15/2005	239	5,736
DS	MC	822	*T.O. Discoverer Enterprise*	1/5/2005	6/10/2005	157	3,768
DS	GC	512	*T.O. Discoverer Spirit*	3/12/2005	12/31/2005	295	7,080
SS	MC	734	*T.O. Marianas*	2/12/2005	3/29/2005	46	1,104
SS	MC	734	*T.O. Marianas*	3/29/2005	6/6/2005	70	1,680
SS	GB	205	*The 100*	6/13/2005	7/2/2005	20	480
SS	GB	205	*The 100*	7/2/2005	8/7/2005	37	888
SS	GB	329	*The 100*	12/13/2005	12/31/2005	19	456
SS	GC	141	*The 100*	2/8/2005	4/16/2005	68	1,632
SS	GC	6	*The 100*	4/16/2005	6/11/2005	57	1,368
SS	GC	6	*The 100*	8/7/2005	9/15/2005	40	960
JU	EI	107	*The 150*	9/10/2005	10/14/2005	35	840
JU	EI	37	*The 150*	10/15/2005	12/2/2005	49	1,176
JU	EI	58	*The 150*	12/4/2005	12/31/2005	28	672
JU	GA	210	*The 152*	4/9/2005	7/5/2005	88	2,112
JU	HI	163	*The 152*	2/4/2005	4/8/2005	64	1,536
JU	HI	197	*The 152*	7/6/2005	8/31/2005	57	1,368
JU	WC	101	*The 152*	1/24/2005	2/4/2005	12	288
JU	VR	39	*The 156*	1/2/2005	2/2/2005	32	768
JU	MP	118	*The 200*	9/18/2005	1/3/2006	105	2,520
JU	MP	7	*The 200*	1/20/2005	1/22/2005	3	72
JU	MP	7	*The 200*	1/22/2005	3/16/2005	54	1,296
JU	VK	385	*The 200*	3/19/2005	4/13/2005	26	624
JU	HI	73	*The 201*	7/1/2005	7/1/2005	1	24
JU	HI	73	*The 201*	7/1/2005	9/12/2005	74	1,776

Table 6.3

Drilling Vessel Activity Data (Continued)

Rig Type	Surface Area Code	Surface Block Number	Rig Name	Rig Move on Date	Rig Move off Date	Days	Hours
JU	PS	1145	*The 201*	2/28/2005	3/17/2005	18	432
JU	PS	1166	*The 201*	1/31/2005	2/15/2005	16	384
JU	PS	1166	*The 201*	2/15/2005	2/25/2005	11	264
JU	PS	1166	*The 201*	2/26/2005	2/28/2005	3	72
JU	WC	153	*The 201*	5/25/2005	5/27/2005	3	72
JU	WC	153	*The 201*	11/19/2005	12/31/2005	43	1,032
JU	WC	442	*The 202*	11/23/2005	12/31/2005	39	936
JU	EI	159	*The 203*	7/17/2005	7/26/2005	10	240
JU	GA	298	*The 203*	6/7/2005	7/3/2005	27	648
JU	HI	A276	*The 203*	5/24/2005	6/6/2005	14	336
JU	EI	123	*The 204*	4/19/2005	5/28/2005	40	960
JU	SS	62	*The 204*	3/1/2005	3/23/2005	23	552
JU	WD	64	*The 204*	5/29/2005	7/1/2005	34	816
JU	WD	64	*The 204*	7/1/2005	7/14/2005	14	336
JU	WD	64	*The 204*	7/14/2005	7/28/2005	15	360
JU	BA	502	*The 207*	1/29/2005	2/15/2005	18	432
JU	EC	213	*The 207*	1/10/2005	1/27/2005	18	432
JU	MU	804	*The 207*	5/14/2005	6/15/2005	33	792
JU	EI	100	*The 250*	3/12/2005	4/15/2005	35	840
JU	EI	83	*The 250*	4/15/2005	5/19/2005	35	840
JU	MI	654	*The 251*	9/28/2005	12/22/2005	86	2,064
JU	SS	73	*The 251*	3/25/2005	4/20/2005	27	648
JU	VR	249	*The 251*	12/24/2005	12/31/2005	8	192
JU	WC	43	*The 251*	4/22/2005	9/21/2005	153	3,672
JU	WC	43	*The 251*	11/26/2005	12/24/2005	29	696
JU	EI	268	*The 253*	1/30/2005	2/6/2005	8	192
JU	EI	98	*The 253*	2/8/2005	4/29/2005	81	1,944
JU	VR	237	*The 253*	1/1/2005	1/3/2005	3	72
JU	WC	542	*The 253*	7/6/2005	12/1/2005	149	3,576
SU	VR	69	*The 75*	4/18/2005	4/30/2005	13	312
SU	WC	39	*The 75*	12/27/2005	12/31/2005	5	120
BR	SM	217	*Todco 27*	10/29/2005	12/31/2005	64	1,536
BR	SM	217	*Todco 48*	10/27/2005	10/29/2005	3	72

6.1.3 Pipelaying Operations

Product from oil platforms is generally transported to shore via pipeline. New pipelines are constantly being laid linking new platforms to shore or increasing the capacity of the existing network. Pipelines also require occasional maintenance and repair. To install, maintain, or replace sections of pipeline necessitates considerable vessel support. In the GMAQS, the number of vessels needed to lay a given length of pipe in 24 hours was estimated (U.S. DOI, MMS 1995). From these assumptions, it was calculated that it takes 0.4 total vessel hours to lay one foot of pipe.

The MMS data documents the length and location of individual sections constructed or maintained from January 2005 to December 2005 (U.S. DOI, MMS 2007). These new pipeline segments were mapped to individual lease blocks in the Gulf of Mexico using Geographic Information System (GIS) tools. The total length of pipeline constructed within a lease block was calculated for each lease block, along with the total vessel hours included in these activities, based on the following equation:

$$T_{pi} = \Sigma\ (L_i \times 0.4\ \text{hrs/ft})$$

where:

T_{pi} = Total vessel time involved in pipelaying or maintenance for lease block i (hours)
L_i = Length of individual pipe segment within the boundaries of lease block i (feet)

Because of the major hurricanes that occurred in the Gulf of Mexico in 2005, pipelaying operations decreased significantly from October to the end of the year. Strong wave action associated with hurricanes typically leads to submarine mudslides where pipelines are damaged or destroyed; for the 2005 hurricane season 183 pipeline segments were damaged. Because of this extensive damage, it is believed that the pipelaying fleet continued operations during the last quarter of 2005 to repair pipelines damaged by the hurricanes. To estimate vessel hours of operation, activity data from January through September were averaged to estimate typical monthly operations. The difference in the averaged activity level and the reported pipelaying activity levels for October, November, and December were assumed to be additional pipeline repair activity that were not captured in MMS's pipelaying activity data. The vessel hours associated with new pipelaying and repair are summarized in Table 6.4.

Table 6.4

Pipelaying Activity

Activity	Hours of Activity in 2005
New Pipelaying	1,238,710
Repair	241,543

Emissions associated with pipelaying vessels are attributed to the operation of the primary diesel engine used for propulsion, and other smaller diesel engines that are used to run generators, air compressors, welding equipment, or small cranes and winches. For this inventory, it was assumed that the main propulsion engines are medium-speed diesel engines. Assumptions about average horsepower and load factors (Table 6.5) were obtained from the GMAQS (U.S. DOI, MMS 1995) and applied to the Swedish emission factors (SEPA 2004) as noted in Table 6.1. Releases of gas or oil from pipelines during construction were not considered in this study.

Table 6.5

Average Pipelaying Vessel Characteristics

Average Vessel kW	Load Factor
895	0.75

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

In 2005, total hours of new pipelaying activity were 1,238,710. Average vessel kW of pipelaying vessels is 894.84, load factor is 0.75, and the emission factor for NO_x is 10.6 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 1{,}238{,}710 \times 894.84 \times 0.75 \times 10.6 \times 1.10231 \times 10^{-6}$$
$$E = 9713.73 \text{ tons of } NO_x$$

The pipelaying activity is summarized with both total pipe length constructed and total hours by MMS lease block in Table 6.6. New pipeline construction were mapped using the data provided by the MMS and are provided in Figure 6.2. Repair activities were applied to blocks where MMS documented pipeline damage.

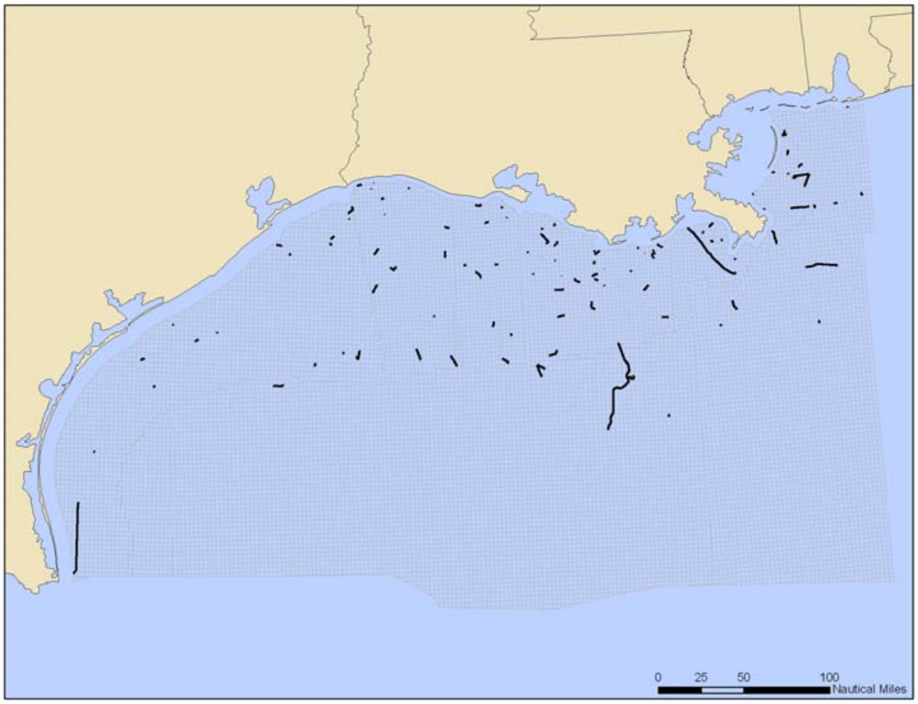

Figure 6.2. Pipeline locations and MMS lease blocks.

Table 6.6

Pipelaying Activity Data

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA1	17	WC	1,079	432
LA1	18	WC	11,387	4,555
LA1	21	WC	3,455	1,382
LA1	44	WC	1,822	729
LA1	48	WC	3,441	1,376
LA1	57	WC	1,044	417
LA1	66	WC	1,828	731
LA1	95	WC	5,838	2,335
LA1	96	WC	2,803	1,121
LA1	168	WC	2,996	1,198
LA10	7	MP	8,860	3,544
LA10	69	MP	8,324	3,330
LA10	98	MP	14,239	5,696
LA10	99	MP	6,238	2,495
LA10	100	MP	11,752	4,701
LA10	108	MP	6,684	2,674
LA10	109	MP	6,289	2,516
LA10A	161	MP	16,000	6,400
LA10A	178	MP	14,013	5,605

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA10A	179	MP	14,238	5,695
LA10A	180	MP	14,238	5,695
LA10A	182	MP	2,156	862
LA10A	183	MP	14,572	5,829
LA10A	204	MP	16,725	6,690
LA10A	207	MP	7,936	3,174
LA10A	252	MP	4,682	1,873
LA10A	256	MP	5,389	2,156
LA10A	275	MP	2,597	1,039
LA10A	280	MP	37,513	15,005
LA10A	281	MP	5,629	2,251
LA10A	289	MP	11,108	4,443
LA10A	291	MP	5,126	2,050
LA10A	292	MP	10,242	4,097
LA10A	293	MP	10,205	4,082
LA10A	294	MP	10,177	4,071
LA10A	295	MP	10,151	4,060
LA10A	296	MP	10,152	4,061
LA10A	297	MP	10,149	4,060
LA10A	298	MP	1,204	481
LA10B	53	BS	2,166	867
LA11	3	CA	24,281	9,713
LA11	13	CA	2,051	821
LA11	18	CA	15,623	6,249
LA11	25	CA	865	346
LA1A	328	WC	2,974	1,189
LA1A	334	WC	6,099	2,440
LA1A	335	WC	13,219	5,287
LA1A	342	WC	5,279	2,112
LA1A	368	WC	11,070	4,428
LA1A	369	WC	15,708	6,283
LA1A	417	WC	13,593	5,437
LA1A	421	WC	15,084	6,034
LA1A	422	WC	2,797	1,119
LA1A	444	WC	754	301
LA1B	599	WC	6,120	2,448
LA1B	603	WC	9,421	3,768
LA1B	604	WC	6,710	2,684
LA1B	622	WC	16,139	6,456
LA1B	625	WC	2,944	1,178
LA2	89	EC	13,613	5,445
LA2	90	EC	5,445	2,178

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA2	131	EC	1,156	462
LA2	142	EC	15,346	6,138
LA2	149	EC	8,544	3,418
LA2A	265	EC	10,790	4,316
LA2A	278	EC	633	253
LA2A	359	EC	11,345	4,538
LA2A	363	EC	7,161	2,864
LA2A	364	EC	10,718	4,287
LA2A	378	EC	6,473	2,589
LA2A	379	EC	1,181	472
LA3	26	VR	5,234	2,094
LA3	27	VR	15,387	6,155
LA3	28	VR	3,364	1,346
LA3	69	VR	3,222	1,289
LA3	70	VR	13,528	5,411
LA3	164	VR	10,614	4,245
LA3	171	VR	1,119	448
LA3	187	VR	18,813	7,525
LA3	188	VR	232	93
LA3	195	VR	12,333	4,933
LA3A	15	SM	26,549	10,620
LA3B	310	VR	15,171	6,069
LA3B	311	VR	429	171
LA3B	313	VR	4,143	1,657
LA3C	146	SM	20,178	8,071
LA3C	147	SM	756	302
LA3C	184	SM	3,857	1,543
LA3C	195	SM	6,010	2,404
LA3C	196	SM	16,853	6,741
LA3C	197	SM	1,529	612
LA3D	217	SM	13,116	5,247
LA3D	229	SM	1,453	581
LA3D	236	SM	4,584	1,833
LA4	39	EI	4,346	1,739
LA4	53	EI	14,464	5,786
LA4	56	EI	9,626	3,850
LA4	64	EI	276	110
LA4	75	EI	19,700	7,880
LA4	83	EI	2,216	887
LA4	85	EI	19,045	7,618
LA4	86	EI	2,268	907
LA4	98	EI	8,402	3,361

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA4	100	EI	17,104	6,842
LA4	113B	EI	5,527	2,211
LA4	141	EI	189	75
LA4	142	EI	4,150	1,660
LA4	175	EI	6,152	2,461
LA4	188	EI	1,165	466
LA4	213	EI	14,008	5,603
LA4	214	EI	14,497	5,799
LA4	215	EI	4,593	1,837
LA4A	280	EI	12,387	4,955
LA4A	281	EI	14,163	5,665
LA4A	371	EI	6,762	2,705
LA4A	384	EI	14,888	5,955
LA4A	385	EI	9,711	3,885
LA4A	397	EI	9,695	3,878
LA5	62	SS	4,707	1,883
LA5	63	SS	2,865	1,146
LA5	72	SS	12,200	4,880
LA5	73	SS	6,173	2,469
LA5	97	SS	10,350	4,140
LA5	110	SS	2,833	1,133
LA5	119	SS	1,137	455
LA5	133	SS	11,207	4,483
LA5	134	SS	38,117	15,247
LA5	135	SS	4,268	1,707
LA5	144	SS	3,389	1,355
LA5	145	SS	11,834	4,734
LA5	146	SS	664	266
LA5	149	SS	1,900	760
LA5	150	SS	12,337	4,935
LA5	154	SS	12,608	5,043
LA5	167	SS	3,222	1,289
LA5	218	SS	22,120	8,848
LA5	229	SS	59,578	23,831
LA5A	242	SS	21,998	8,799
LA5A	332	SS	3,476	1,390
LA5A	355	SS	15,131	6,052
LA6	21	BM	20,253	8,101
LA6	27	BM	5,556	2,222
LA6	28	BM	7,188	2,875
LA6	29	BM	6,671	2,668
LA6	30	BM	9,496	3,798

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA6	35	BM	1,509	604
LA6	37	BM	12,075	4,830
LA6	38	BM	10,831	4,333
LA6	47	BM	7,668	3,067
LA6	48	BM	18,429	7,372
LA6	77	BM	2,305	922
LA6	138	BM	2,028	811
LA6	147	BM	17,740	7,096
LA6	148	BM	2,810	1,124
LA6A	254	ST	9,862	3,945
LA6A	255	ST	14,279	5,712
LA6A	256	ST	1,175	470
LA6B	5	PL	2,573	1,029
LA7	18	GI	9,292	3,717
LA7	19	GI	2,565	1,026
LA7	20	GI	17,499	7,000
LA8	20	WD	536	214
LA8	21	WD	6,872	2,749
LA8	31	WD	11,776	4,710
LA8	38	WD	6,127	2,451
LA8	39	WD	12,458	4,983
LA8	41	WD	13,557	5,423
LA8	42	WD	6,106	2,442
LA8	58	WD	2,407	963
LA8	59	WD	2,742	1,097
LA8	62	WD	10,404	4,162
LA8	66	WD	15,690	6,276
LA8	67	WD	10,975	4,390
LA8	71	WD	2,057	823
LA8	72	WD	19,933	7,973
LA8	73	WD	3,163	1,265
LA8	91	WD	12,851	5,140
LA8	92	WD	15,748	6,299
LA8	102	WD	2,183	873
LA8	103	WD	17,267	6,907
LA8	104	WD	8,267	3,307
LA8A	112	WD	4,016	1,606
LA8A	113	WD	17,225	6,890
LA8A	125	WD	17,088	6,835
LA8A	126	WD	4,857	1,943
LA8A	128	WD	15,555	6,222
LA8A	129	WD	12,251	4,900

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
LA8A	145	WD	1,514	605
LA9	60	SP	11,411	4,564
LA9A	67	SP	36,693	14,677
LA9A	70	SP	47,152	18,861
LA9A	77	SP	9,228	3,691
LA9A	88	SP	10,426	4,170
LA9A	89	SP	5,055	2,022
NG15-01	157	EB	12,535	5,014
NG15-01	158	EB	15,463	6,185
NG15-01	159	EB	9,366	3,746
NG15-03	4	GC	3,274	1,310
NG15-03	5	GC	454	182
NG15-03	24	GC	13,672	5,469
NG15-03	25	GC	6,455	2,582
NG15-03	48	GC	17,298	6,919
NG15-03	49	GC	17,127	6,851
NG15-03	50	GC	4,715	1,886
NG15-03	69	GC	17,682	7,073
NG15-03	92	GC	5,931	2,372
NG15-03	93	GC	11,615	4,646
NG15-03	113	GC	16,996	6,798
NG15-03	137	GC	6,811	2,725
NG15-03	157	GC	20,819	8,328
NG15-03	158	GC	4,159	1,664
NG15-03	201	GC	23,152	9,261
NG15-03	202	GC	18,444	7,378
NG15-03	244	GC	11,590	4,636
NG15-03	245	GC	11,426	4,570
NG15-03	285	GC	6,129	2,452
NG15-03	286	GC	17,474	6,989
NG15-03	287	GC	15,964	6,386
NG15-03	288	GC	8,511	3,404
NG15-03	329	GC	16,388	6,555
NG15-03	373	GC	16,359	6,544
NG15-03	417	GC	16,358	6,543
NG15-03	461	GC	16,354	6,541
NG15-03	505	GC	17,093	6,837
NG15-03	549	GC	18,004	7,202
NG15-03	562	GC	9,307	3,723
NG15-03	592	GC	3,535	1,414
NG15-03	593	GC	13,215	5,286
NG15-03	636	GC	18,391	7,356

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
NG15-03	680	GC	4,588	1,835
NH15-12	905	EW	3,082	1,233
NH15-12	933	EW	6,472	2,589
NH15-12	949	EW	5,110	2,044
NH15-12	950	EW	12,069	4,828
NH15-12	977	EW	529	212
NH15-12	994	EW	17,174	6,870
NH16-04	827	MO	2,071	828
NH16-04	988	MO	11,612	4,645
NH16-07	20	VK	9,409	3,764
NH16-07	983	VK	27,960	11,184
NH16-10	21	MC	35,565	14,226
NH16-10	250	MC	12,277	4,911
NH16-10	251	MC	15,463	6,185
NH16-10	252	MC	11,921	4,768
NH16-10	292	MC	11,182	4,473
NH16-10	293	MC	15,323	6,129
NH16-10	294	MC	4,255	1,702
NH16-10	296	MC	3,619	1,448
NH16-10	297	MC	15,466	6,187
NH16-10	298	MC	15,468	6,187
NH16-10	299	MC	12,357	4,943
NH16-10	538	MC	33,353	13,341
NH16-10	582	MC	13,919	5,568
NH16-10	583	MC	19,656	7,862
NH16-10	711	MC	3,461	1,384
NH16-10	755	MC	2,163	865
NH16-10	822	MC	10,302	4,121
TX1	1031	PS	16,298	6,519
TX1	1040	PS	16,296	6,518
TX1	1052	PS	16,292	6,517
TX1	1061	PS	16,289	6,516
TX1	1072	PS	16,286	6,515
TX1	1083	PS	16,283	6,513
TX1	1092	PS	16,281	6,513
TX1	1103	PS	16,278	6,511
TX1	1112	PS	16,275	6,510
TX1	1124	PS	16,272	6,509
TX1	1132	PS	16,269	6,508
TX1	1145	PS	17,343	6,937
TX1	1151	PS	10,048	4,019
TX1	1152	PS	24,856	9,942

Table 6.6

Pipelaying Activity Data (Continued)

PROT_#	Block Lab	Area Code	Length (ft)	Hours
TX1	1166	PS	15,755	6,302
TX2A	996	PN	3,051	1,221
TX2A	1011	PN	17,216	6,886
TX2A	1018	PN	16,301	6,520
TX2A	A9	PN	3,993	1,597
TX3A	A53	MU	4,300	1,720
TX4	638	MI	17	7
TX4	639	MI	14,275	5,710
TX4	A5	MI	1,461	584
TX5	491	BA	5,874	2,350
TX5	544	BA	4,005	1,602
TX5	545	BA	1,969	788
TX5	578	BA	7,228	2,891
TX5	A2	BA	4,806	1,922
TX6	190	GA	14,347	5,739
TX6	191	GA	2,168	867
TX6	210	GA	3,207	1,283
TX6	227	GA	2,602	1,041
TX7	162	HI	1,830	732
TX7	163	HI	6,240	2,496
TX7	170	HI	12,513	5,005
TX7	228	HI	8,045	3,218
TX7	A6	HI	11,133	4,453
TX7A	39	HI	14,352	5,741
TX7A	45	HI	6,114	2,446
TX7A	46	HI	10,110	4,044
TX7A	74	HI	4,698	1,879
TX7B	A520	HI	2,920	1,168
TX7B	A553	HI	10,310	4,124
TX7C	A336	HI	11,711	4,684
TX7C	A339	HI	2,479	992
TX7C	A340	HI	1,373	549
TX7C	A343	HI	24,116	9,646
TX7C	A356	HI	8,103	3,241

6.1.4 Support Helicopters

Helicopters are used extensively in the Gulf of Mexico to move light supplies and personnel to and from platforms. Total aggregated helicopter activity data for 2005 for the Gulf area were obtained from the FAA; these data only quantified the number of landing and takeoffs

(LTOs) associated with offshore support helicopters; they do not provide information on the types of helicopters that are active or the hours of operation.

Data on the types of helicopters used to support offshore oil platforms in the Gulf of Mexico were obtained from the Helicopter Safety Advisory Conference's (HSAC*) Gulf of Mexico Offshore Helicopter Operations and Safety Review* (HSAC 2006). The HSAC compiled voluntary activity data disaggregated into single engine, twin engine, and heavy twin engine helicopters. Using the HSAC data, percentages based on the helicopter types were developed and applied to the FAA activity data (FAA 2006), as noted in Table 6.7.

Table 6.7

HSAC and FAA Data

Type	HSAC Data	Percent Profile	Adjusted FAA Data
Single	1,062,942	81.10%	1,865,186
Light Twin	65,076	4.96%	114,191
Med/Heavy Twin	182,718	13.94%	320,622
Total	1,310,736	100.00%	2,300,000

The helicopter emission factors were obtained from multiple sources, including the *Final Air Quality Management Plan, 1991 Revision, Final Technical Report III-G, 1987 Aircraft Emission Inventory in the South Coast Air Basin*, developed by the California South Coast Air Quality Management District (SCAQMD 1991). Staff at the California Air Resources Board noted that these emission factors have not been updated since 1991. Additional helicopter emission factors were obtained from EPA's *Procedures for Emission Inventory Preparation Volume IV: Mobile Sources* (U.S. EPA 1992), as well as data from the Allison helicopter engine manufacturer (Allison Helicopter Engine Manufacture 2002), and helicopter test data from the Department of the Navy's *Environmental Assessments* (U.S. Department of the Navy 1999*)*. Helicopter emission factors were also obtained from the latest versions of the FAA's Emission Dispersion and Modeling System (EDMS) software.

The emission factors were disaggregated into the helicopter types used in the HSAC's data. The emission test data for each aircraft type were converted to LTO-based emission factors by weighting the lb/min test results by the amount of minutes the helicopter spent in each mode as noted in the following equation:

$$EF_{LTO} = \sum TD_i \times P_i$$

where:

EF_{LTO} = LTO-Based emission factor (pound per LTO)
TD_i = Test data for Mode i (pound per minute)
i = Mode (i.e., take off, climbout, approach and idle)
P_i = Period helicopter is in mode (minute/LTO)

The average trip length was relatively short (16 minutes) (HSAC 2006); it is assumed that helicopters typically hop from platform to platform. In addition to the 16 minute flight time, it was assumed that the helicopter idles for an additional 15 minutes while on the platform. Therefore the emission estimates and factors are based on a short LTO cycle of 31 minutes.

The LTO-based emission factors for each helicopter type were averaged to yield the emission factors used in this study. These average emission factors are summarized in Table 6.8. CO_2 emission factors are not readily available, therefore factors were developed based on the assumption that 87% of the fuel is converted to CO_2. It also was assumed that helicopters with three engines were similar to medium/heavy twin-engine helicopters. Some of data obtained for military helicopters were not included in the average because some of the emission factors were more than an order of magnitude different from the factors obtained from other data sources and a credible explanation for the difference could not be provided; also most of the helicopters used to support oil platform activities are commercial, not military helicopters.

Table 6.8

Helicopter Emission Factors by Helicopter Type

Type	CO lb/LTO	HC lb/LTO	NO_x lb/LTO	SO_2 lb/LTO	PM lb/LTO	CO_2 lb/LTO
Single Average	5.745	0.537	0.289	0.032	N/A	58.800
Light Average	9.602	6.167	2.235	0.960	0.918	268.869
Medium Average	11.372	4.939	5.676	2.455	0.918	689.261

N/A = not available

The emission factors developed from this project were applied to the activity data to estimate emissions using the following equation:

$$E_i = EF_i / 2000 \times LTO_i$$

where:

E_i = Helicopter emisions for helicopter type i (tons per year)
EF_i = Helicopter emission factor for helicopter type i (pounds/LTO).
LTO_i = Landing and take off cycle for helicopter type i (cycles per year).
i = Helicopter type (i.e., Single, Light, or Medium)
2000 = Conversion factor pounds per ton.

Example Calculation:

The emission factor of NO_x for single engine helicopter is 0.289 pounds/LTO, and the LTOs for single engine helicopters in 2005 were 1,865,186.

$E_{Single} = EF_{Single} / 2000 \times LTO_{Single}$

$E = 0.289/2000 \times 1{,}865{,}186$
$E = 270$ tons of NO_x

Helicopter emissions were assigned to lease blocks with active platforms that have heliports (Figure 6.3), as most of the emissions associated with support helicopters occurs while the craft is near or at the platform. Spatial allocation of helicopter emissions was made using the equation below:

$$E_{Hi} = E_H \times (P_{Hi}/P_{HT})$$

where:

E_{Hi} = Support helicopter emissions associated with lease block i (tons)
E_H = Total helicopter emissions (tons)
P_{Hi} = Number of platforms with heliports in lease block i
P_{HT} = Total number of platforms with heliports

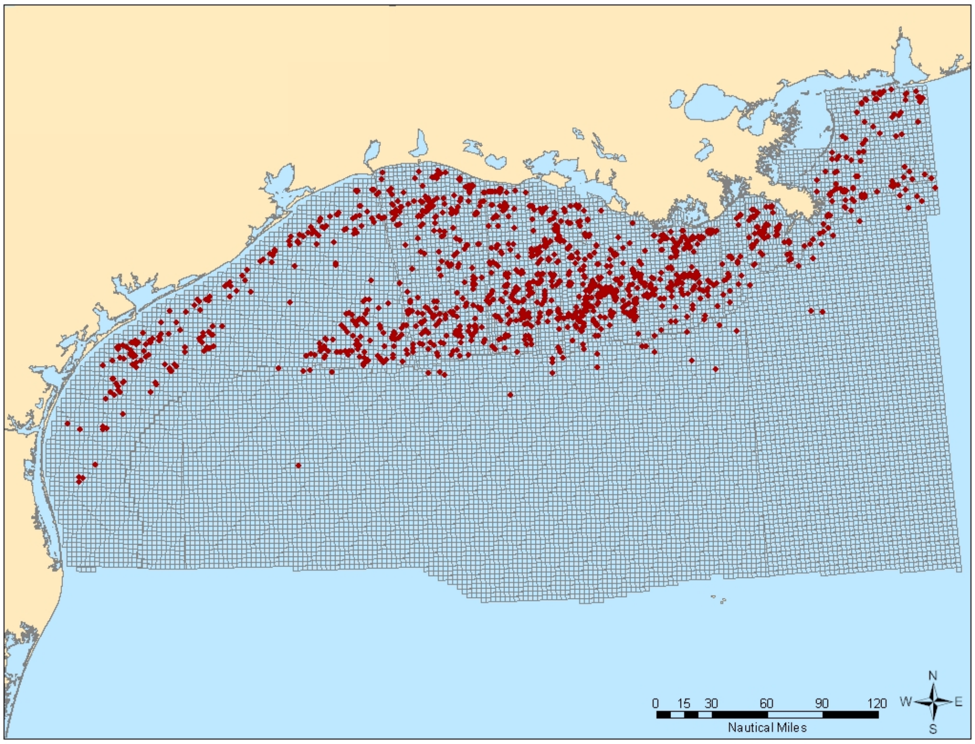

Figure 6.3. Location of active platforms with heliports.

6.1.5 Support Vessels

Support vessels include crew boats that transport workers to and from work sites, supply vessels that carry supplies to offshore sites, and tug boats and barges that transport heavy equipment and supplies. Emissions associated with support vessels are attributed to the operation of the primary diesel engine used for propulsion and other smaller diesel engines that are used to run generators or small cranes and winches for loading and unloading the vessels.

Support vessel population data were obtained from the Offshore Marine Service Association (OSMA 2006). However, this dataset did not include information about vessel characteristics. Some vessel characteristics data were obtained from *A-Z of Offshore Support Vessels of the World* published by the Oilfield Publications Limited (2004). Most of the vessel characteristics data used in this study were obtained from the U.S. EPA's commercial marine vessel studies. The EPA groups vessels based on the cylinder displacement of the main propulsion engine:

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

Most of the support vessels are propelled with Category 1 (44.8%) or Category 2 (51.1%) engines. On average, these vessels have 2.22 engines with a total vessel horsepower range between 740 and 7,502, with the typical value being 2,289 horsepower, derived from data obtained from the EPA report: *Category 2 Vessel Census, Activity and Spatial Allocation Assessment and Category 1 and Category 2 In-port/at Sea Split* (U.S. EPA 2007).

Based on the EPA's Category 2 vessel study (U.S. EPA 2007), it was estimated that support vessels operated at sea 232 days a year, 66 days per year they were in port, and 67 days per year they were involved in required maintenance activities. Because the vast majority of these vessels are provided through leasing agreements, it was assumed that for the days these vessels are available that they operate for 24 hours a day.

The vessel population estimate and the average hours of operation were used to calculate the total annual hours that support vessels operate in Federal waters (Table 6.9).

Table 6.9

Support Vessel Census, kW rating, and Annual Hours of Operation

Type	Vessel Count			Average Total kW			Typical at Sea Underway Hours	Typical at Sea Idle Hours
	Category 1	Category 2	Category 3	Category 1	Category 2	Category 3		
Anchor Handling	4	19	2	2,995	3,393	5,123	5,568	1,584
Supply/Crew Boats	396	261	2	1,779	2,516	2,984	5,568	1,584
Lift Boats	38	75	0	1,342	1,581		5,568	1,584
Tugs/Tow Boats	17	161	22	3,418	3,320	6,016	5,568	1,584
Total	455	516	26					

Offshore support vessel load factors were provided by the U.S. Coast Guard's National Offshore Safety Advisory Committee (McGill 2006). The load factors for offshore support vessels vary, with most of the time spent at 85% load while at sea underway, and 10% load while idling adjacent to the platform. Regulations require that support vessels can not tie-up to platforms, instead they idle nearby while offloading their cargo, and hence they do not shut down their engines while loading and unloading at the platform (McGill 2006).

The operating mode times, load factors, and typical horsepower ratings were applied to the Swedish Emission Factors (SEPA 2004) as provided in Table 6.1 to obtain the emissions for each support vessel type.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

Four Category 1 anchor handling vessels spent 22,272 hours at sea in total. Average kW of Category 1 anchor handling vessels is 2,994.73 kW, load factor is 0.85, and the emission factor for NO_x is 12.0 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 22{,}272 \times 2{,}994.73 \times 0.85 \times 12.0 \times 1.10231 \times 10^{-6}$$
$$E = 749.93 \text{ tons of } NO_x$$

Support vessel emissions were assigned equally to all active platforms. Underway support vessel emissions were spatially apportioned based on the location of active offshore platform and the location of the closest port using the equation below:

$$E_{SVi} = E_{SV} \times (S_{li}/S_{lt})$$

where:

E_{SVi} = Support vessel emissions associated with lease block i (tons)
E_{SV} = Total underway emissions associated with support vessels (tons)
S_{li} = Sum of the lengths of all support vessel fairways within the boundaries of the lease block i (miles)
S_{lt} = Total sum of all support vessel fairways in the GOM (miles)

Figure 6.4 shows the active lease blocks to which support vessels travel. Emissions for lease blocks closer to shore are probably overestimated using the above methods, as it is assumed that support vessels only travel between local ports and specific platforms. Support vessels may actually travel to multiple platforms before returning to port. At this time, data are not readily available to map actual support vessel routes.

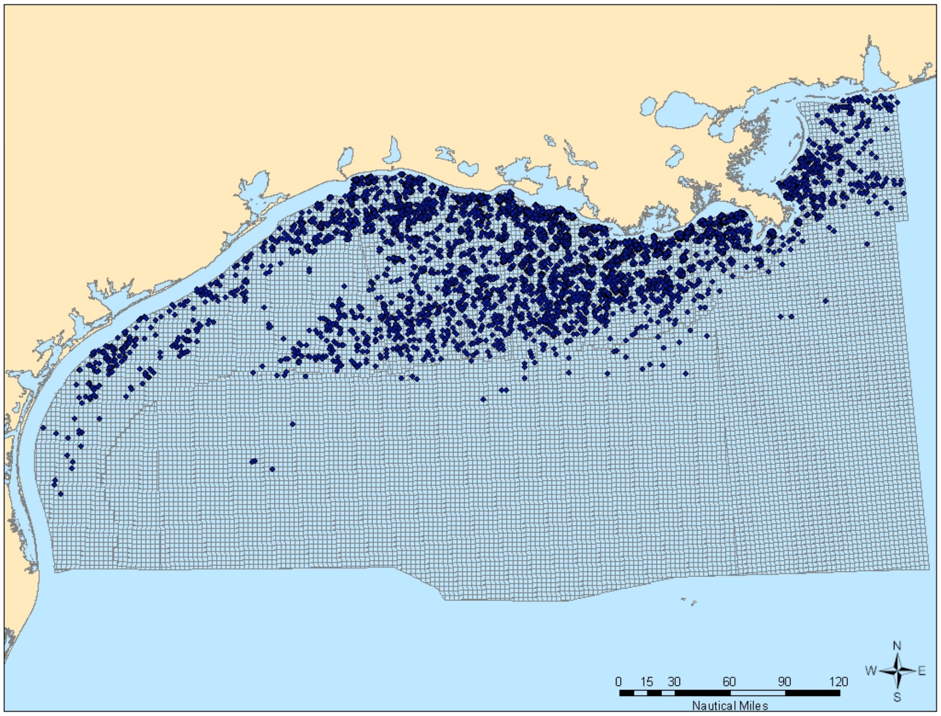

Figure 6.4. Active offshore platforms with MMS lease blocks.

6.1.6 Survey Vessels

Survey vessels are used in the Gulf of Mexico to map geologic formations and seismic properties. These survey mapping activities are needed to evaluate potential oil reserves in the Gulf. The most common survey technique uses blasts from underwater air guns. The sound waves from the air gun blasts are deflected by underground geologic strata and detected by sound wave receptors trailed behind the survey vessel (Figure 6.5). There are two types of surveys that can be performed: two dimensional (2-D) and three dimensional (3-D). 3-D surveys are the dominant and preferred exploration technique in the Gulf of Mexico. Most modern survey vessels tow multiple streamers (sound wave reception devices) such that for every linear mile traveled, they acquire data for a square mile of subsurface area (Brinkman 2002a, 2002b).

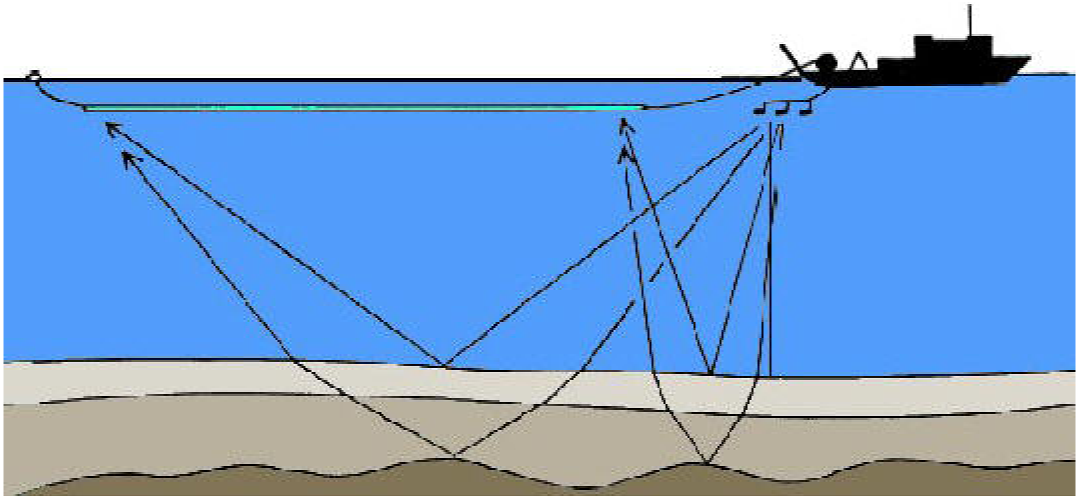

Figure 6.5. Typical geophysical survey vessel operations.

Attempts were made to obtain survey vessel data from the vessel operators. Unfortunately the operators only provided data for 4 of the 14 survey vessels. Therefore, survey vessel data were developed by adjusting the average characteristics of the 4 vessels and applying them to the remaining 10 vessels.

The survey vessel information included the number of continuous days the vessel could operate before heading back to port. The average number of continuous days was 19.63. It was then assumed the vessel would need a week at port to be re-supplied and maintained. Therefore, it was estimated that in one year survey vessels typically were at sea for approximately 269 days and at port for approximately 96 days. With 14 survey vessels, it was assumed that collectively all survey vessels operated at sea for 90,397 hours. The survey data also included engine kilowatt ratings. The survey results noted that the average kilowatt rating for survey vessels was found to be 1,025. These engines are assumed to be medium-speed diesel engines, and the load factor was assumed to be 90%, which was obtained from the GMAQS (U.S. DOI, MMS 1995).

Emissions associated with survey vessels are primarily from marine diesel engines used for propulsion and to provide electricity and compressed air to operate the survey equipment. Emissions were estimated by applying the activity hours and load factors to the Swedish marine engine emission factors provided in Table 6.1.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

Total hours of operation of all survey vessels were 90,397. The average kW is 1,025, load factor is 0.90, and the emission factor for NO_x is 13.2 g/kWh.

$E = AH \times kW \times LF \times EF \times CF$

$E = 90{,}397 \times 1{,}025 \times 0.90 \times 13.2 \times 1.10231 \times 10^{-6}$
$E = 1{,}213.38$ tons of NO_x

Because survey data are considered proprietary, emissions were allocated to each lease block based on the surface area of the lease block, as noted in the following equation:

$$E_{Si} = E_S \times (S_{ii}/S_{ti})$$

where:

E_{Si} = Survey vessel emissions associated with lease block i (tons)
E_S = Total survey vessel emissions (tons)
S_{ii} = Surface area of inactive lease block i (square miles)
S_{ti} = Total surface area of all inactive lease blocks (square miles)

6.2 NON-PLATFORM NON-OIL/GAS PRODUCTION RELATED SOURCES

Non-OCS oil and gas production sources include biogenic and geogenic sources, as well as vessels related to commercial fishing, CMV transits, the LOOP, military operations, and vessel lightering activities.

6.2.1 Biogenic and Geogenic Emissions

The primary biogenic and geogenic sources of air pollution that were evaluated for this study are: subsurface seeps of crude oil, subsurface seeps of natural gas (including methane hydrates), and emissions from bacterial processes and ocean processes. In the previous inventory effort, credible emission estimates could only be developed for VOC subsurface seeps of oil and N_2O from bacterial processes. Published studies were reviewed to determine if any new data sources were available to improve the 2000 emission estimates for these source categories. New references were uncovered, but the new data were not specific for the Central and Western areas of the Gulf of Mexico, nor could they be used to enhance the base year 2000 emission estimates. Data were identified to develop CO_2, CH_4, and VOC emission estimates for mud volcanoes in the Gulf of Mexico, which represents a new geogenic emission source.

Subsurface Seeps of Crude Oil

Subsurface seeps of oil, more commonly referred to as oil seeps, occur when crude oil deposits beneath the ocean floor escape into the ocean waters because of cracks and vents in the floor. Cracks can open and close as the result of several geological activities. The volume of oil seeping into the ocean can be relatively significant though. The total amount of oil that is released into the ocean does not, however, find its way to the surface and end up as air emissions. Some ocean-dwelling biota develop communities surrounding oil seeps and utilize the hydrocarbons as a source of nutrients. Other free floating organisms in the water column consume portions of the escaping oil as the material rises to the surface. Although these processes do mitigate the amount of oil that reaches the surface for possible volatilization, there is significant uncertainty and variability on the amounts that do reach the surface. Air pollutants that can be emitted from oil seeps include VOC, CH_4, CO_2, and air toxics. Based on the data found in the literature, only VOC emissions can be estimated at this time.

The MMS and other researchers have conducted a significant amount of work to study the extent of oil seeps in the Gulf of Mexico and off the coast of California. Much of this investigation has focused on the occurrence of communities of chemosynthetic organisms and oil slicks. Both factors have been shown to correspond to significant oil seep activity. Estimates have been made of the total quantity of oil seeping into various ocean waters based on studies of oil slicks both at the ocean level and from satellite and space shuttle photography. These data have been input to models capable of estimating overall oil seepage rates. Crucial variables in the models include wind speed, oil layer thickness, and the oil degradation half-life. Over the last 10 years, several different and sometimes highly variable estimates of total oil seepage into the Gulf of Mexico have been prepared. With improvements in remote sensing technology, better estimates are being made possible. Some of the work places oil seepage in the northern Gulf at $2.5 – 6.9 \times 10^5$ barrels/yr (Mitchell et al. 1999). Converting to tons, the average estimate of seepage in the northern Gulf is 73,000 tons/yr.

Using this figure, emissions can be estimated using either the oil seepage emission factor (105 lbs/barrel oil released) developed by the California Air Resources Board (CARB 1993) or the average mass volatilization from oil slicks predicted by the MMS open ocean weathering model (U.S. DOI, MMS 1998). One model prediction showed that after 10 days time, 34% of the oil mass from a slick would have evaporated. The application of these methods results in similar mass emission estimates as shown below.

1) 73,000 tpy x 294 gal/ton x 1 bbl/42 gal x 105 lbs/bbl = ~26,827 tons/yr VOC

2) 73,000 tpy x 0.34 = 24,820 tons/yr VOC

For the purposes of this MMS non-platform inventory we will use an average of the two estimates (25,823.5 tons/yr). It should also be noted that none of the studies provided accurate definitions of the Northern Gulf, such that it was not possible to map the study area to MMS lease blocks. In which case, it is assumed that these emission estimates are for the whole Northern Gulf area. When adjusted to represent only the Central and Western Gulf, the VOC emissions decline to 13,561 tpy.

Bacterial Processes

Bacterial process sources include plankton producing dimethylsulfide (DMS) and sediment bacteria producing methane. DMS released from protozoa and zooplankton has been linked to the formation of tropospheric aerosols and cloud condensation nuclei, which can result in negative influences on global warming (Gabric et al. 1993). Estimates of DMS flux from the GOM range from 9.2 $\mu mol/m^2/day$ (in January) to 13.8 $\mu mol/m^2/day$ (in July) (Andreae and Ferek 1992). Note, DMS is not one of the pollutants included in this study. As described previously, sediment bacteria methane generation and potential atmospheric release is not well characterized and cannot be estimated for the purposes of this inventory.

N_2O is produced by deep-water bacteria, and is transferred to the atmosphere through upwelling and air-sea transfer mechanisms (Nevison et al. 1995). Bouwman et al. (1995) compared several earlier inventories of ocean N_2O to create a gridded annual N_2O inventory available as part of the Global Emission Inventory Activity (GEIA) data set. Based on this information (Nevison et al. 1995), total annual emissions for the GOM study area have been estimated to be 3,710 tons N_2O –N/Year. When adjusted to represent only the Western and Central Gulf, the N_2O estimate is 1,948 tons.

Mud Volcanoes

Mud volcanoes are submarine formations that excrete gases or liquids. The gases they release often contain CH_4, CO_2, and VOCs. Four mud volcanoes have been identified in the Gulf of Mexico (Kohl and Roberts 1994). As information about the pollutant release rates for each volcano were not readily available, data concerning typical volumetric emission release rates for mud volcanoes were obtained from a study performed by Dimitrov (2003). The Dimitrov study also provided speciation values to allow for estimation of the CH_4, CO_2, and VOC releases. The volume of CH_4, CO_2, and VOC were converted to mass emissions using the chemical density of each pollutant. Most VOC emitted from mud volcanoes are higher carbon compounds such as isobutane, so the isobutane density was used to for the VOC mass emission estimate. Adjustments were made to the methane estimate to account for the observation that 80% of the CH_4 emitted by mud volcanoes is consumed by biologic organisms as reported by Zhang and Noakes (2006). The emission estimates and locations of the mud volcanoes are noted Table 6.10.

Table 6.10

Mud Volcano Locations and Emission Characteristics

Location	Typical Emission Rate M^3/yr	CH_4 Fraction (%)	CO_2 Fraction (%)	VOC Fraction (%)
Garden Banks Block 382	3.60E+06	90	8	2
Green Canyon Block 143	3.60E+06	90	8	2
Green Canyon Block 272	3.60E+06	90	8	2
Mississippi Canyon Block 929	3.60E+06	90	8	2

Biogenic emissions were applied to all lease blocks based on the surface area of each lease block; the exception being the mud volcanoes, their emissions were assigned to the lease block where the volcano was located. Except for volcanoes, the allocations were made based on the surface area of the lease blocks using the equation below:

$$E_{bgi} = E_{bg} \times (S_i/S_{TNG})$$

where:

E_{bgi} = Biogenic/geogenic emissions associated with lease block i (tons)
E_{bg} = Total biogenic/geogenic emissions for GOM (tons)

S_i = Surface area of lease block i (square miles)
S_{TG} = Surface area of total Gulf lease blocks (square miles)

6.2.2 Commercial Fishing

The Gulf of Mexico is an active commercial fishing area, providing a wide range of fish and seafood products. Detailed commercial fishing data were obtained from the National Oceanic & Atmospheric Administration (NOAA) National Marine Fisheries Service (U.S. DOC, NMFS 2007). Activity data were provided for one of the three types of offshore fishing activities that occur in the Gulf of Mexico: pelagic long line (U.S. DOC, NMFS, SEFSC 2007, Pattela 2001, Poffenberger, 2001). 2005 data were not available for reef and shrimp operations. Therefore, reef and shrimp operations were grown to represent 2005 levels using fish catch data for 2000 and 2005 (U.S. DOC, NMFS 2007) yielding a growth factor for both fishing operations; these growth factors are shown in Table 6.11.

Table 6.11

2005 Growth Factors for Reef
and Shrimp Fishing Vessels Based on Pounds Caught

Year	Fish Type	Pounds	Growth Factor
2000	Reef Fish	9,238,679	
2005	Reef Fish	7,006,897	0.758
2000	Shrimp	288,579,843	
2005	Shrimp	214,363,124	0.743

The activity data for these different fishing operations were provided as latitude and longitude for pelagic long line fishing operations, and in terms of NMFS' statistical zones for reef and shrimp fishing. The adjusted activity for shrimp and reef fishing are presented in Table 6.12. (The line fishing activity data includes over 3,000 records, and cannot be provided in a hardcopy format.)

Table 6.12

Shrimp and Reef Fishing Vessel Activity Data

NMFS Zones	2005 Shrimp Fishing Vessel Hours	2005 Reef Fishing Vessel Hours
10	4,759	14,178
11	15,490	11,962
12	7,578	2,072
13	27,387	11,767
14	26,636	8,134
15	10,513	5,637
16	12,142	8,309
17	22,771	15,865
18	22,285	7,343
19	25,182	4,786
20	8,007	3,591
21	6,692	1,160
Total	189,441	94,804

Emissions associated with commercial fishing vessels are attributed to the operation of diesel engines used for propulsion and other smaller diesel engines that are used to run generators or small cranes and winches to lift fish nets and lines onto the vessel. To estimate emissions from operating these diesel engines, the emission factors provided in Table 6.1 were used.

Assumptions about typical fishing vessel horsepower (300 HP) were obtained from the GMAQS (U.S. DOI, MMS 1995), and typical operating loads were assumed to be 80% for underway operations, and 10% for maneuvering while setting the nets. These emission and load factors were applied to the kW-hours of operation developed from the NMFS data to calculate emissions for this source category.

Commercial fishing locations were also provided by the NMFS. Reef and shrimp fishing operations are delineated by NMFS statistical zones (Figure 6.6). For line fishing operations, operating hours were estimated based on the assumption that it takes approximately 24 hours to tend each set. The Southeast Fisheries Science Center (SEFSC 2007) provided latitude and longitude coordinates for line fishing operations. Emissions were spatially allocated for these three activities by overlaying a GIS plot of MMS lease blocks.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

Shrimp fishing vessels spent 189,441 hours at sea in 2005. The average kW is 223.71, load factor is 0.80, and the emission factor for NO_x is 13.2 g/kWh.

$E = AH \times kW \times LF \times EF \times CF$

$E = 189{,}441 \times 223.71 \times 0.80 \times 13.2 \times 1.10231 \times 10^{-6}$
$E = 493.3$ tons of NO_x

Commercial fishing emission estimates for reef and shrimp fishing operations were spatially allocated using the following formula:

$$E_{CFi} = E_{CFz} \times (S_i/S_{CFz})$$

where:

E_{CFi} = Commercial fishing emissions for lease block i (tons)
E_{CFz} = Commercial fishing emissions for NMFS area z (tons)
S_i = Surface area of lease block i (square miles)
S_{CFz} = Total surface area of NMFS area z (square miles)

Where a lease block was included in two NMFS areas, the assignment was made proportional to the area of the NMFS zone that the lease block occupied. For example, lease block AB is split between NMFS zones 12 and 13. 75% of lease block AB is included in zone 12 and 25% of lease block AB is in zone 13. In this example, emissions associated with NMFS zones 12 and 13 would be split in lease block AB, proportional to the area with which each zone is associated.

Line fishing emissions were assigned to individual lease blocks based on the latitude and longitude coordinates provided by NMFS and the estimated hours of operation.

With regard to recreational fishing, it was determined that the majority of recreational fishing occurs within State waters, and therefore this source category was not included in this inventory. It is recognized that some small portion of recreational fishing occurs near platforms that are not in State waters. Unfortunately, data could not be identified to quantify recreational fishing near oil platforms.

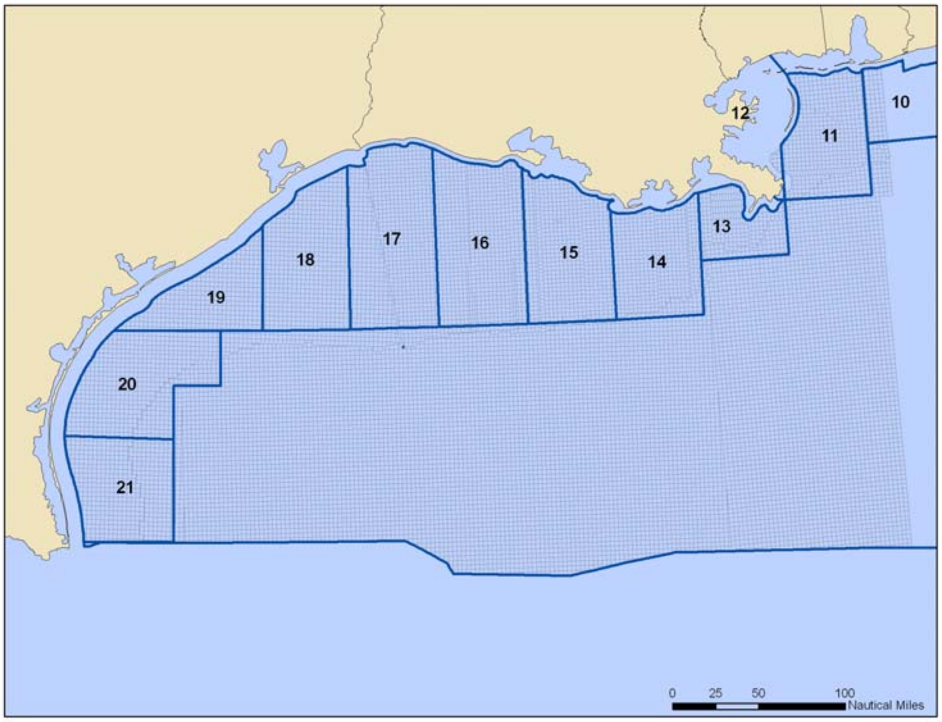

Figure 6.6. NMFS fishing zones with lease blocks.

6.2.3 Commercial Marine Vessels

The CMVs are involved in transporting a wide range of agricultural, manufacturing, and chemical products through the Gulf of Mexico. The majority of CMVs tend to be powered by diesel engines that combust diesel fuel or a mixture of diesel fuel and residual oils. According to the CMV data compiled for this study, out of 32,000 vessels, 34 vessels (0.1%) were steam powered; given the small number of steam ships, these vessels were not included in this inventory. Some marine vessel emissions may occur due to evaporative losses of volatile chemical products; however, most of the emissions associated with CMVs are from the combustion of the fuels used to propel the vessels.

Vessel activity data were obtained from the 2005 vessel movement data obtained from U.S Department of Transportation, Maritime Administration (MARAD 2006). It should be noted that this dataset only includes vessels have that have international cargo and go through customs procedures. Domestic cargo traffic were not included unless a vessel had international cargo and stopped at multiple domestic ports; those activity data were captured, as the vessel would continue to go through customs procedures at every port visited. Also, because the MARAD data includes both entrance and clearance data, there is double-counting that needs to be corrected. Duplicate entrance data were removed. If there was only an entrance record and no clearance record, the entrance record was retained. These MARAD data provide a conservative estimate of vessel activity, actually activity levels are probably larger than the values used in this inventory effort.

Because vessels report the previous and next port of call, it was possible to identify the vessel routes the ships take, and these routes were matched to U.S. Army Corps of Engineer shipping lanes based on the assumption that each vessel will take the shortest route into and out of the area, as noted in Figure 6.7.

The entrance and clearance data also included International Maritime Organization (IMO) numbers, a vessel identification code, which allowed the data to be linked to an IMO database to obtain vessel characteristics, such as vessel type, vessel speed, and total engine kW rating. The vessel characteristics were averaged by vessel type, and are summarized in Table 6.13. A large number of vessel trips could not be linked to a vessel type; for these cases the average speed and vessel kW rating were used as vessel characteristics.

Table 6.13

Average Vessel Speed, Total kW, and Total Hours by Vessel Type

Trip Count	Type	Avg Speed	Avg Total kW	Total Hours
292	Auto Carriers	18.71	10,523	5,454
5,905	Bulk Materials	14.46	7,867	114,830
1,823	Container Ships	20.22	16,873	29,688
1,331	Cruise Ships	20.20	39,883	24,789
31	Ferries	19.35	11,600	305
3,507	General Cargo	14.47	5,440	77,605
8	Miscellaneous	11.86	5,214	218
282	Refrigerated	18.64	7,810	4,157
319	Roll On / Roll Off	15.21	7,978	6,763
7,774	Tankers	14.81	9,136	158,066
187	Tug Boats	13.47	3,314	4,623
21,858	Unknown	15.60	10,668	200,859
66	Offshore	12.09	5,906	1,364

The CMV emission estimates for diesel powered vessels were developed for individual shipping lanes for each vessel type. Hours of operation along a shipping lane segment were estimated by dividing the length of the shipping lane segment by the average vessel speed for a given vessel. These hours of operation were multiplied by the number of trips that the vessel type made along the segment to get the total hours of operation. The total hours of operation for a specified segment and vessel type were multiplied by the average vessel kW rating to get kW-hours to transit the shipping lane segment. These kW-hours were applied to load (80%) and emission factors for diesel engines summarized in Table 6.1 to get the vessel type emission for a given segment.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

All auto carriers spent 5,454 hours at sea in 2005. The average kW is 10,523, load factor is 0.80, and the emission factor for NO_x is 13.2 g/kWh.

$E = AH \times kW \times LF \times EF \times CF$

$E = 5{,}454 \times 10{,}523 \times 0.80 \times 13.2 \times 1.10231 \times 10^{-6}$
$E = 668.07$ tons of NO_x

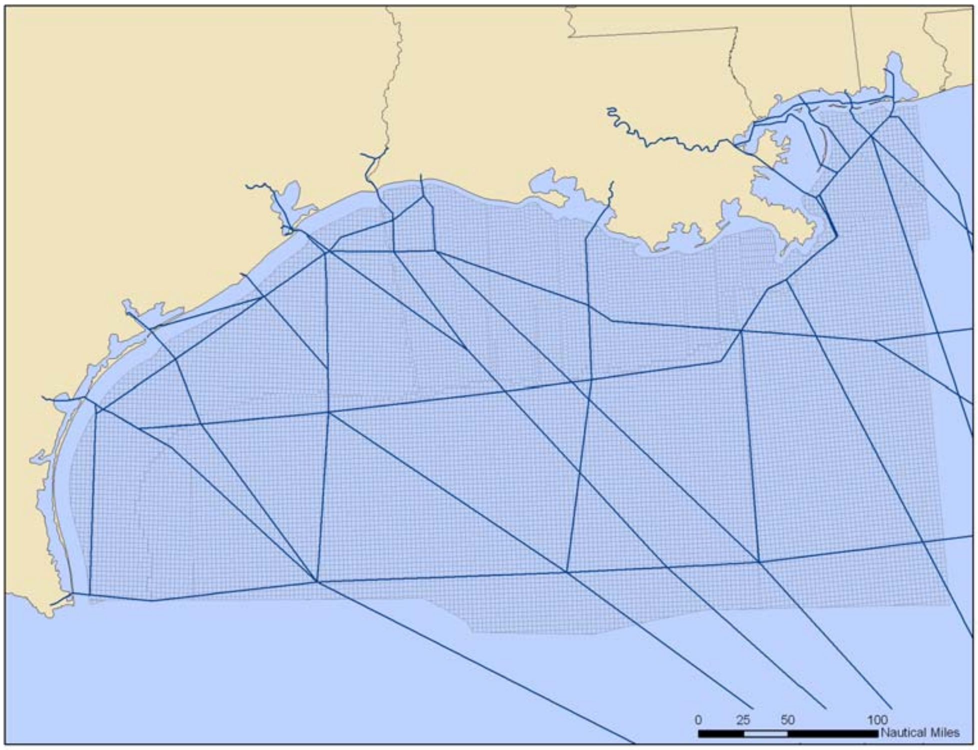

Figure 6.7. Commercial marine vessel shipping lanes.

The CMV emission estimates were spatially allocated to individual shipping lane segments. To estimate the emissions for a specified lease block a GIS layer of the lease block boundaries was overlaid upon the project's shipping lanes and shipping lane emissions within the lease block boundaries were summed for each lease block.

6.2.4 LOOP

The LOOP is a platform located 45 miles from shore. This offshore port allows large oil tankers to unload product without having to enter and maneuver inside urban ports. The LOOP consists of several emission sources, one 1000 kW generator, four 7,500 hp pumps, support vessels, as well as the oil tankers that use the facility.

Unfortunately, 2005 activity data were not available for this inventory effort. Therefore, base year 2000 activity data were adjusted to reflect 2005 activity data using oil production as the growth factor. The base year 2000 hours of operation for the generator and pumps were previously obtained from the LOOP's web site (www.loopllc.com). This site included detailed information about the individual vessels that used the platform in 2000, and the line vessels that assisted the oil tankers in getting to and from the mooring points. The 2000 data represents the facility operating at full capacity; these values were adjusted to account for the 7 days that the platform was not operating due to power failures associated with the 2005 hurricanes.

The LOOP engine characteristics, including kW rating, load factors, and hours of operation are summarized in Table 6.14.

Table 6.14

LOOP Hours of Operation, kW Rating, and Load Factors

Vessel Type	Mode	Hours of Activity	Average kW	Load Factor
Tankers	Approach	8,301	25,989	0.55
Tankers	Idling	1,716	25,989	0.10
Support Vessels	Maneuvering	6,465	895	0.25
Generator	--	8,566	1,000	0.50
Pump	--	3,300	22,371	1.00

The emissions for the LOOP were calculated by applying the Swedish emission factors (SEPA 2004) noted in Table 6.1, to average kW rating and hours of operation.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

All tankers spent 8,301 hours at sea in 2005. The average kW of tankers is 25,989, load factor is 0.55 for approaching mode, and the emission factor for NO_x is 17.0 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 8{,}301 \times 25{,}989 \times 0.55 \times 17.0 \times 1.10231 \times 10^{-6}$$
$$E = 2223.49 \text{ tons of } NO_x$$

Vessels also emit VOCs through evaporative losses from tanker ballasting operations. Ballasting consists of pumping water into a vessel after the product has been removed, providing increased stability for the tanker. Evaporative emissions from ballasting were also calculated in this effort. These estimates were derived from product transfer data for each vessel that used the LOOP and emission factors included in the EIIP guidance documents (EIIP 1999). Again, 2005 data were not available, and 2000 data were adjusted using oil throughput data. It is assumed that for each call, 2.13 tons of VOC are emitted. It was estimated that in 2005 the LOOP had 269 calls.

Platform, ballasting, support vessel, and tanker idling emissions were all assigned to the latitude and longitude coordinates of the LOOP. Emissions associated with the vessel approach were assigned to the associated shipping lane as noted in Figure 6.8.

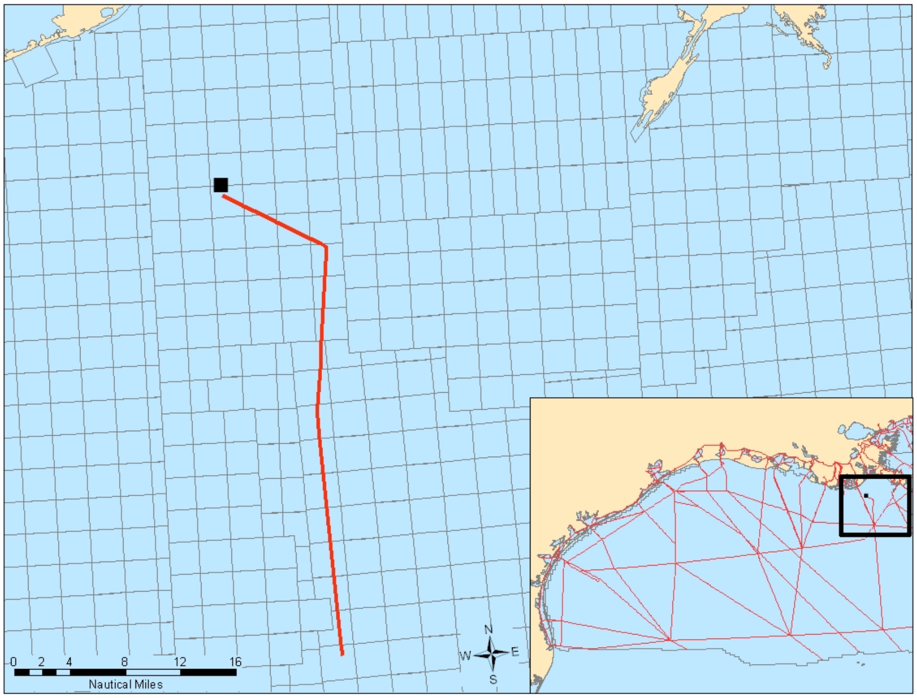

Figure 6.8. Shipping lane approach and location of LOOP.

6.2.5 Military Vessel Operations

The U.S. Navy and Coast Guard frequently patrol and have maneuvers in the Gulf of Mexico. The U.S. military vessel fleet consists of vessels powered by a variety of engines, including older residual-fueled steam turbines, marine diesel engines, and high speed diesel turbines.

Contacts were made with the Navy to obtain activity data necessary to estimate vessel emissions. Unfortunately, no data were provided. Therefore, the emission estimates developed for the U.S. Navy for the GMAQS were used for in this inventory (U.S. DOI, MMS 1995).

The Coast Guard provided data that included the number of vessels with a homeport in the Gulf of Mexico, the type of vessel, the name of the vessel, and the total number of operating days for some of the vessels. From this data, the average number of operating hours was calculated for each type of ship. Engine horsepower was obtained for some of but not all of the vessels via the vessel's homepage. Where vessel horsepower data were not readily available, averages for vessel types were developed using available data for sister ships. The average hours of operation and horsepower ratings are summarized in Table 6.15.

Table 6.15

Average Horsepower and Operating Hours by
Coast Guard Vessel Type

Boat Class	Type	Horsepower Rating	Hours of Operation	Vessel Count
WLB 225	Buoy Tenders	6,200	2,152.8	1
WMEC 210	Cutters	5,000	3,840.0	2
WPB 87	Patrol	3,050	1,518.5	14

To estimate emissions from the Coast Guard marine diesel engines, the Swedish emission factors noted in Table 6.1 were applied to the hours of operation and the vessel kW rating (which was converted from the horsepower). It was assumed that the Coast Guard vessels had typically operate at a load factor of 85% while in Federal waters.

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

Buoy tenders spent 89.7 days at sea in 2005. It is assumed that they operate 24 hours a day. Therefore, total hours of operation were 2,152.8. The average kW is 4,623, load factor is 0.85 for approaching mode, and the emission factor for NO_x is 17.0 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 2{,}152.8 \times 4{,}623 \times 0.85 \times 17.0 \times 1.10231 \times 10^{-6}$$
$$E = 158.53 \text{ tons of } NO_x$$

Because it was not possible to identify where Navy vessels operate, the emissions were allocated to individual lease blocks through out the Central and Western areas of the Gulf of Mexico. All Coast Guard vessel emissions were allocated by vessel relative to the home port and the area where the vessels patrol (Figure 6.9). The allocations were made based on the surface area of the lease blocks using the equation below:

$$E_{MVi} = E_{MV} \times (S_i/S_{TNG})$$

where:

E_{MVi} = Military vessel emissions associated with lease block i (tons)
E_{MV} = Total military vessel emissions for GOM (tons)

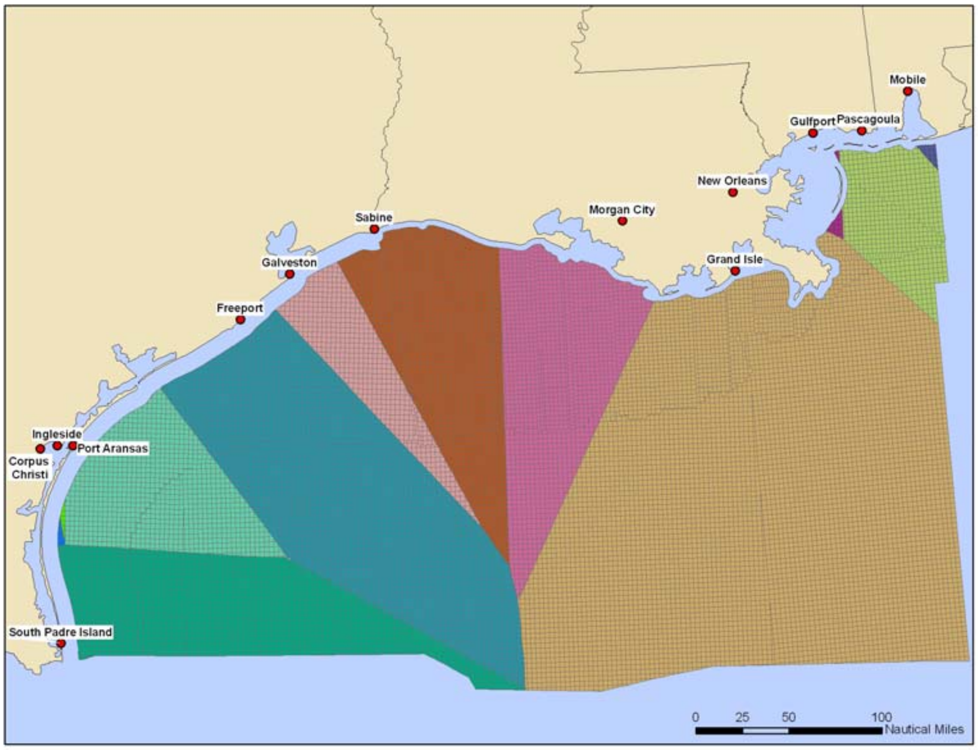

Figure 6.9. Coast Guard districts used to allocate emissions.

S_i = Surface area of lease block i (square miles)
S_{TG} = Surface area of total Gulf lease blocks (square miles)

6.2.6 Vessel Lightering

Lightering is the transfer of cargo to smaller ships that bring the product into port. Lightering occurs off-shore in three designated areas. Emissions associated with lightering are attributed to primary propulsion engines of the vessels involved in lightering, secondary engines (e.g., pumps and winches), and evaporative emissions associated with ballasting.

Skaugen Petrotrans is the largest lightering company in the world, and provides the majority of ship-to-shore transfers of crude oil to Houston. Vessel lightering activity was obtained from Skaugen's web site and included the number of lightering operations, the total number of lightering days, and the daily lightered volume of product.

To calculate the emissions from the large tanker ships involved in the lightering process, the activity data obtained from the Skaugen Petrotrans (2007) web site were converted into hours of operation. It was assumed that each operating day was 24 hours long. For the escort vessels, the total volume of product transferred was divided by the average escort capacity which was obtained from the U.S. Coast Guard in order to estimate the total number of escort vessel trips made annually. This was then multiplied by the average escort trip time. The average escort trip time was calculated based on the distance in Federal waters between the centroid of the three lightering areas and Galveston, TX, divided by the average escort vessel speed (12 miles an hour) (U.S. DOI, MMS 1995). The tanker operating time and the escort vessel time are summarized in Table 6.16.

Table 6.16

Lightering Times

Tanker operating days	3,904
Tanker operating hrs	93,696
Escort Trip hrs	7,826

The emission factors used are presented in Table 6.1; assumptions about engine horsepower and load factors that were obtained from the GMAQS (U.S. DOI, MMS 1995) are presented in Table 6.17.

Table 6.17

Lightering Vessel Characteristics

Type	Avg. kW	Load Factor – Idling	Load Factor - At Sea
Large Oil Tanker	25,592	0.1	--
Escort	12,412	0.1	0.8

Emission estimates were developed using the approach discussed in Section 6.1.1. An example of how the equation in Section 6.1.1 was used for this vessel category is provided below.

Example Calculation:

The total hours of operation of large oil tankers were 93,696. The average kW rating is 25,592, load factor is 0.1 for idling mode, and the emission factor for NO_x is 13.6 g/kWh.

$$E = AH \times kW \times LF \times EF \times CF$$

$$E = 93{,}696 \times 25{,}592 \times 0.1 \times 13.6 \times 1.10231 \times 10^{-6}$$

$$E = 3{,}594.74 \text{ tons of } NO_x$$

As lightering occurs, the ships pump water into their holds to enhance the stability of the vessel, referred to as ballasting. As water enters the hold during ballasting, organic vapors are displaced into the atmosphere. Activity data also were collected to quantify ballasting and estimate evaporative emissions using the equations listed below:

Evaporative Lightering:

$$Ev = Pt \times TOCc \times VOC/TOC \text{ conversion factor}$$

where:

Ev = Evaporative emissions (tons)
Pt = Annual amount of product transferred (gallons)
TOCc = Total organic compound content of crude oil (1 lb of TOC/120 gal of crude oil)
VOC/TOC = TOC to VOC conversion factor (0.85)

Evaporative Ballasting:

$$Eb = Cap \times 0.40 \times TOCc \times VOC/TOC$$

where:

Eb = Ballasting emissions (tons)
Cap = Capacity (gallons)
0.40 = Percent of capacity (percent)
TOCc = Total organic compound content of crude oil (1 lb of TOC/120 gal of crude Oil)
VOC/TOC = TOC to VOC conversion factor (0.85)

Tanker, escort idling, and evaporative emissions were assigned to the center of the lightering zones. Escort underway emissions were assigned to the shipping lanes that line the lightering zones to the port of Galveston/Houston as noted in Figure 6.10.

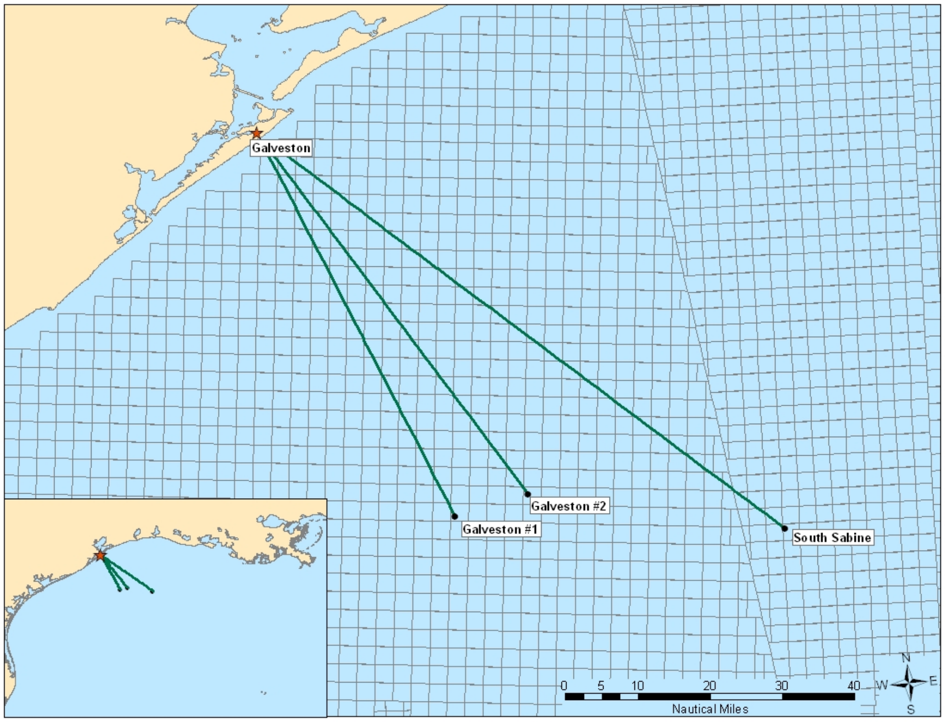

Figure 6.10. Centroid of the vessel lightering zone and shipping lane to Galveston.

7. DEVELOPMENT OF THE DIURNAL EMISSIONS CURVES

7.1 INTRODUCTION

Diurnal emission curves allow inventory emission estimates for a given category to be temporally allocated, across a 24-hour time period, on a 1-hour basis. Hour-by-hour emission estimates of this nature are required in order to run advanced photochemical simulation models such as the Urban Airshed Model. State agencies and the EPA may run such models, inclusive of Gulf of Mexico offshore sources, to address ozone and regional haze issues.

Source operations (and in turn their emissions) are, by their nature, inherently continuous and reasonably uniform or intermittent and non-uniform. For example, production processes are typically continuous (24 hours/day) and consistent because companies want to maximize the utilization of resources and obtain as much return on their investment as possible. Fluctuating operational levels are not consistent with these missions.

Other source types that are not directly production-driven may only operate to fulfill a specific need and may have an operation that is limited by other physical conditions (e.g., is only done in daylight). Meteorological conditions, for example, may also affect a source’s daily temporal profile (e.g., higher temperatures at mid day could mean higher emissions than at midnight).

The ERG developed diurnal emission curves for all sources in this study, platform as well as non-platform. Since the objective of having diurnal profiles is to support photochemical modeling, the temporal profiles presented in this section are for a typical day in August, during the ozone season. Like onshore situations, the Gulf of Mexico offshore source population consists of stationary point sources, and various mobile and natural source types. Caution should be used when applying these curves for September through December temporal allocations; these months are atypical because of the widespread damage caused by hurricanes Katrina and Rita.

7.2 APPROACH

The Gulfwide study source population consists of point sources, mobile sources, and natural sources. Because it is infeasible to survey every individual piece of equipment in the study area, offshore industry trends in daily operation were developed for a subset of sources within each major category grouping. This information was then applied to the category as a whole.

The temporal profiles presented here were developed for a typical day in the ozone season. In a typical summer day, activity for production platforms, drilling, tanker-shipping, space cooling, drill rig mobilization, and setting of new platforms were expected to be fairly continuous on a 24-hour basis. This would be especially true for the latter two categories, since companies want to maximize such activities during the good summer weather months. Activities such as helicopter traffic and supply boats are not continuous and generally cycle in conjunction with daylight hours.

The ERG obtained the temporal profiling data from a number of sources. Activity levels and diurnal variations are best determined through surveys or estimated using engineering judgement by people familiar with the sources. Direct monthly survey data are available for platform equipment: the monthly hours of operation for each piece of equipment were provided by platform operators through GOADS data collection.

For non-platform sources, information was derived from published industry statistics and the 1995 MMS study *Gulf of Mexico Air Quality Study, Final Report* (U.S. DOI, MMS 1995). COMM Engineering provided information on the daily operational patterns and characteristics of the sources based on their permitting experience with offshore oil and gas operations. Lastly, default allocation algorithms and values were obtained from EPA guidance documents dealing with modeling inventories and modeling requirements for the ozone and $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) (U.S. EPA 1991, 1999, 2001). These guidance documents are designed to help inventory preparers determine hourly emissions.

7.3 SOURCE CATEGORY GROUPINGS AND DIURNAL PATTERNS

The following platform operations are estimated to have essentially constant and uniform operation, with no significant variation in emissions throughout a 24-hour ozone season day (Figure 7.1). The assumed uniform operations for the platform sources are based on information provided by COMM Engineering and in the EPA study *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursor's of Ozone* (U.S. EPA 2001):

- Amine units;
- Drilling operations;
- Combustion flares;
- Fugitive emissions;
- Glycol dehydrators;
- Losses from flashing;
- Mud degassing;
- Pneumatic pumps;
- Pressure and level controllers; and
- Cold vents.

The following non-platform operations are also estimated to have essentially constant and uniform operations. For the most part, the assumed uniform operation for these sources is based on information in the 1995 U.S. DOI, MMS study:

- Commercial marine vessels;
- LOOP activities;
- Military vessels;
- Oceangoing barges; and
- Survey and exploration vessels.

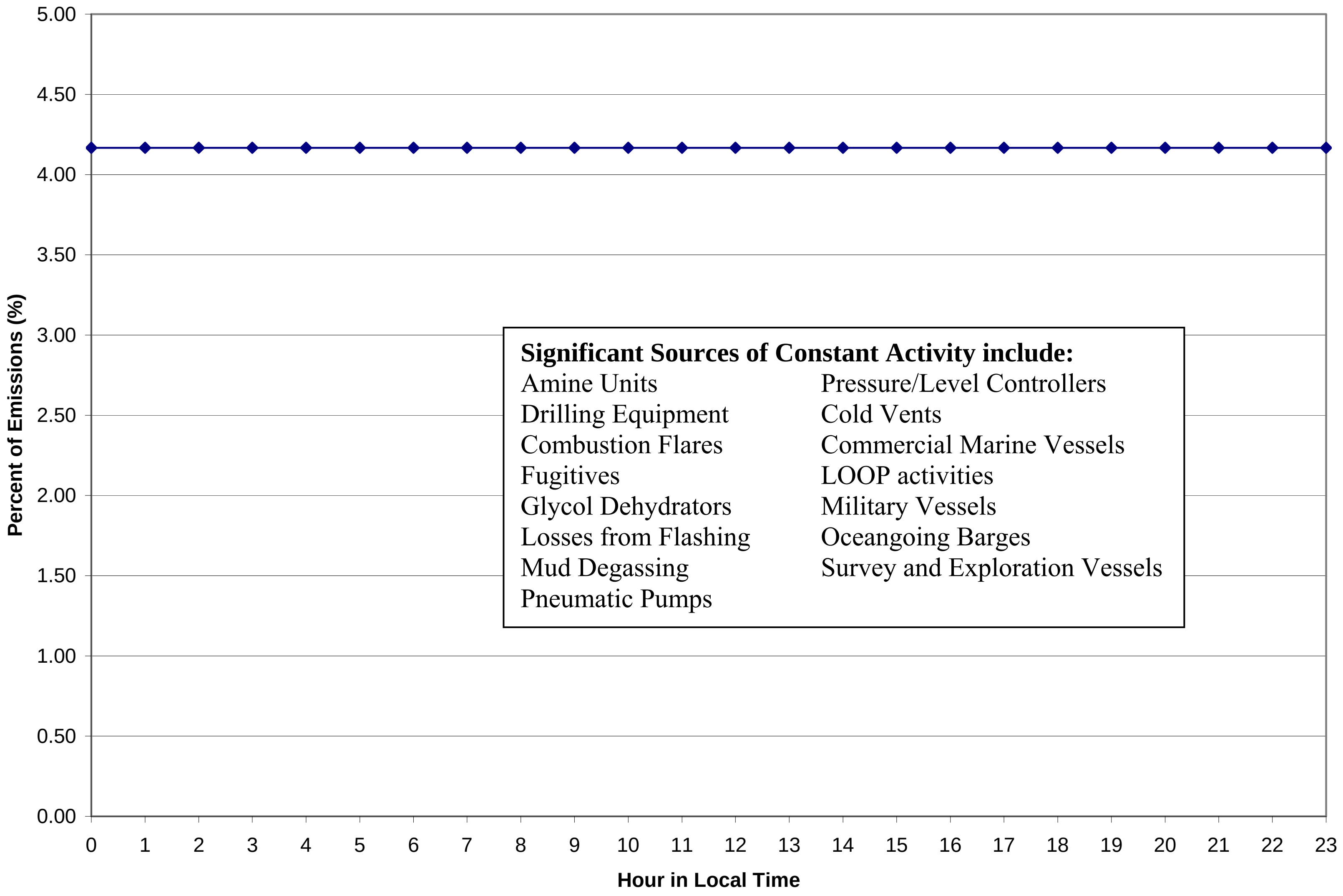

Figure 7.1. Duirnal emission curve for sources of constant activity.

Figures 7.2 and 7.3 represent diurnal emission curves for equipment groups that have slight diurnal variation: boilers/heaters/burners, internal combustion engines, and turbines. Diurnal curves are expressed as the percentage of total emissions that occur at each 1-hour interval for each emission source. Temporal profiles from the EPA were used to calculate these percentages (U.S. EPA, 2001).

Figure 7.4 presents the diurnal curve for source categories whose variation is temperature-driven throughout a 24-hour ozone season day:

- Biogenic Ocean Processes;
- Loading Losses;
- Oil Seeps; and
- Storage Tanks.

This curve is based on the fluctuation in average air and water temperature (recommended by COMM Engineering) in the GOM (U.S. DOC, NOAA 2001), as shown in Figure 7.5.

Figure 7.6 presents the diurnal curve for two non-platform operations which average 21 hours of operation per day. This information is based on an offshore operators committee survey, as summarized in the U.S. DOI, MMS 1995 report. No further information was found for these operations. The curve assumes no significant activity between the hours of midnight and three a.m. This assumption is simply based on "engineering judgement."

- Helicopters; and
- Support Vessels - Crew Boats, Supply Boats, Tugs, Barges.

Table 7.1 presents the hourly data as a percent of total emissions for each equipment group, and a short explanation as to the data sources used to develop the pattern. Table 7.2 presents the Source Classification Codes (SCCs) used to develop the curves from the (U.S. EPA 2001) study *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursor's of Ozone*.

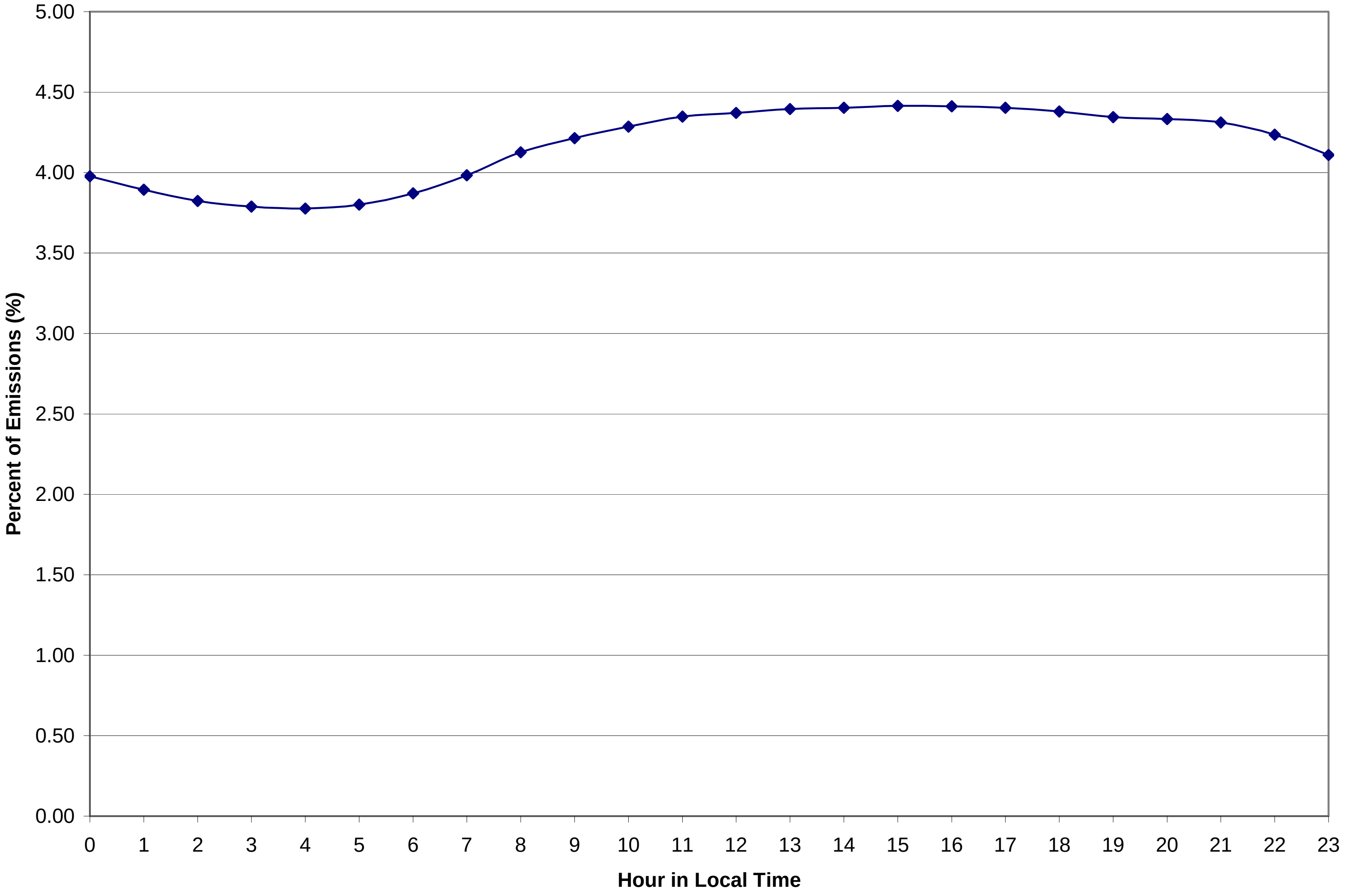

Figure 7.2. Diurnal emission curve for boilers/heaters/burners.

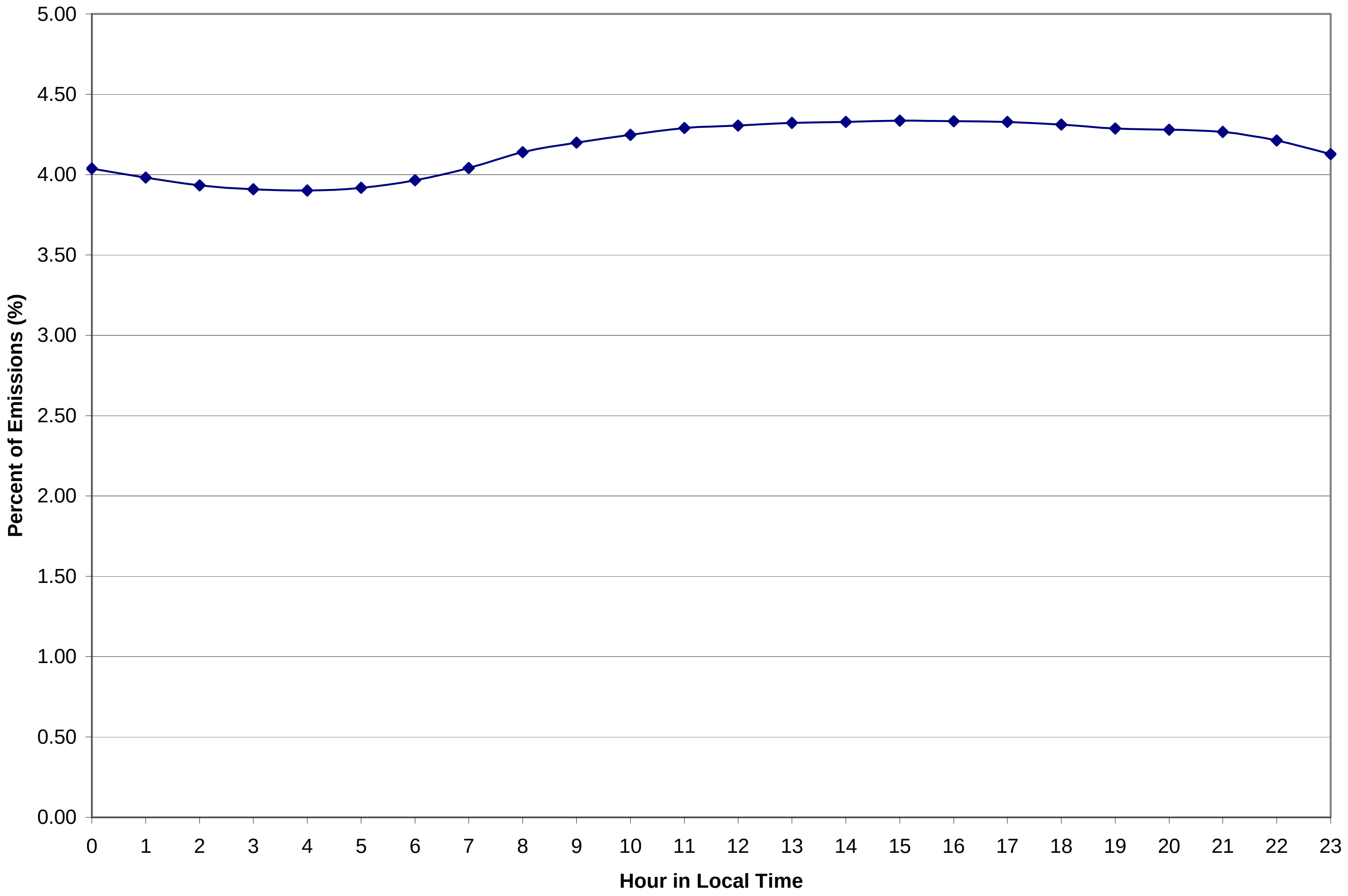

Figure 7.3. Diurnal emission curve for natural gas turbines and internal combustion engines.

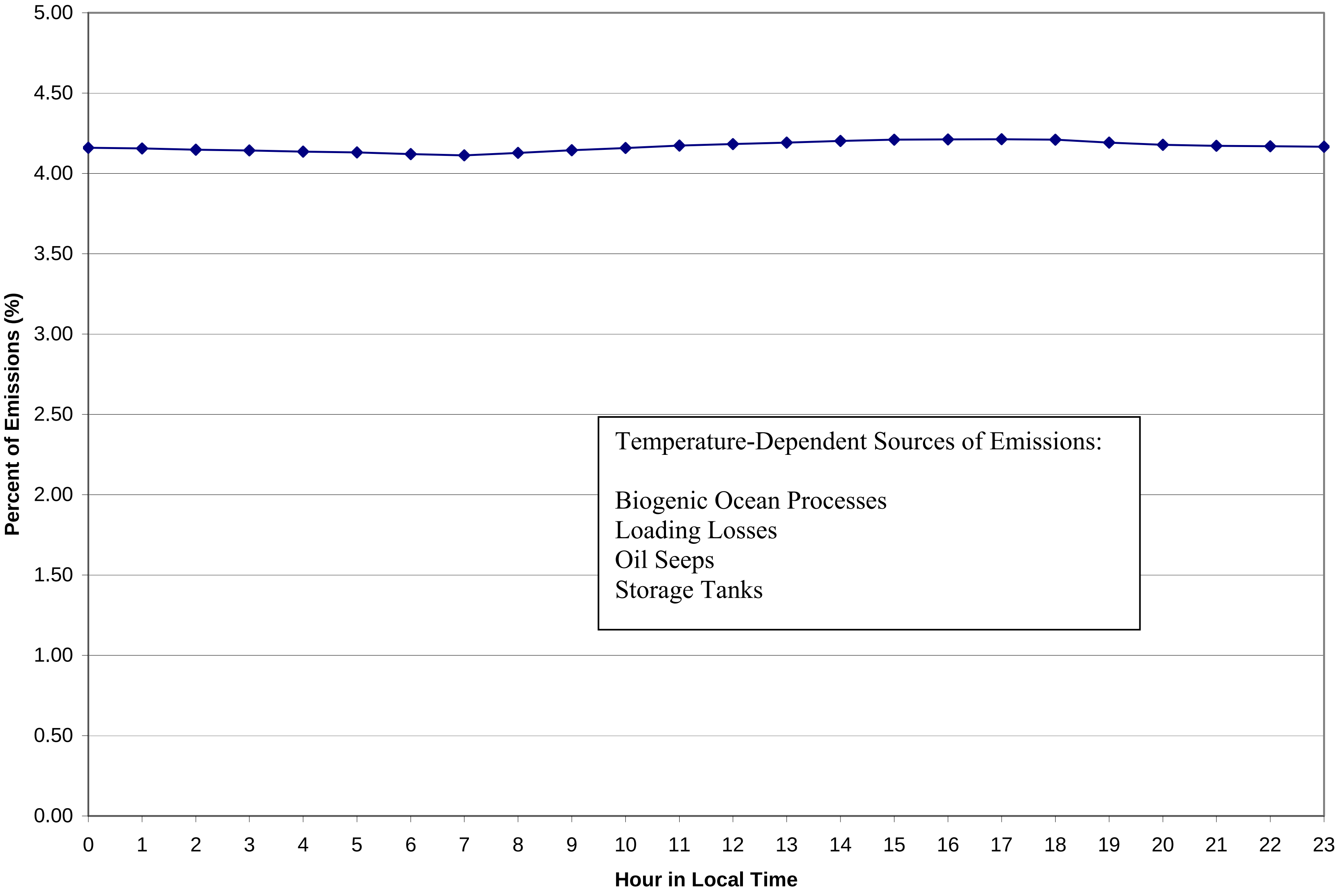

Figure 7.4. Diurnal emission curve for temperature dependent activities.

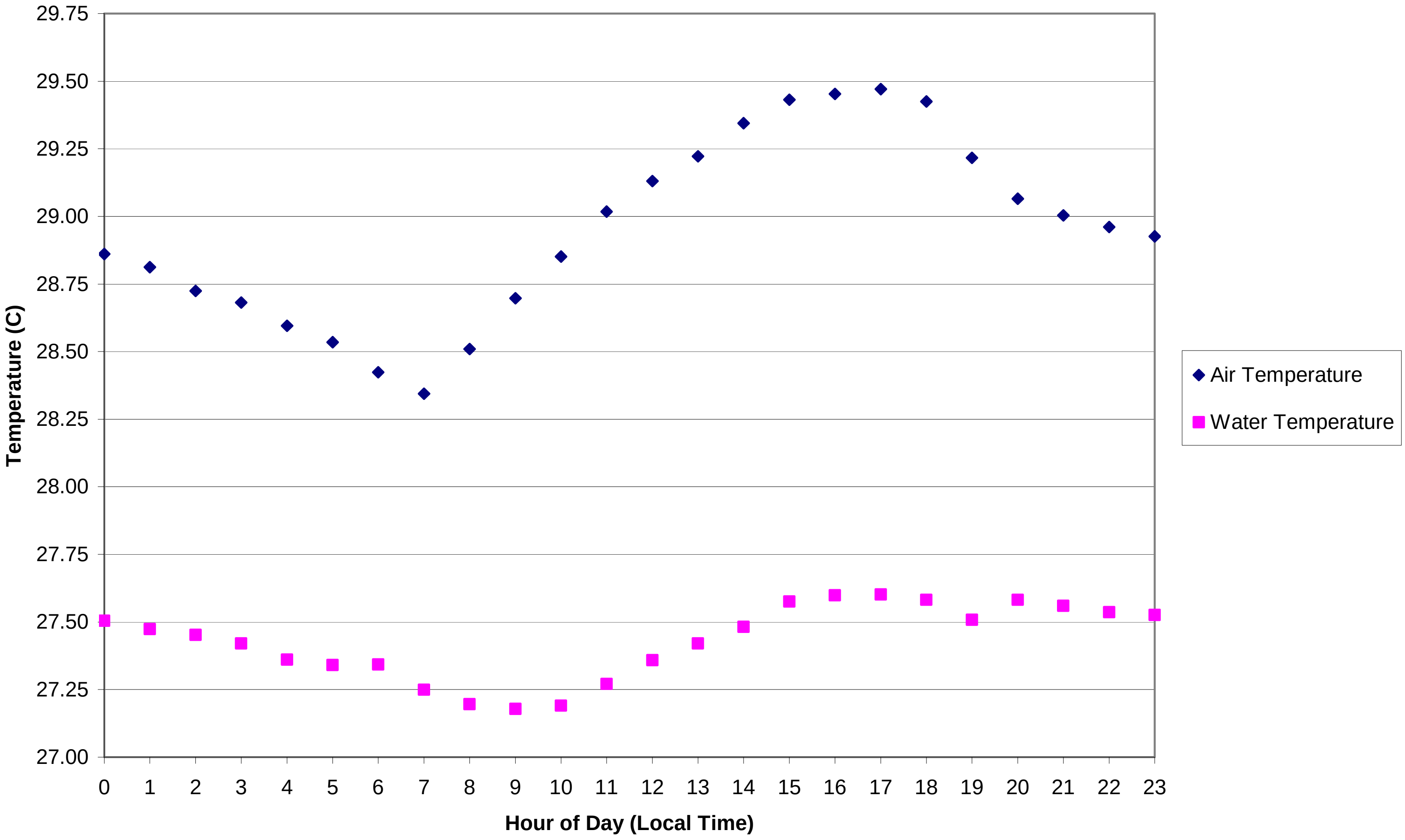

Figure 7.5. Average air and water temperatures for 17 Gulf of Mexico buoys in August 2000.

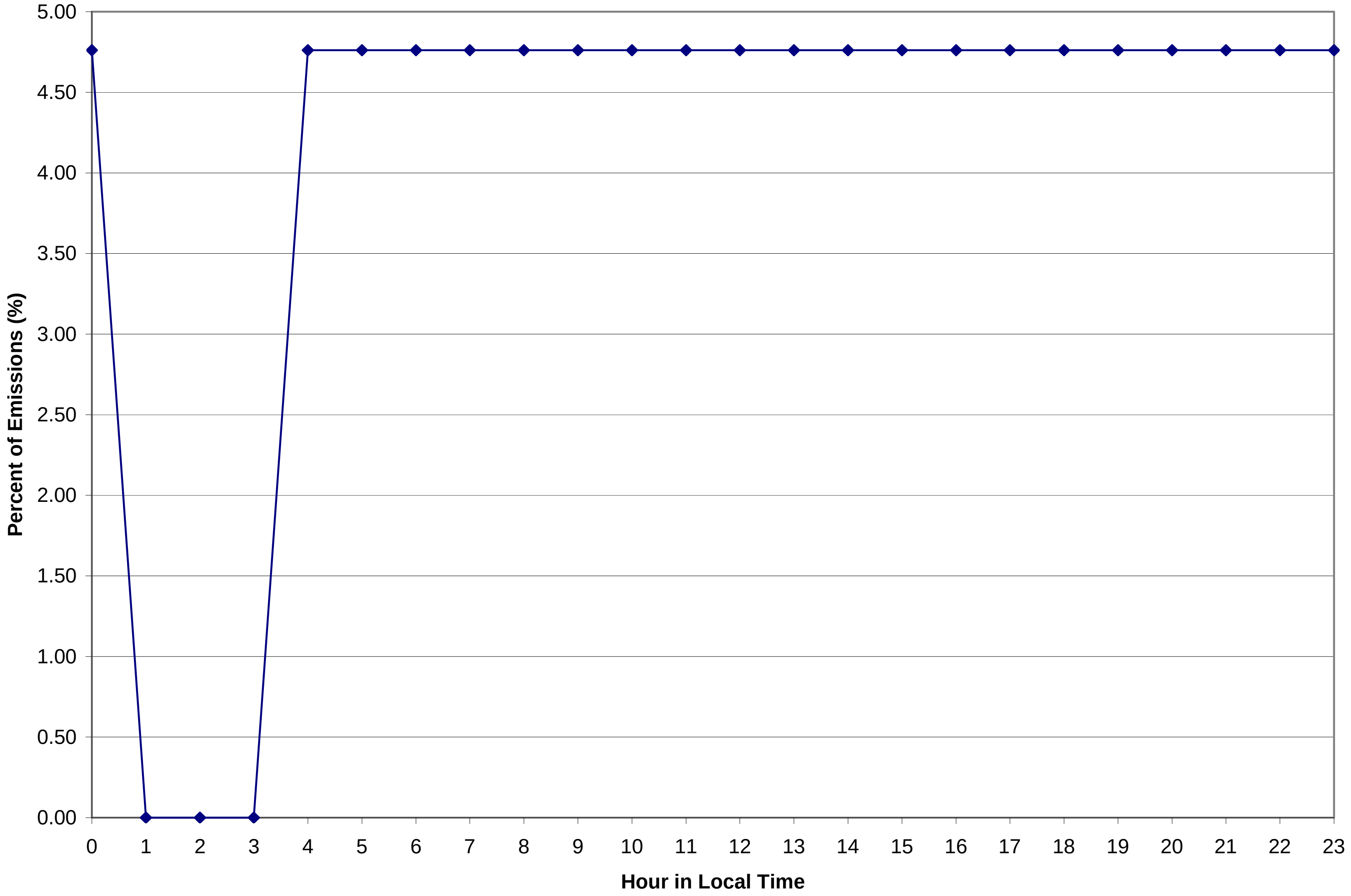

Figure 7.6. Diurnal emission curve for helicopters and support vessels.

Table 7.1

Diurnal Emission Percentages for Activity Groups

	Percentage of Emissions (%)				
Hour (Local Time)	Constant Activity Sources[1]	Boiler/Heater/ Burners[2]	Natural Gas Turbines and ICEs[3]	Temperature-Dependent Sources[4]	Helicopters & Supply Vessels[5]
0	4.17	3.98	4.04	4.16	4.76
1	4.17	3.89	3.98	4.15	0.00
2	4.17	3.82	3.93	4.15	0.00
3	4.17	3.79	3.91	4.14	0.00
4	4.17	3.78	3.90	4.14	4.76
5	4.17	3.80	3.92	4.13	4.76
6	4.17	3.87	3.97	4.12	4.76
7	4.17	3.98	4.04	4.11	4.76
8	4.17	4.13	4.14	4.13	4.76
9	4.17	4.21	4.20	4.14	4.76
10	4.17	4.29	4.25	4.16	4.76
11	4.17	4.35	4.29	4.17	4.76
12	4.17	4.37	4.31	4.18	4.76
13	4.17	4.39	4.32	4.19	4.76
14	4.17	4.40	4.33	4.20	4.76
15	4.17	4.42	4.34	4.21	4.76
16	4.17	4.41	4.33	4.21	4.76
17	4.17	4.40	4.33	4.21	4.76
18	4.17	4.38	4.31	4.21	4.76
19	4.17	4.34	4.29	4.19	4.76
20	4.17	4.33	4.28	4.18	4.76
21	4.17	4.31	4.27	4.17	4.76
22	4.17	4.24	4.21	4.17	4.76
23	4.17	4.11	4.13	4.16	4.76

[1] = Using information provided by U.S. DOI, MMS (1995), temporal profiles from U.S. EPA (2001), and by engineering judgement, hourly emissions are assumed to be constant and uniform

[2] = Temporal profiles from U.S. EPA (2001) were used to calculate these percentages for boilers, heaters, and burners

[3] = Temporal profiles from U.S. EPA (2001) were used to calculate these percentages for natural gas turbines

[4] = Hourly temperature data were retrieved from NOAA to create a profile for sources dependent upon temperature

[5] = Using information provided by U.S. DOI, MMS (1995) and by engineering judgement, activities for these sources are assumed to operate continuously from 4 a.m. to midnight

Table 7.2

SCCs of Interest for Platform Operations (diurnal patterns)

MMS Group Category	SCC	SCC DESCRIPTION
Amine Units	3-10-002-01	Industrial Processes: Oil and Gas Production - Natural Gas Production, Gas Sweetening: Amine Process
	3-10-003-05	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Gas Sweeting: Amine Process
Boilers/Heaters/ Burners	1-01-006-01	External Combustion Boilers: Electric Generation - Natural Gas, Boilers > 100 Million Btu/hr except Tangential
	1-01-006-02	External Combustion Boilers: Electric Generation - Natural Gas, Boilers < 100 Million Btu/hr except Tangential
	1-01-006-04	External Combustion Boilers: Electric Generation - Natural Gas, Tangentially Fired Units
	1-010-07-01	External Combustion Boilers: Electric Generation - Process Gas, Boilers > 100 Million Btu/hr
	1-010-07-02	External Combustion Boilers: Electric Generation - Process Gas, Boilers < 100 Million Btu/hr
	1-020-06-01	External Combustion Boilers: Industrial - Natural Gas, > 100 Million Btu/hr
	1-020-06-02	External Combustion Boilers: Industrial - Natural Gas, 10-100 Million Btu/hr
	1-020-06-03	External Combustion Boilers: Industrial - Natural Gas, < 10 Million Btu/hr
	1-020-06-04	External Combustion Boilers: Industrial - Natural Gas, Cogeneration
	1-020-07-01	External Combustion Boilers: Industrial - Process Gas, Petroleum Refinery Gas
	1-03-006-01	External Combustion Boilers: Commercial/Institutional - Natural Gas, > 100 Million Btu/hr
	1-030-06-02	External Combustion Boilers: Commercial/Institutional - Natural Gas, 10-100 Million Btu/hr
	1-030-06-03	External Combustion Boilers: Commercial/Institutional - Natural Gas, < 10 Million Btu/hr
	3-100-04-04	Industrial Processes: Oil and Gas Production - Process Heaters, Natural Gas
	3-100-04-05	Industrial Processes: Oil and Gas Production - Process Heaters, Process Gas
	3-100-04-14	Industrial Processes: Oil and Gas Production - Process Heaters, Natural Gas: Steam Generators
	3-100-04-15	Industrial Processes: Oil and Gas Production - Process Heaters, Process Gas: Steam Generators
Drilling	3-100-01-22	Industrial Processes: Oil and Gas Production - Crude Oil Production, Drilling and Well Completion
	3-100-02-22	Industrial Processes: Oil and Gas Production - Natural Gas Production, Drilling and Well Completion
Flares	3-100-01-60	Industrial Processes: Oil and Gas Production - Crude Oil Production, Flares
	3-100-02-05	Industrial Processes: Oil and Gas Production - Natural Gas Production, Flares
	3-100-02-15	Industrial Processes: Oil and Gas Production - Natural Gas Production, Flares Combusting Gases >1000 BTU/scf
	3-100-02-16	Industrial Processes: Oil and Gas Production - Natural Gas Production, Flares Combusting Gases <1000 BTU/scf
	3-100-01-01	Industrial Processes: Oil and Gas Production - Crude Oil Production, Complete Well: Fugitive Emissions
	3-100-01-24	Industrial Processes: Oil and Gas Production - Crude Oil Production, Valves: General
	3-100-01-25	Industrial Processes: Oil and Gas Production - Crude Oil Production, Relief Valves

Table 7.2

SCCs of Interest for Platform Operations (diurnal patterns) (Continued)

MMS Group Category	SCC	SCC DESCRIPTION
Fugitives (Continued)	3-100-01-26	Industrial Processes: Oil and Gas Production - Crude Oil Production, Pump Seals
	3-100-01-27	Industrial Processes: Oil and Gas Production - Crude Oil Production, Ranges and Connections
	3-100-01-30	Industrial Processes: Oil and Gas Production - Crude Oil Production, Fugitives: Compressor Seals
	3-100-01-31	Industrial Processes: Oil and Gas Production - Crude Oil Production, Fugitives: Drains
	3-100-02-07	Industrial Processes: Oil and Gas Production - Natural Gas Production, Valves: Fugitive Emissions
	3-10-002-02	Industrial Processes: Oil and Gas Production - Natural Gas Production, All Equipment Leak Fugitives (Valves, Flanges, Connections, Seals, Drains)
	3-100-02-23	Industrial Processes: Oil and Gas Production - Natural Gas Production, Relief Valves
	3-100-02-24	Industrial Processes: Oil and Gas Production - Natural Gas Production, Pump Seals
	3-100-02-25	Industrial Processes: Oil and Gas Production - Natural Gas Production, Compressor Seals
	3-100-02-26	Industrial Processes: Oil and Gas Production - Natural Gas Production, Flanges and Connections
	3-100-02-31	Industrial Processes: Oil and Gas Production - Natural Gas Production, Fugitives: Drains
	3-100-03-06	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Process Valves
	3-100-03-07	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Relief Valves
	3-100-03-08	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Open-ended Lines
	3-100-03-09	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Compressor Seals
	3-100-03-10	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Pump Seals
	3-100-03-11	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Flanges and Connections
	3-100-02-27	Industrial Processes: Oil and Gas Production - Natural Gas Production, Glycol Dehydrator Reboiler Still Stack
	3-100-02-28	Industrial Processes: Oil and Gas Production - Natural Gas Production, Glycol Dehydrator Reboiler Burner
	3-100-03-01	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Reboiler Still Vent: Triethylene Glycol
	3-100-03-02	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Reboiler Burner Stack: Triethylene Glycol
Glycol Dehydrators	3-100-03-03	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Phase Separator Vent: Triethylene Glycol
	3-100-03-04	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Ethylene Glycol: General
	3-100-03-21	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Niagaran Formation (Mich.)
	3-100-03-22	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Prairie du Chien Formation (Mich.)

Table 7.2

SCCs of Interest for Platform Operations (diurnal patterns) (Continued)

MMS Group Category	SCC	SCC DESCRIPTION
	3-100-03-23	Industrial Processes: Oil and Gas Production - Natural Gas Processing Facilities, Glycol Dehydrators: Antrim Formation (Mich.)
	3-100-01-32	Industrial Processes: Oil and Gas Production - Crude Oil Production, Atmospheric Wash Tank (2nd Stage of Gas-Oil Separation): Flashing Loss
Losses from Flashing	4-04-003-12	Petroleum and Solvent Evaporation: Petroleum Liquids Storage (non-Refinery) – Oil and Gas Field Storage and Working Tanks, Fixed Roof Tank, Crude Oil, working+breathing+flashing losses
	4-04-003-22	Petroleum and Solvent Evaporation: Petroleum Liquids Storage (non-Refinery) – Oil and Gas Field Storage and Working Tanks, External Floating Roof Tank, Crude Oil, working+breathing+flashing
	4-04-003-32	Petroleum and Solvent Evaporation: Petroleum Liquids Storage (non-Refinery) – Oil and Gas Field Storage and Working Tanks, Internal Floating Roof Tank, Crude Oil, working+breathing+flashing
Natural Gas Turbines and ICEs	2-010-02-01	Internal Combustion Engines: Electric Generation - Natural Gas, Turbine
	2-010-02-08	Internal Combustion Engines: Electric Generation - Natural Gas, Turbine: Evaporative Losses (Fuel Delivery System)
	2-010-02-09	Internal Combustion Engines: Electric Generation - Natural Gas, Turbine: Exhaust
	2-02-002-01	Internal Combustion Engines: Industrial - Natural Gas, Turbine
	2-02-002-03	Internal Combustion Engines: Industrial - Natural Gas, Turbine: Cogeneration
	2-02-002-08	Internal Combustion Engines: Industrial - Natural Gas, Turbine: Evaporative Losses (Fuel Delivery System)
	2-02-002-09	Internal Combustion Engines: Industrial - Natural Gas, Turbine: Exhaust
	2-03-002-02	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Turbine
	2-03-002-03	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Turbine: Cogeneration
	2-03-002-04	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Cogeneration
	2-03-002-05	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Reciprocating: Crankcase Blowby
	2-03-002-06	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Reciprocating: Evaporative Losses (Fuel Delivery System)
	2-03-002-07	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Reciprocating: Exhaust
	2-03-002-08	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Turbine: Evaporative Losses (Fuel Delivery System)
	2-03-002-09	Internal Combustion Engines: Commercial/Institutional - Natural Gas, Turbine: Exhaust

8. RESULTS

8.1 SUMMARY OF STUDY APPROACH

The MMS' *Year 2005 Gulfwide Emission Inventory Study* includes all major oil and gas production platforms and non-platform sources in the Central and Western Gulf of Mexico on the OCS. Pollutants covered in the inventory are the criteria pollutants—CO, NO_x, PM_{10}, $PM_{2.5}$, SO_2, and VOC; as well as greenhouse gases—CO_2, CH_4, and N_2O.

The MMS attempted to collect activity data from each active major offshore oil and gas production platform in the Gulf of Mexico on the OCS. Operators were provided with the GOADS-2005 Visual Basic activity data collection software for compiling monthly data for calendar year 2005. A total of 1,585 oil and gas production platforms submitted monthly equipment activity data files. The platform equipment surveyed includes:

- Amine units;
- Boilers/heaters/burners;
- Diesel engines;
- Drilling equipment;
- Combustion flares;
- Fugitive sources;
- Glycol dehydrators;
- Loading operations;
- Losses from flashing;
- Mud degassing;
- Natural gas engines;
- Natural gas turbines;
- Pneumatic pumps;
- Pressure/level controllers;
- Storage tanks; and
- Cold vents.

Rigorous QA/QC was performed on the activity data collected from platform operators. Tasks were implemented to correct the number of operating hours provided for a given month, fill in missing monthly operating data (if the equipment was operational), verify and correct activity values such as fuel heating value, make sure that the equipment shown to be vented included a vent ID and activity record, fill in missing stack parameters with surrogates, and double-check exit velocity and fuel usage totals by recalculating the parameters. The monthly activity data collected from the platform operators were then combined with emission factors and algorithms to develop the platform production equipment emission estimates. Inventory data files were compiled with the oil and gas production platform data suitable for use in air quality modeling applications. In addition to monthly emission estimates by pollutant and individual piece of equipment, the files include the company, structure and complex ID, lease number, block and area number, and latitude/longitude. For each piece of equipment, stack parameter information such as outlet height, exit velocity, and exhaust gas temperature is also presented.

Emission estimates were also developed for criteria air pollutants and greenhouse gases for non-platform sources operating in the Gulf of Mexico on the OCS for the 2005 calendar year. The non-platform sources included in this study are noted below.

Non-platform oil/gas production sources:

- Drilling vessels;
- Pipelaying operations;
- Support helicopters;
- Support vessels; and
- Survey vessels.

Non-platform non-oil/gas production sources:

- Biogenic and geogenic sources;
- Commercial fishing vessels;
- Commercial marine vessels;
- LOOP;
- Military vessels (Coast Guard/Navy); and
- Vessel lightering.

Estimates for a new geogenic source category were developed, mud volcanoes. After intensive research and data gathering of activity data specific to each source category, the compiled activity data underwent detailed QA/QC. For most marine vessel source categories, the emission factors used to calculate the vessel emissions from the engines were obtained from a study performed by the Swedish Environmental Protection Agency (SEPA 2004). The resulting non-platform emission estimates were then disaggregated into MMS lease blocks, and inventory data files were compiled with the non-platform data, suitable for use in air quality modeling applications.

8.2 PRESENTATION OF ANNUAL EMISSION ESTIMATES

The platform and non-platform emission estimates developed for criteria pollutants and greenhouse gases are presented in Tables 8.1 through 8.12. For an overview of the results, Table 8.1 summarizes the total platform criteria pollutant emission estimates, Table 8.2 summarizes the total non-platform criteria pollutant emission estimates, and Table 8.3 presents the combined platform and non-platform criteria pollutant estimates. To facilitate more detailed review, Tables 8.4 through 8.9 present platform and non-platform emission estimates by pollutant. The greenhouse emission estimates are provided in Tables 8.10, 8.11, and 8.12.

As noted previously, it is important to keep in mind the widespread damage in the Gulf of Mexico caused by Hurricanes Katrina and Rita, which impacted the inventory results for September through December.

Table 8.1

Total Platform Emission Estimates for Criteria Pollutants

Equipment	CO Emissions (tpy)	NO_x Emissions (tpy)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
Amine Units	0	0	0	0	979	<1
Boilers/heaters/ Burners	456	780	10	10	3	30
Diesel Engines	1,908	6,915	309	308	378	361
Drilling Equipment	1,174	4,420	79	77	558	111
Combustion Flares	964	185	<1	0	2	16
Fugitives	0	0	0	0	0	17,647
Glycol Dehydrators	0	0	0	0	0	997
Loading Losses	0	0	0	0	0	4
Losses From Flashing	0	0	0	0	0	870
Mud Degassing	0	0	0	0	0	61
Natural Gas Engines	82,073	57,647	272	272	18	1,638
Natural Gas Turbines	3,237	12,633	75	75	24	83
Pneumatic Pumps	0	0	0	0	0	1,189
Pressure/level Controllers	0	0	0	0	0	908
Storage Tanks	0	0	0	0	0	9,253
Cold Vents	0	0	0	0	0	18,073
Total Emissions (tpy)[a]	89,813	82,581	746	743	1,961	51,241

[a] Totals may not sum due to rounding

Table 8.2

Total Non-Platform Emission Estimates for Criteria Pollutants

Source Category	CO Emissions (tpy)	NO_x Emissions (tpy)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
Drilling Rigs	3,372	36,787	613	613	4,902	613
Pipelaying Vessels	2,016	9,714	367	367	1,650	367
Support Helicopters	7,729	1,307	199	199	478	1,645
Support Vessels	14,379	150,958	2,614	2,614	20,341	2,614
Survey Vessels	101	1,214	18	18	147	18
Total OCS Oil/Gas Production Sources (tpy)	27,597	199,979	3,812	3,812	27,520	5,257
Biogenic and Geogenic Sources	0	0	0	0	0	14,358
Commercial Fishing Vessels	89	1,009	16	16	124	16
Commercial Marine Vessels	3,494	94,756	1,159	1,159	8,793	1,639
LOOP	169	3,339	46	46	345	633
Military Vessels	492	5,213	135	135	1,025	54
Vessel Lightering	641	6,084	174	174	791	7,734
Total Non-OCS Oil/Gas Production Sources (tpy)	4,885	110,402	1,530	1,530	11,078	24,434
Total Non-Platform Emissions (tpy)[a]	32,482	310,380	5,342	5,342	38,598	29,692

[a] Totals may not sum due to rounding

Table 8.3

Total Platform and Non-Platform Emission Estimates for Criteria Pollutants

Equipment/ Source Category	CO Emissions (tpy)	NO_x Emissions (tpy)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
Total Platform Emissions	89,813	82,581	746	743	1,961	51,241
Drilling Rigs	3,372	36,787	613	613	4,902	613
Pipelaying Vessels	2,016	9,714	367	367	1,650	367
Support Helicopters	7,729	1,307	199	199	478	1,645
Support Vessels	14,379	150,958	2,614	2,614	20,341	2,614
Survey Vessels	101	1,214	18	18	147	18
Total OCS Oil/Gas Production Source Emissions	117,410	282,560	4,558	4,555	29,481	56,498
Total Non-OCS Oil/Gas Production Source Emissions	4,885	110,402	1,530	1,530	11,078	24,434
Total Emissions (tpy)[a]	122,295	392,961	6,088	6,085	40,559	80,933

[a] Totals may not sum due to rounding

Table 8.4

Annual CO Emission Estimates for All Sources

Equipment/Source Category	CO Emissions (tpy)
Natural Gas Engines	82,073
Support Vessels	14,379
Support Helicopters	7,729
Commercial Marine Vessels	3,494
Drilling Rigs	3,372
Natural Gas Turbines	3,237
Pipelaying Vessels	2,016
Diesel Engines	1,908
Drilling Equipment	1,174
Combustion Flares	964
Vessel Lightering	641
Military Vessels	492
Boilers/heaters/burners	456
LOOP	169
Survey Vessels	101
Commercial Fishing Vessels	89
Total Emissions (tpy)[a]	122,295

[a] Totals may not sum due to rounding

Table 8.5

Annual NO_x Emission Estimates for All Sources

Equipment/Source Category	NO_x Emissions (tpy)
Support Vessels	150,958
Commercial Marine Vessels	94,756
Natural Gas Engines	57,647
Drilling Rigs	36,787
Natural Gas Turbines	12,633
Pipelaying Vessels	9,714
Diesel Engines	6,915
Vessel Lightering	6,084
Military Vessels	5,213
Drilling Equipment	4,420
LOOP	3,339
Support Helicopters	1,307
Survey Vessels	1,214
Commercial Fishing Vessels	1,009
Boilers/heaters/burners	780
Combustion Flares	185
Total Emissions (tpy)[a]	392,961

[a] Totals may not sum due to rounding

Table 8.6

Annual PM_{10} Emission Estimates for All Sources

Equipment/Source Category	PM_{10} Emissions (tpy)
Support Vessels	2,614
Commercial Marine Vessels	1,159
Drilling Rigs	613
Pipelaying Vessels	367
Diesel Engines	309
Natural Gas Engines	272
Support Helicopters	199
Vessel Lightering	174
Military Vessels	135
Drilling Equipment	79
Natural Gas Turbines	75
LOOP	46
Survey Vessels	18
Commercial Fishing Vessels	16
Boilers/heaters/burners	10
Combustion Flares	<1
Total Emissions (tpy)[a]	6,088

[a] Totals may not sum due to rounding

Table 8.7

Annual $PM_{2.5}$ Emission Estimates for All Sources

Equipment/Source Category	$PM_{2.5}$ Emissions (tpy)
Support Vessels	2,614
Commercial Marine Vessels	1,159
Drilling Rigs	613
Pipelaying Vessels	367
Diesel Engines	308
Natural Gas Engines	272
Support Helicopters	199
Vessel Lightering	174
Military Vessels	135
Drilling Equipment	77
Natural Gas Turbines	75
LOOP	46
Survey Vessels	18
Commercial Fishing Vessels	16
Boilers/heaters/burners	10
Total Emissions (tpy)[a]	6,085

[a] Totals may not sum due to rounding

Table 8.8

Annual SO_2 Emission Estimates for All Sources

Equipment/Source Category	SO_2 Emissions (tpy)
Support Vessels	20,341
Commercial Marine Vessels	8,793
Drilling Rigs	4,902
Pipelaying Vessels	1,650
Military Vessels	1,025
Amine Units	979
Vessel Lightering	791
Drilling Equipment	558
Support Helicopters	478
Diesel Engines	378
LOOP	345
Survey Vessels	147
Commercial Fishing Vessels	124
Natural Gas Turbines	24
Natural Gas Engines	18
Boilers/heaters/burners	3
Combustion Flares	2
Total Emissions (tpy)[a]	40,559

[a] Totals may not sum due to rounding

Table 8.9

Annual VOC Emission Estimates for All Sources

Equipment/Source Category	VOC Emissions (tpy)
Cold Vents	18,073
Fugitives	17,647
Biogenic and Geogenic Sources	14,358
Storage Tanks	9,253
Vessel Lightering	7,734
Support Vessels	2,614
Support Helicopters	1,645
Commercial Marine Vessels	1,639
Natural Gas Engines	1,638
Pneumatic Pumps	1,189
Glycol Dehydrators	997
Pressure/level Controllers	908
Losses From Flashing	870
LOOP	633
Drilling Rigs	613
Pipelaying Vessels	367
Diesel Engines	361
Drilling Equipment	111
Natural Gas Turbines	83
Mud Degassing	61
Military Vessels	54
Boilers/heaters/burners	30
Survey Vessels	18
Commercial Fishing Vessels	16
Combustion Flares	16
Loading Losses	4
Amine Units	<1
Total Emissions (tpy)[a]	80,933

[a] Totals may not sum due to rounding

Table 8.10

Total Greenhouse Gas Emission Estimates for Platform Sources[a]

Equipment Types	CH_4 Emissions (tpy)	CO_2 Emissions (tpy)	N_2O Emissions (tpy)
Amine Units	4	0	0
Boilers/heaters/burners	12	651,640	12
Diesel Engines	8	305,921	N/A[b]
Drilling Equipment	0	227,917	N/A
Combustion Flares	326	10,786	<1
Fugitives	84,201	0	0
Glycol Dehydrators	6,811	0	0
Losses From Flashing	19,149	435	0
Mud Degassing	316	1	0
Natural Gas Engines	15,582	3,307,482	N/A
Natural Gas Turbines	340	4,342,651	118
Pneumatic Pumps	12,114	245	0
Pressure/level Controllers	6,141	136	0
Cold Vents	69,494	1,565	0
Total Emissions (tpy)[c]	214,499	8,848,779	130

[a] Emission factors for these pollutants were not available for loading losses and storage tanks

[b] N/A = not available

[c] Totals may not sum due to rounding

Table 8.11

Total Greenhouse Gas Emission Estimates for Non-Platform Sources

Source Category	CH_4 Emissions (tpy)	CO_2 Emissions (tpy)	N_2O Emissions (tpy)
Biogenic and Geogenic Sources	1,874	2,284	1,948
Commercial Fishing	<1	50,536	2
Commercial Marine Vessels	33	3,471,670	180
Drilling Rigs	12	1,998,734	95
LOOP	1	137,376	7
Military Vessels	<1	326,398	2
Pipelaying Vessels	7	657,052	28
Support Helicopters	N/A[a]	180,684	N/A
Support Vessels	52	8,282,197	392
Survey Vessels	<1	59,953	3
Vessel Lightering	4	318,784	15
Total Emissions (tpy)[b]	1,986	15,485,668	2,673

[a] N/A = Not available

[b] Totals may not sum due to rounding

Table 8.12

Total Platform and Non-Platform Emission Estimates for Greenhouse Gases

Equipment/ Source Category	CH_4 Emissions (tpy)	CO_2 Emissions (tpy)	N_2O Emissions (tpy)
Total Platform Emissions	214,499	8,848,779	130
Drilling Rigs	12	1,998,734	95
Pipelaying Vessels	7	657,052	28
Support Helicopters	N/A[a]	180,684	N/A
Support Vessels	52	8,282,197	392
Survey Vessels	<1	59,953	3
Total OCS Oil/Gas Production Source Emissions	214,571	20,027,399	649
Total Non-OCS Oil/Gas Production Source Emissions	1,913	4,307,048	2,154
Total Emissions (tpy)[a]	216,484	24,334,447	2,803

[a] N/A = Not available

[b] Totals may not sum due to rounding

8.3 LIMITATIONS

The development of any emissions inventory is dependent upon the completeness, accuracy, and temporal periods of the activity data obtained and the emission factors used. One key limitation and source of uncertainty associated with an OCS oil/gas production platform inventory effort pertains to the completeness of the platform activity data gathered and used to develop emission estimates. While it is difficult to confirm that all affected lessees and operators of federal oil, gas, and sulfur leases in the Gulf of Mexico OCS region provide files to MMS as required, ERG worked closely with MMS for the 2005 inventory study to identify and track major source facilities that should be reporting, according to the MMS Technical Information Management (TIMS) database. Through this process, minor sources such as living quarters and caissons that need not submit files were identified, as well as major sources that should submit files. Unfortunately, 2005 was an atypical inventory year due to widespread hurricane damage. Although MMS followed-up with reminders to these major sources, 2005 GOADS data were not submitted for all major platforms.

As discussed in Section 3, the GOADS-2005 Visual Basic activity data collection software was revised to operate more efficiently such that platform and equipment descriptions were entered into the system only once instead of monthly. A data import feature was also added and the platform-equipment lists from the 2000 inventory were made available to minimize the effort of re-entering this static information for the 2005 inventory. Thus, the monthly data entry requirements were reduced to just those dynamic platform and equipment activity data elements that changed on a month-to-month basis. At the equipment level, however, it was still difficult to know how well the operators understand what activity data are being requested in order to provide accurate monthly activity data. For example, losses from flashing may occur at all points where an oil stream undergoes a pressure drop. It is believed that emissions from flashing have been greatly underestimated because operators did not completely report the sources.

When operators failed to enter data or entered data that were considered atypical or suspect, ERG attempted to reconcile the data by reviewing the comments, contacting the operators, or developing surrogate data. For the atypical months of September, October, November, and December, care was taken when surrogate data were applied because of the widespread damage in the Gulf of Mexico by Hurricanes Katrina and Rita. Null or extremely low activity data values were not replaced with averages from the previous months.

Based on a comment by a Science Review Board member, ERG investigated the possibility that NO_x emission estimates from combustion equipment need to be adjusted to take into consideration the impact of humidity in reducing NO_x emissions. This was not an issue for non-platform source categories, as the emission factors used for these sources were adjusted for humidity. With regard to platform sources, ERG reviewed a paper titled *Applying Humidity and Temperature Corrections to On and Off-Road Mobile Source Emissions* (Lindhjem et al. 2004). This paper summarized the results of studies there were performed for the TCEQ (SwRI 2003). These studies indicated that when the dew point is over 15°C, a moisture correction may be needed. The emission rates were found to decrease most significantly in the evening and early morning (Lindhjem et al. 2004). These studies recommended emission adjustments consistent with the various engine applications, technologies, and fuel types. The background studies indicated that the configuration and design of the engines determine the model-specific correction factors. In addition, the studies found a change in diesel engine technology in 1994, meaning different correction factors would need to be applied for engines manufactured before and after 1994. The ERG investigated the possibility of compiling (or developing) NO_x correction factors for each combustion equipment type in the 2005 platform equipment files. It was concluded that the information available for combustion equipment in the inventory were not sufficient to justify the level of effort required to develop NO_x correction factors with any reasonable level of certainty. Based on the studies reviewed, application of correction factors could result in emission reductions of less than 10% of affected sources, similar to the reductions estimated for the Houston area.

As discussed in Section 6, emission estimates for marine diesel engines were developed using updated emission factors. Limitations remain for some of the non-platform emission estimates, however, based on the availability of activity data, as well as the quality of the emission factors. The new marine vessel emission factors for NO_x, CO, SO_2, VOC, CH_4 and N_2O have uncertainty ratings between 10% and 20%. The new PM emission factors have uncertainty ratings between 20% and 50%. For some source categories, activity data that previously had been available to the public were no longer available because of national security concerns. This was apparent with regard to obtaining lightering vessel data from the U.S. Coast Guard. Fortunately, this problem was addressed by obtaining more accurate data directly from the company that provides most all of the lightering escort services. Issues of national security were also noted for the LOOP, which previously provided vessel-specific schedules on their public web site. The 2005 activity data for the LOOP were therefore developed by adjusting the 2000 data also to account for the period that the platform was shut down during to the 2005 hurricane season.

Limitations associated with other non-platform source categories include the date that some of the helicopter emission factors were developed (early 1990's); the proprietary nature of the survey data, resulting in the allocation of survey vessel emissions to each lease block based on the surface area of the lease block; and the unavailability of up-to-date vessel data for the U.S. Navy. In addition, CMV activity were obtained from MARAD customs data. Vessels that do not go through customs procedures are not included, thus, actual CMV emissions may be higher than those reported here. The severe impact of the hurricanes also resulted in changes in operations for non-platform source categories such as drilling rigs and pipelaying vessels.

One last limitation to note is that while this inventory provides emission estimates for directly-emitted pollutants, it does not take into account changes of the emissions due to in-plume chemistry. These changes are based on the reactivity of the individual pollutant species, and transformation rates to secondary pollutants. For example, the inventory does not quantify how the NO_x and VOC emissions affect the chemical composition of the marine boundary layer, particularly in the formation of ozone and hydroxyl radicals. Such transformation of pollutants will need to be modeled in order to account for all factors that impact the transformation rate.

8.4 COMPARISON WITH OTHER STUDIES

At the completion of any emissions inventory effort, one final, useful QA/QC check is to compare the inventory results with those from similar inventories. The most applicable inventory to compare the results presented here is the 2000 *Gulfwide Emission Inventory for Regional Haze and Ozone Modeling* (Wilson et al. 2004a). The 2000 inventory report provided a detailed comparison of the 2000 inventory with the GMAQS (U.S. DOI, MMS 1995); that comparison will not be reproduced here. The following discussion compares the emission estimates developed for base year 2000 and the base year 2005 emission estimates presented here, by equipment type, source category, and pollutant. Similarities and differences between the two inventories will be discussed. As noted previously, Hurricanes Katrina and Rita severely impacted the September through December inventory results for 2005.

An overall comparison of pollutant-specific emission estimates for platform and non-platform sources is presented in Table 8.13. The CO and VOC emission estimates vary slightly from 2000 to 2005. Large differences are seen, however, in the PM_{10} estimates (52% increase), the NO_x estimates (93% increase), and the SO_2 estimates (52% increase). The following sections will examine these differences for the platform and non-platform emission estimates.

Table 8.13

Comparison of Total Platform and Non-Platform Criteria Pollutant
for Base Years 2000 and 2005 Emission Estimates

Base Year	CO Emissions (tpy)	NO_X Emissions (tpy)	PM_{10} Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
2000	113,303	203,349	4,016	26,760	85,008
2005	122,295	392,961	6,088	40,559	80,933
Percent Difference	8%	93%	52%	52%	-5%

8.4.1 OCS Oil and Gas Production Platforms

As noted previously, the emission estimation methods for platform sources are relatively unchanged between the 2000 and the 2005 inventories, the exception being the boilers/heaters/burners, flare-pilot, and natural gas turbine PM emission factors. Otherwise, any changes in emission levels, then, are due to the number of platforms included in the inventory, increases or decreases in activity levels, fuel type (for combustion sources), and how well the operators interpreted and completed the requested fields in the GOADS activity data collection software.

As shown in Table 8.14, for platform sources, only SO_2 shows a large difference in the emission estimates from 2000 to 2005. The SO_2 estimate shows a 43% decrease in 2005 emissions; the majority of the reductions are in the amine unit emission estimates, which are

Table 8.14

Comparison of Base Years 2000 and 2005 OCS Platform Criteria Pollutant Emission Estimates

	2000					2005				
Source Category	CO Emissions (tpy)	NO_X Emissions (tpy)	PM_{10} Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)	CO Emissions (tpy)	NO_x Emissions (tpy)	PM_{10} Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
Amine Units	0	0	0	2100	1	0	0	0	979	<1
Boilers/heaters/ Burners	511	446	29	2	21	456	780	10	3	30
Diesel Engines	894	4,043	194	143	217	1,908	6,915	309	378	361
Drilling Equipment	7,759	9,783	176	1,197	487	1,174	4,420	79	558	111
Combustion Flares	471	90	2	1	8	964	185	<1	2	16
Fugitives	0	0	0	0	29,826	0	0	0	0	17,647
Glycol Dehydrators	0	0	0	0	2,572	0	0	0	0	997
Loading Losses	0	0	0	0	7	0	0	0	0	4
Losses From Flashing	0	0	0	0	3,625	0	0	0	0	870
Mud Degassing	0	0	0	0	353	0	0	0	0	61
Natural Gas Engines	80,679	56,546	241	17	1,542	82,073	57,647	272	18	1,638
Natural Gas Turbines	1,830	7,141	147	12	47	3,237	12,633	75	24	83
Pneumatic Pumps	0	0	0	0	2,316	0	0	0	0	1,189
Pressure/level Controllers	0	0	0	0	990	0	0	0	0	908
Storage Tanks	0	0	0	0	5,627	0	0	0	0	9,253
Cold Vents	0	0	0	0	11,897	0	0	0	0	18,073
Total Emissions (tpy)[a]	92,144	78,049	789	3,472	59,536	89,813	82,581	746	1,961	51,241

[a] Totals may not sum due to rounding

unaffected by the number of platforms included in the inventories, but impacted by the hurricanes in September and October. Emission estimates for drilling activities also contribute to this reduction. Platform estimates for CO are relatively steady, with an overall decrease of 3%. CO emission levels increased for some source categories such as diesel engines, natural gas turbines, and combustion flares, but decreased for drilling activities for all months in 2005. Platform estimates for NO_x are also somewhat steady, with an overall increase of 6%. Diesel engines, combustion flares, and natural gas turbines showed increases in activity (hence, increases in NO_x emissions), but these increased emissions are again offset by decreased drilling activity. Platform estimates for PM_{10} show a slight decrease of 5% in total emissions, with decreased emission estimates for a number of source categories including boilers/heaters/burners (most likely due to the updated emission factor for natural gas usage), drilling activities, and natural gas turbines (again due to the emission factor). PM_{10} estimates from diesel engines increased due to increased activity levels. For VOCs, the 14% reduction in emission estimates is due in large part to the fugitive sources, with a decrease in 2005 emissions of 12,000 tons. Some of this change reflects MMS' goal to only include major platform sources in the inventory. In 2000, fugitive records were provided by 2,880 platforms, compared to 1,585 in 2005. Reductions are also seen in the emission estimates for losses from flashing; this is primarily due to activity or reporting reductions. In the 2000 inventory, over 200 records were processed for losses from flashing. In the 2005 inventory, only 92 records were flagged as "active," with the majority of emissions routed to system, vented (remotely), or flared (remotely). Emission estimates were only developed for active records, vented (or flared) locally.

Table 8.15 presents a comparison of emission estimates for greenhouse gases in the 2005 inventory and the 2000 inventory.

8.4.2 Non-Platform Sources

As shown in Table 8.16, for non-platform sources, emission estimates for all criteria pollutants show increases in the 2005 inventory compared to the 2000 inventory. Non-platform sources account for the overall 2005 PM_{10} increase of 52%, most of the overall 2005 NO_x increase, and the overall 2005 SO_2 increase of 52%, shown in Table 8.13. For the most part, emissions from non-platform sources are higher in the 2005 inventory relative to the 2000 inventory for two reasons: 1) for source categories with the more up-to-date emission marine diesel engine emission factors, the emission factors tend to be higher than the older EPA marine vessel emission factors; and 2) new, more accurate activity data were used in the 2005 inventory for support helicopters, support vessels, survey vessels, and CMVs, which tended to be higher than the 2000 values. For SO_2, support vessels and CMVs accounted for the majority of the increase. Vessel lightering is a category where some emissions are noted as declining; this is primarily due to the use of more accurate (and reduced) activity data for escort vessels.

Higher emission estimates associated with the new marine diesel engine emission factors affect all pollutants, with most dramatic changes noted with NO_x and VOC. An evaluation was performed of the EPA emission factors used in the 2000 Gulfwide Inventory and the Swedish emission factors used in this 2005 Gulfwide Inventory. Variance between the two sets of emission factors suggested that they were similar except for NO_x, which was consistently higher in the Swedish factors for slow and medium speed diesel engines. Though the variance was

Table 8.15

Comparison of Base Years 2000 and 2005 OCS Platform Greenhouse Gas Emission Estimates[a]

	2000			2005		
Source Category	CH_4 Emissions (tpy)	CO_2 Emissions (tpy)	N_2O Emissions (tpy)	CH_4 Emissions (tpy)	CO_2 Emissions (tpy)	N_2O Emissions (tpy)
Amine Units	18	0	0	4	0	0
Boilers/heaters/Burners	9	741,563	9	12	651,640	12
Diesel Engines	5	168,906	N/A	8	305,921	N/A[b]
Drilling Equipment	69	508,714	N/A	0	227,917	N/A
Combustion Flares	159	290	0	326	10,786	<1
Fugitives	107,141	0	0	84,201	0	0
Glycol Dehydrators	11,400	0	0	6,811	0	0
Losses From Flashing	79,756	1,812	0	19,149	435	0
Mud Degassing	1,836	7	0	316	1	0
Natural Gas Engines	15,112	3,377,352	N/A	15,582	3,307,482	N/A
Natural Gas Turbines	192	2,454,703	67	340	4,342,651	118
Pneumatic Pumps	15,480	298	0	12,114	245	0
Pressure/level Controllers	11,796	217	0	6,141	136	0
Cold Vents	330,780	7,047	0	69,494	1,565	0
Total Emissions (tpy)[c]	573,753	7,260,909	76	214,499	8,848,779	130

[a] Emission factors for these pollutants were not available for loading operations and storage tanks

[b] N/A = not available

[c] Totals may not sum due to rounding

Table 8.16

Comparison of Base Years 2000 and 2005 OCS Non-Platform Criteria Pollutant Emission Estimates

	2000					2005				
Source Category	CO Emissions (tpy)	NO_X Emissions (tpy)	PM_{10} Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)	CO Emissions (tpy)	NO_x Emissions (tpy)	PM_{10} Emissions (tpy)	SO_2 Emissions (tpy)	VOC Emissions (tpy)
Drilling Rigs	2,147	20,453	508	3,440	197	3,372	36,787	613	4,902	613
Pipelaying Vessels	1,408	13,416	333	2,257	129	2,016	9,714	367	1,650	367
Support Helicopters	6,060	1,438	107	2,257	129	7,729	1,307	199	478	1,645
Support Vessels	7,314	56,660	1,415	9,680	757	14,379	150,958	2,614	20,341	2,614
Survey Vessels	15	151	4	25	1	101	1,214	18	147	18
Total OCS Oil/Gas Production Sources (tpy)	17,228	94,375	2,423	15,963	3,400	27,597	199,979	3,812	27,520	5,257
Biogenic and Geogenic Sources	0	0	0	0	13,561	0	0	0	0	14,358
Commercial Fishing Vessels	150	1,519	38	255	13	89	1,009	16	124	16
Commercial Marine Vessels	1,936	19,487	498	3,545	182	3,494	94,756	1,159	8,793	1,639
LOOP	294	1,159	31	204	646	169	3,339	46	345	633
Military Vessels	361	3,674	103	774	33	492	5,213	135	1,025	54
Vessel Lightering	1,190	5,086	134	2,547	7,639	641	6,084	174	791	7,734
Total Non-OCS Oil/Gas Production Sources (tpy)	3,931	30,925	804	7,325	22,074	4,885	110,402	1,530	11,078	24,434
Total Non-Platform Emissions (tpy)[a]	21,159	125,300	3,227	23,288	25,472	32,482	310,380	5,342	38,598	29,692

[a] Totals may not sum due to rounding

similar for VOC, most of emission factors used in this study were at the higher end of the range, while most of the factors used in the previous 2000 study were at the lower end of the range. EPA emission factors were higher for at sea maneuvering, but this only occurred for a limited number of cases, such as vessel lightering and while offloading product at the LOOP.

There are also a number of cases where the emission estimates are lower in the 2005 inventory; these tend to be due to declining activities as noted for commercial fishing vessels, pipelaying operations, and the LOOP. When the reduced activity data are combined with the more recent emission factors, however, some pollutant emission estimates for these sources categories show an increase due to the fact that the new emission factors have values greater than the old factors.

8.5 RECOMMENDATIONS

For platform sources, ERG and MMS have discussed the possibility of revising GOADS so that operators create a platform record, but flag the platform as a minor source that does not need to report monthly activity data. This will streamline the QA/QC process from the standpoint of tracking completeness. It will also likely aid the MMS in determining if excluding these minor sources has an adverse impact on the quality of the inventory for fugitive sources. We also believe that emissions from flashing have been greatly underestimated because operators did not completely report the sources. We suggest more operator training, and possibly revisions to GOADS to increase reporting for this potentially important emission source. One other equipment record that may need to be reviewed and revised is amine units. We feel that the most accurate estimates for amine units are developed externally of the DBMS using the AMINECalc model inputs, and this should be the only option in GOADS.

For non-platform sources, future inventory development efforts will build upon the foundation developed in previous MMS inventories. With each inventory, significant improvements have been made to the estimation methods and activity data gathering methods for non-platform source categories. For example, for the 2005 inventory, ERG obtained data from the Offshore Marine Service Association, TCEQ, the Coast Guard, a local marine exchange, and EPA to more accurately estimate the number and horsepower rating of support vessels operating in the Gulf of Mexico. These same data sources should be used for future inventories. For support helicopters, acquiring FAA data for the Gulf of Mexico eliminated the need for a potentially costly (but less effective) survey effort. For CMVs, accounting for domestic marine vessel traffic in Federal waters will provide more accurate emission estimates. In addition, for the 2005 inventory, average vessel characteristics were used to estimate emissions. In the future, use of vessel specific data are available and will provide more accurate estimates.

Lastly, one major improvement that can be made for the non-platform emission inventory is the development of monthly emission estimates rather than annual estimates. The U.S. Coast Guard’s Vessel Traffic System (VTS) data includes a compilation of global positioning system (GPS) information on all vessels entering the central area of the Gulf of Mexico. These monthly data can be disaggregated by vessel type and used to develop monthly estimates from the annual emission values.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.