Outer Continental Shelf Air Permit Application

(Air Quality Modeling Analysis)

Chukchi Sea

Devil's Paw Prospect

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AECOM Environment

Submitted to:
ConocoPhillips
Anchorage, Alaska

Submitted by:
AECOM
Westford, MA
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1.0 Introduction

1.1 Project Overview

The modeling report documents the procedures and results of the ambient air quality impact analysis conducted in support of the air quality permit application. Modeling was generally conducted with the procedures described in the modeling protocol, "Modeling Protocol for an Ambient Air Quality Impact Analysis for Proposed Exploratory Drilling (Devil's Paw Prospect) in the Chukchi Sea, Revision 02" (AECOM 2009). The Protocol was submitted to United States Environmental Protection Agency (USEPA) Region 10 on November 25, 2009 and described the preliminary project design and outlined specific procedures for conducting the ambient air quality impact analysis. The following changes to protocol procedures have been incorporated to the modeling analysis documented herein:

- Project mobile vessel emissions, referred to as secondary emissions in the protocol, were included in the significance modeling analysis as well as cumulative modeling. The protocol proposed only including jack-up drill rig emissions in the significance analysis;
- The protocol referenced buoy meteorological data that ultimately was not used in the analysis since the data record is less than 1 month;
- The methodology for determining short-term PM_{10} and $PM_{2.5}$ regional background concentrations that were used in the cumulative impact analysis was refined slightly from that proposed in the protocol;
- Although well testing activities were discussed in the protocol, they are not included in the ambient air quality impact analysis because CP is not seeking to permit well testing;
- The protocol stated that stationary sources associated with Shell Gulf of Mexico, Inc. (Shell) exploratory drilling would be included in the cumulative modeling analysis but that Shell's mobile sources would not be included. Instead, all of Shell OCS source's potential emissions, including those from mobile support vessels, were included in the cumulative impact analysis; and
- The protocol stated that in the cumulative analysis, Shell's OCS source would be modeled in the worst-case location with respect to CP as found through modeling the Shell OCS Source on the specific leases that Shell intends to operate on as detailed in the current Shell Exploration Plan. However, a more conservative approach was taken in the cumulative analysis, where the Shell OCS Source locations were based on the Shell lease blocks that are closest to CP lease blocks, not just those included in the current Shell Exploration Plan.

The project area is shown in **Figure 1-1**. Because this project lies outside the jurisdiction of the State of Alaska, but is within the 200 mile jurisdiction of the United States (US), these activities require an air quality permit to be issued by USEPA Region 10.

Total potential emissions for any regulated pollutant emitted by the project are less than 250 tons per year. As such, a Prevention of Significant Deterioration (PSD) permit (Part 52) is not required; CP is therefore submitting a Part 71 permit for the exploratory drilling program. Based on a comprehensive review of applicable rules, policy, and guidance, CP concluded that any ambient air quality impact analysis supporting the Part 71 permit application needed to demonstrate that impacts from the proposed project, while it is an OCS Source, show compliance with the National Ambient Air Quality Standards (NAAQS) for NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. As documented in this report, the modeling analysis demonstrates that project impacts will not cause or significantly contribute to an exceedance of the NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$ NAAQS.

Based on the definition of an OCS Source (40 CFR 55 Section 55.2), as a vessel, the jack-up drill rig is not an OCS Source until it is attached and erected upon the sea floor. Therefore, the drill rig is only an OCS Source between the time the rig platform is fully jacked into position above the water, locked into place, and ready for drilling and the point the platform is unlocked and begins to be lowered prior to relocation. As such, the ambient air quality impact analysis only includes emissions that will occur while the drill rig is an OCS Source.

Chapter 2.0 below provides additional details regarding the project equipment and permitting approach used for the planned project.

1.2 Model Selection Overview

Air quality dispersion modeling was conducted with the Offshore and Coastal Dispersion model (OCD). The OCD model is one of the dispersion models approved for use in USEPA's Guideline on Air Quality Models (GAQM) (USEPA 2005). The OCD model was selected for this application because it is the only GAQM model approved for predicting short-range impacts with the unique ability to simulate over water plume dispersion and transport from emission sources located on an offshore platform.

The OCD model contains special algorithms that consider the inherent differences in meteorology associated with a marine environment as opposed to other GAQM models that are tailored for applications over land. Furthermore, where other GAQM models use building downwash calculations that characterize airflow around solid structures fixed to the ground, the OCD model incorporates specialized downwash algorithms that consider airflow between the bottom of a structure, such as a jack-up rig, and the surface of the water. Chapter 3.0 provides more details regarding the OCD model application, including model inputs and implementation methodology.

1.3 Meteorological Data Overview

The OCD model requires the following meteorological inputs:

1) hourly representative of over water surface meteorological data observations to characterize the over water dispersion environment;

2) hourly observations from a land based station to represent over land dispersion; and

3) upper air data in the form of mixing heights.

As discussed below there were two sources of over water meteorological data available to characterize the over water meteorology for this OCD application: 1) data recorded by research vessels in the vicinity of the project area (see **Figures 1-1**and **1-2**) data collected at the National Weather Service (NWS) station in Wainwright (see **Figure 1-1**). In all cases, Wainwright NWS data was the closest representative source of over land data. Representative mixing heights were available from Barrow, Alaska (see **Figure 1-1**).

Based on these available data sources, two meteorological data bases were developed for input to the OCD model:

- Five years of recent meteorological data (1999, 2002, 2004, 2005, and 2006) from the Wainwright NWS station fulfilling both over water and the over land data requirements coupled with concurrent mixing heights from Barrow; and
- Several months (late July through early November 2008; overlapping the planned exploratory drilling period) of "onsite" over water data recorded by research vessels in the vicinity of the project area fulfilling over water data requirements, concurrent over land data measured at Wainwright NWS data fulfilling the over land data requirements, and concurrent mixing heights from Barrow.

These two meteorological data sets were preprocessed separately to develop two databases used for input to OCD. Separate OCD model iterations were executed with each database. As discussed further in the results sections below, the compliance demonstration, including the results of both the significance modeling and cumulative modeling, were based on modeling conducted with the 5-year Wainwright NWS database. Additional details regarding the development of the two meteorological databases used as input to OCD can be found in Chapter 4.0.

1.4 Significant Impact Analysis Overview

The first step in the ambient air quality impact analysis was to determine maximum ambient air quality impacts due to project potential emissions for comparison to the USEPA Significant Impact Levels (SILs). According to 40 CFR 55.2, the OCS potential to emit includes the OCS Source (drill rig) as well as those vessels associated with the project, which provide support and operate within 25 miles of the drill rig.

Based on standard modeling practice (USEPA 1990), the model predicted impacts resulting from the project potential emissions are first compared to the SILs. For pollutants and averaging periods where the modeled project impacts are below SILs, no further analysis is required and the compliance status with the NAAQS is not altered by the project. For pollutants and averaging periods where the project model predicted impacts are greater than the SILs, compliance with the NAAQS must be demonstrated with cumulative modeling of project sources, existing facility sources and background sources plus a representative background concentration component to represent potential minor sources not explicitly modeled.

As detailed in Chapter 6.0, the Significant Impact Analysis resulted in predicted impacts less than the SILs for 3-hour, 24-hour, and annual SO_2 Modeling results exceeded the SILs for 1-hour and 8-hour CO, 24-hour and annual $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2. Therefore, no further analysis was conducted for 3-hour, 24-hour, and annual SO_2 and the NAAQS compliance status is not altered by the project for these pollutants and averaging periods. However, a cumulative modeling analysis was conducted for 1-hour and 8-hour CO, 24-hour and annual $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2 to demonstrate compliance with the NAAQS. Chapter 6.0 provides additional details regarding the significant impact analysis including the results.

1.5 Regional Background Data Overview

For those pollutants where the maximum modeled project impacts were greater than the SILs, regional background concentrations for the cumulative impact analysis were developed to represent contributions from nearby sources not explicitly included in the dispersion modeling. These background concentrations were added to the cumulative modeled impacts (as described below and in Chapter 8.0) before demonstrating compliance with the NAAQS.

For CO and NO_2, the maximum short-term and long-term average concentrations recorded as part of the Wainwright Near-Term Ambient Air Quality Monitoring Program (Wainwright Monitoring Program) measured from November 2008 through October 2009 were used to develop regional background concentrations. For annual $PM_{2.5}$, the maximum long-term average concentration measured as part of the Wainwright Monitoring Program from March 2009 through October 2009 was used.

24-hour particulate concentrations (PM_{10} and $PM_{2.5}$) measured as part of the same monitoring program in Wainwright include, and are dominated by, the contribution from local fugitive dust sources that are not representative of the offshore project area which contains no fugitive dust sources. Simply adding particulate concentrations measured at Wainwright to model predicted concentrations would not be representative of over water locations. Therefore, a representative 24-hour background concentration over water was determined by summing the following two components:

- A regional background concentration including contributions from sea spray, and Wainwright fugitive dust and combustion sources; and

- A concentration determined through modeling the dominant Wainwright fugitive dust sources in the project area.

The regional background concentration was determined by finding the highest 24-hour measured particulate concentration from among all days dominated by winds blowing from the sea and community sources towards the Wainwright monitor. Dispersion modeling was then used to account for potential air quality impacts in the project area due to fugitive dust from sources associated with the Wainwright Airport. The modeled fugitive dust source emission rate was based on the maximum particulate impacts measured by the Wainwright Monitoring Program.

Additional details regarding the regional background data used in the cumulative analysis, including specific values, are provided in Chapter 7.0 and **Appendix M**.

1.6 Cumulative Impact Analysis Overview

Maximum project impacts exceeded the SILs for CO, NO_2, PM_{10}, and $PM_{2.5}$ (lowest proposed SILs for $PM_{2.5}$); therefore, a cumulative impact analysis was conducted to demonstrate compliance with the NAAQS for these pollutants. This modeling demonstration involved assessing the cumulative air quality impacts of 1) proposed project sources; 2) nearby off-site sources not related to the project; and 3) impacts from minor and naturally occurring sources not modeled represented by the existing regional background air quality.

The off-site inventory included emissions from the drilling operation planned by Shell Gulf of Mexico Inc. (Shell) in the Chukchi Sea. Shell has yet to be issued a permit for exploration activities to be potentially located near the planned project; however, a complete PSD permit application has been submitted and a draft permit was issued for public comment on January 8, 2010. Shell OCS source's potential emissions were included in the cumulative impact analysis. Shell potential emissions were limited according to the specific constraints included in the Shell air quality permit application and the exploration plan approved by Minerals Management Service for the first year of operation. According to the exploration plan, Shell intends to conduct activities on the Burger, Cracker Jack, or the SW Shoebill prospect, all of which are shown on **Figure 1-1** relative to the Devil's Paw Prospect.

Existing onshore stationary sources such as power plant combustion engines as well as residential and commercial heating sources in Wainwright, Point Lay, and Barrow were also considered for possible inclusion in the cumulative analysis. However, as described in Chapter 8.0, it was concluded that none of the existing sources would cause a significant concentration gradient in the project area and did not need to be explicitly modeled following GAQM Section 8.2.3 guidance.

A separate modeling analysis (detailed in **Appendix N**) evaluated whether it was necessary to include other non-project vessels such as cruise ships, supply vessels bound for Barrow and Prudhoe Bay, etc, in the cumulative analysis. Because modeling results indicated that impacts from such vessels will not cause a significant concentration gradient in the project area, it was concluded that they did not need to be modeled in the cumulative analysis.

The results of the cumulative impact analysis, which are summarized in **Table 1-1** and detailed in Chapter 8.0, clearly demonstrates that the project being permitted will not cause or contribute to a violation of the NAAQS for NO_2, SO_2, CO, PM_{10}, or $PM_{2.5}$.

1.7 Digital Record Overview

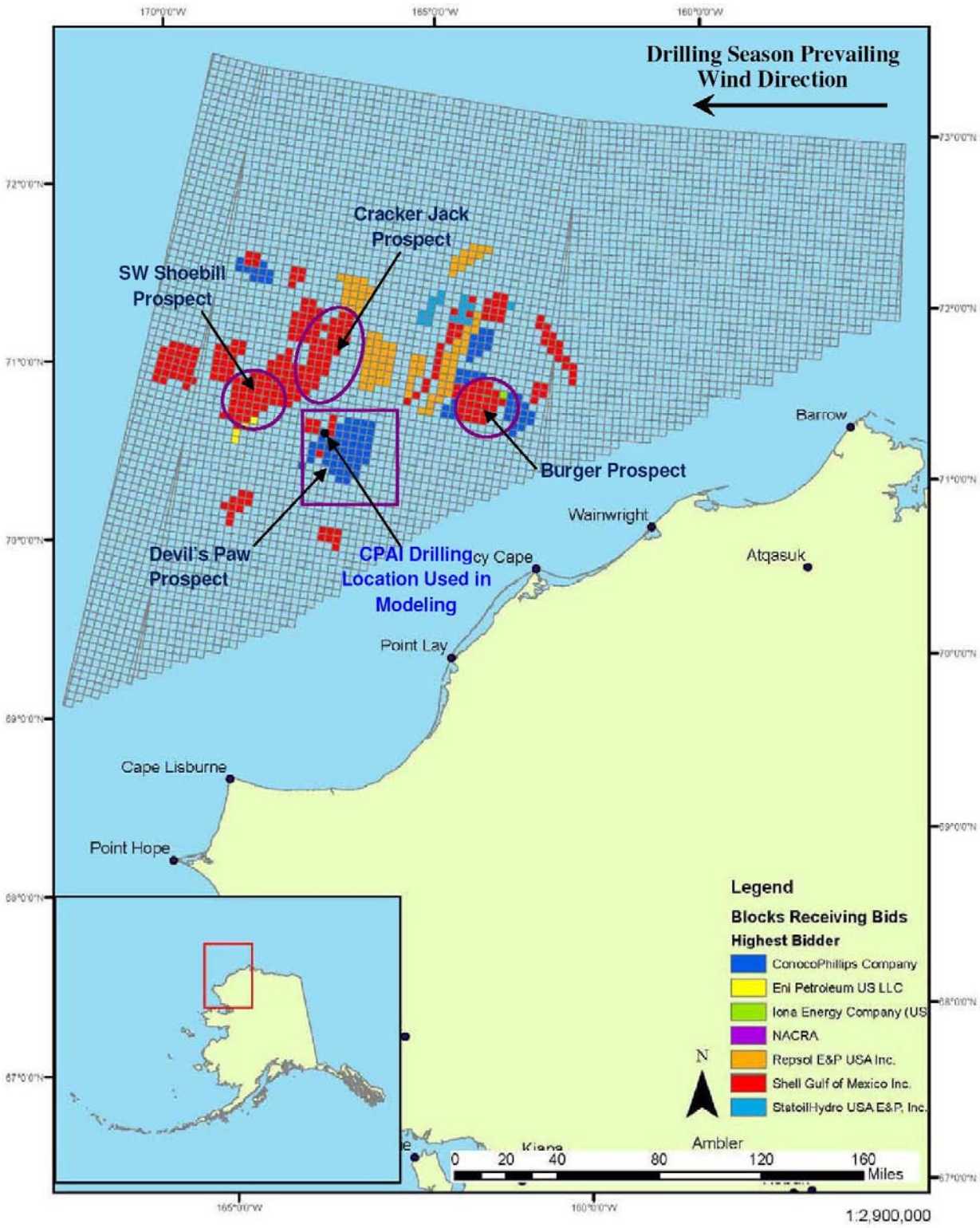
Chapter 9.0 provides details regarding the contents of the digital record that is included with this ambient air quality impact analysis DVD.

Table 1-1 Cumulative Analysis Results Summary

Pollutant	Averaging Period	Overall Maximum Predicted Impact	Background Conc. ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Location of Maximum Predicted Impact	
						Distance from CP Rig (km)	Direction of Impact Relative to CP Rig (deg)
CO	1-hr	2,075	1,050	3,125	40,000	0.11	243
	8-hr	1,094	945	2,039	10,000	0.14	111
NO_2	Annual	12.1	2	14.1	100	0.04	168
$PM_{2.5}$	24-hr	17.9	10	27.9	35	27	315
	Annual	2.3	3	5.3	15	27	315
PM_{10}	24-hr	37.2	49	86.2	150	27	315
SO_2	3-hr	< SIL			1,300	NA	NA
	24-hr	< SIL			365	NA	NA
	Annual	< SIL			80	NA	NA

NA = not applicable; cumulative modeling not required since project impacts less than SILs.

Figure 1-1 Chukchi Sea Sales 193 Lease Areas



2.0 Permitting Approach and Source Inventory

The project area is located from 110 to 150 km offshore; therefore, project air emissions are regulated under the OCS Air Regulations (40 CFR Part 55). Because this project lies outside the jurisdiction of the State of Alaska, but is within the 200 mile jurisdiction of the US, the project requires an air quality permit issued by the USEPA Region 10. Based on the limitations included in the permit application, the proposed project potential air emissions will not exceed 250 tons per year for any criteria pollutant, thus a PSD permit is not required and CP is seeking a Part 71 permit for this project. Total potential project emissions associated with the ambient air quality impact analysis are presented **Table 2-1**. Note that two operational options are planned for the proposed drilling project. Option 1 will include resupply of the drill rig with an Offshore Supply Vessel (OSV) and Option 2 will include resupply by a ware vessel.

To support the permitting effort, an ambient air quality dispersion modeling analysis has been conducted that demonstrates project cumulative impacts are below the NAAQS for NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$.

Table 2-1 CP Proposed Exploratory Drilling Total Potential Emissions

Source Description	Potential Emissions Totals (tpy)			
	NO_X	**CO**	**PM_{10} / $PM_{2.5}$**	**SO_2**
Drill Rig Emission Units	35	47	3.7	0.2
Secondary Vessels (Option 1 – OSV Resupply)	191	126	10	0.4
Secondary Vessels (Option 2 – Ware Vessel Resupply)	188	126	10	0.4
Total Potential Emissions (Option 1– OSV Resupply**)**	**225**	**174**	**14**	**0.6**
Total Potential Emissions (Option 2– Ware Vessel Resupply**)**	**223**	**173**	**14**	**0.6**

The project being permitted will be conducted on waters above the OCS, including an exploratory phase operation conducted to determine the characteristics of the reservoir and formation. Therefore, the project is considered an OCS Source (40 CFR 55.2). As an Exploratory OCS Source, all the equipment, including the drill rig, are considered vessels (i.e., not permanent structures). According to 40 CFR 55.2, vessels considered an OCS Source are 1) those located on the OCS, or in or on waters above the OCS that are temporarily attached to the seabed and erected thereon and 2) those that have a stationary aspect of vessels physically attached to an OCS facility.

As it relates to vessels like the jack-up drill rig, the definition of an OCS Source is very specific in that the vessel is only an OCS Source after it has 1) been attached to the seabed, and 2) erected on the seabed. The jack-up drill rig is not fully erected upon the seabed until the legs have been planted and the rig superstructure/platform has been raised above the water and locked into position prior to conducting routine activities. Subsequently, the drill rig ceases to become an OCS Source once the superstructure/platform is unlocked and begins to be lowered prior to relocation. As such, the ambient air quality impact analysis only includes emissions that will occur while the drill rig is an OCS Source.

As discussed, the modeling analysis includes air emissions from the OCS Source (i.e., the drill rig), as well as emissions from vessels that support and operate within 25 miles of it (i.e., spill response vessels, ice

management vessels, supply vessels, etc.). By definition (40 CFR 55.2), OCS Source potential emissions include emissions from vessels traveling to and from the source when within 25 miles of the source. All OCS Source potential emissions were considered in the ambient air quality impact analysis from the time the drill rig is planted to the sea floor and jacked into place through the time it begins to be jacked down prior to releasing from the sea floor.

2.1 Drill Rig Emissions

Drill rig potential emissions discussed below were included in the significant impact analysis and the cumulative air quality impact analysis. For the planned exploratory program, drill rig potential emissions are associated with the following emission unit types:

- Liquid fuel-fired internal combustion (IC) engines used for power generation;
- Liquid fuel-fired IC engines used for emergency power generation;
- Liquid fuel-fired heaters used for building and process heat;
- A Liquid fuel-fired IC engine used to power the logging winch; and
- A Waste-fired incinerator.

Figures 2-1 and **2-2** show the layout of the jack-up drill rig used for the ambient air quality impact analysis. **Table 2-2** provides a summary of drill rig emissions. Simulation of these sources in the ambient air quality impact analysis is presented in more detail in Chapter 5.0.

Table 2-2 Jack-up Drill Rig Emissions

Source Description	Potential Emissions Totals (tpy)			
	NO_x	CO	PM_{10} / $PM_{2.5}$	SO_2
4 Main Drilling Engines	30.0	46.2[1]	3.4[1]	0.1
Emergency Generator	1.1	0.3	0.0	0.0
2 Cement Engines	1.6	0.1	0.0	0.0
2 Heaters	1.3	0.3	0.1	0.0
Logging Winch	0.8	0.1	0.0	0.0
Incinerator	0.1	0.3	0.2	0.1
Total	**34.8**	**47.3**	**3.7**	**0.20**

[1] Emission rate is consistent with the application but lower than emission rate modeled. Therefore, modeling is conservative.

Figure 2-1 Representative Jack-up Drill Rig Layout (Side View, Cantilever Extended)

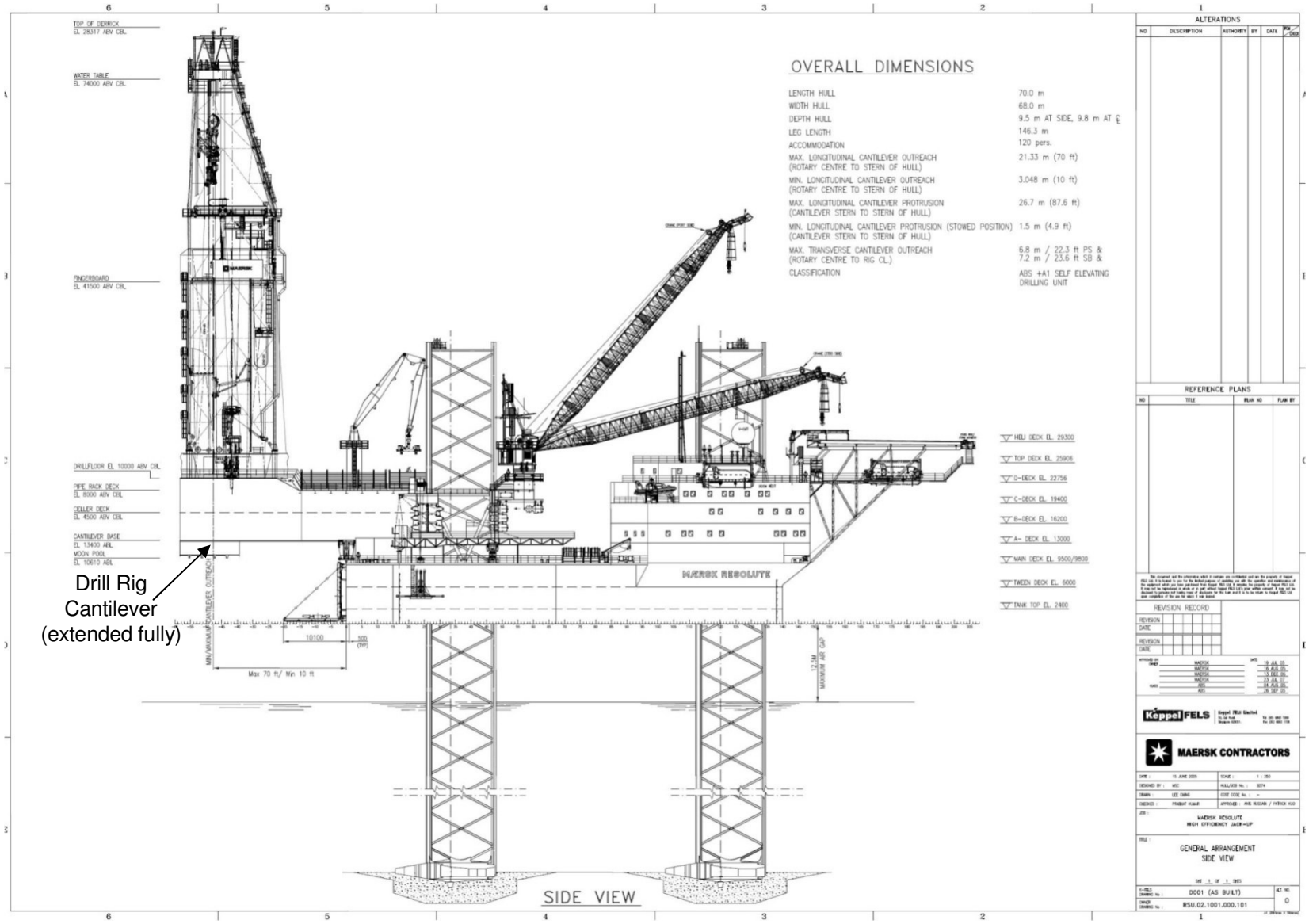
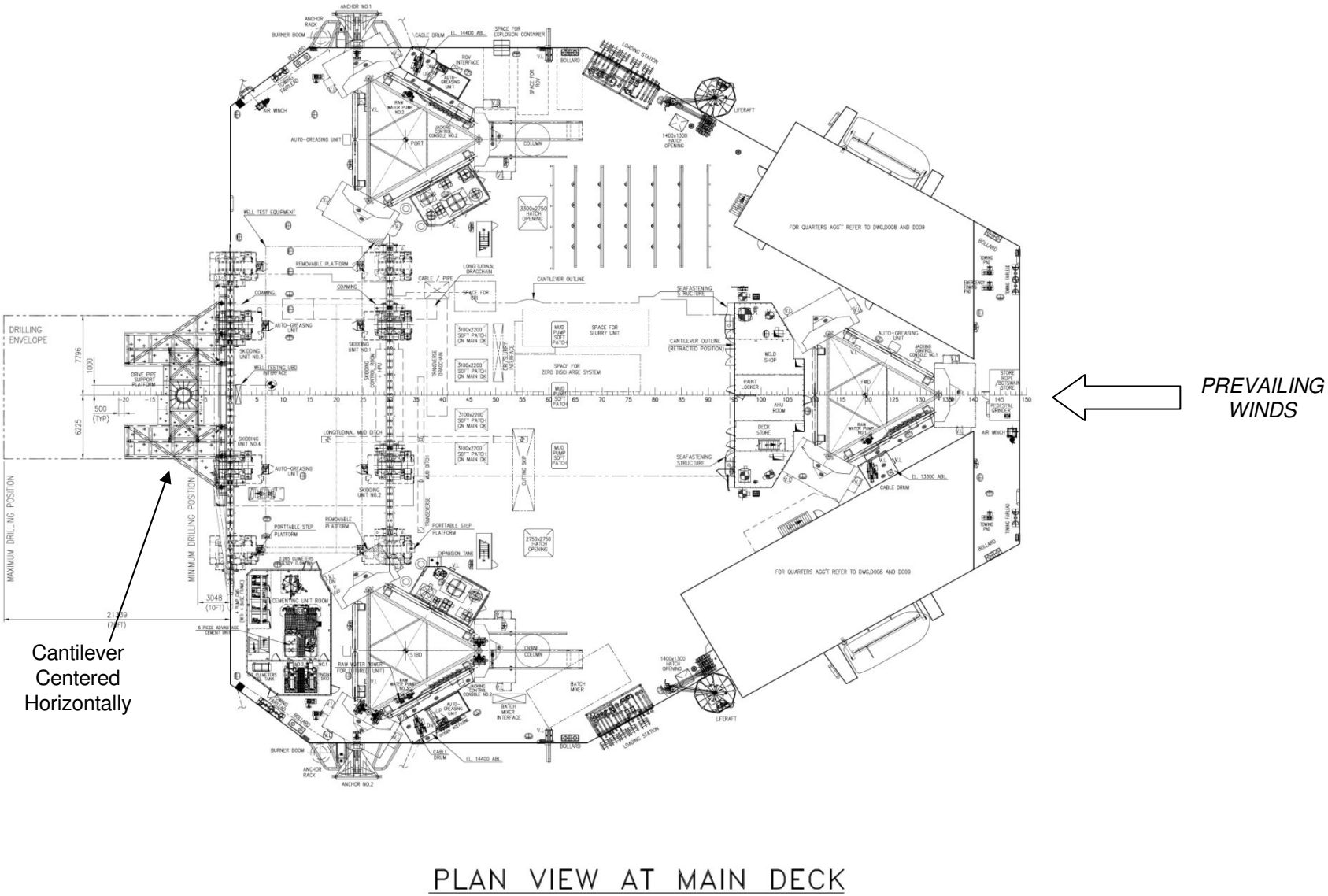


Figure 2-2 Representative Jack-up Drill Rig Layout (Top View, Cantilever Centered)



2.2 Support Vessel Emissions

The following vessel groups were included in the modeled source inventory:

- Ice Management Vessels – Two vessels will be staged near the project area to manage ice sheets that may break loose and drift toward the drilling operation;
- Dedicated Oil Spill Response Vessel (OSRV) – This OSRV will provide both large and small spill response as well as spill coverage in the event of a spill during fuel transfer at the drill rig. This OSRV will carry two small workboats that can be deployed as needed;
- Secondary Oil Spill Response Vessel – One OSRV with two workboats will be maintained further than 25 miles from the drill rig except for mandated spill response exercises;
- Spill Storage Tanker – This vessel is used to store fluids used for, and collected during, a spill event. This tanker will only operate within 25 miles of the drill rig during mandated simulated spill response exercises;
- Anchor Handling Supply Tug (AHST) – This vessel will be used to position the drill rig as it is being erected on the sea floor. Once the drill rig is erected, this vessel will remain in the vicinity of the drill rig until the stability of the drill rig is ensured;
- Offshore Supply Vessels (OSVs) – OSVs are smaller than ware vessels and may be used to shuttle supplies and manpower to the drill rig. Resupply will be provided by either an OSV (Option 1 – OSV Resupply) or ware vessel (Option 2 – Ware Vessel Resupply);
- Ware Vessels – This vessel may be used to transport large amounts of supplies (i.e., fuel, drilling fluids, pipe, etc.) to the project location. Resupply will be provided by either an OSV (Option 1 – OSV Resupply) or ware vessel (Option 2– Ware Vessel Resupply); and
- Research Vessel – A single vessel may be used to conduct biological, climatological, and oceanographic research, and evaluate environmental impacts of the operation.

Tables 2-3 and 2-4 provide a summary of vessel emissions. Note that the only difference between Options 1 and 2 is that Option 1 includes rig resupply by an OSV while Option 2 includes resupply by a ware vessel. The remainder of the vessel groups are included in both Options 1 and 2. Simulation of these sources and their activities in the ambient air quality impact analysis is presented in more detail in Chapter 5.0.

There are various vessels that will operate further than 25 miles from the drill rig and have not been included in the ambient air quality impact analysis. Among these are a Ware Barge and Tug combination that may be used to help in supplying the drill rig and would be located further than 25 miles from the drill rig. The Ware Barge and Tug would bring large amounts of supplies near the project area and act as an intermediate supply transfer point. Once in place, OSVs will lighter supplies between the barge and drill rig.

Table 2-3 Support Vessel Emissions – Option 1 – OSV Resupply

Vessel Description	Potential Emissions Totals for Option 1 – OSV Resupply (tpy)			
	NO_X	CO	PM_{10} / $PM_{2.5}$	SO_2
Ice Breaker 1	46.3[1]	52.7[1]	4.1[1]	0.2
Ice Breaker 2	46.3[1]	52.7[1]	4.1[1]	0.2
Oil Spill Response Vessel (OSRV) Activities	48.9	10.0	0.9	0.0
Anchor Handling Supply Tug (AHST)	4.5	1.1	0.1	0.0
Offshore Supply Vessels (OSVs)	33.0	7.7	0.6	0.0
OSRV Work Boats	2.5	0.2	0.1	0.0
Marine Research Vessel	8.1	1.7	0.2	0.0
Spill Storage Tanker	0.9	0.2	0.0	0.0
Total	**190.5**	**126.3**	**10.0**	**0.4**

[1] Emission rate is consistent with the application but lower than emission rate modeled. Therefore, modeling is conservative.

Table 2-4 Support Vessel Emissions – Option 2 – Ware Vessel Resupply

Vessel Description	Potential Emissions Totals for Option 2 – Ware Vessel Resupply (tpy)			
	NO_X	CO	PM_{10} / $PM_{2.5}$	SO_2
Ice Breaker 1	46.3[1]	52.7[1]	4.1[1]	0.2
Ice Breaker 2	46.3[1]	52.7[1]	4.1[1]	0.2
Oil Spill Response Vessel (OSRV)	48.9	10.0	0.9	0.0
Anchor Handling Supply Tug (AHST)	4.5	1.1	0.1	0.0
Ware Vessel	30.3	7.0	0.6	0.0
OSRV Work Boats	2.5	0.2	0.1	0.0
Marine Research Vessel	8.1	1.7	0.2	0.0
Spill Storage Tanker	0.9	0.2	0.0	0.0
Total	**187.8**	**125.6**	**9.9**	**0.4**

[1] Emission rate is consistent with the application but lower than emission rate modeled. Therefore, modeling is conservative.

3.0 Dispersion Model Selection

The air quality dispersion modeling analysis was conducted with the Offshore and Coastal Dispersion (OCD) model. OCD is approved for use in USEPA's Guideline on Air Quality Models (GAQM) (USEPA 2005). OCD has been recommended for use by the Minerals Management Service for sources located on the OCS (50 FR 12248; 28 March 1985). In addition, the OCD model was selected because it is the only GAQM model with the unique ability to simulate over water plume dispersion and transport from sources located on an offshore platform for short-range applications.

The suitability of an air quality dispersion model for a particular application is dependent upon several factors. The OCD model was selected because it is specifically designed to:

- appropriately characterize the over water dispersion environment of the project sources;
- compute short-range air quality impacts; and
- incorporate platform structure downwash, as opposed to solid structure downwash.

"The OCD model was developed by the Minerals Management Service to simulate plume dispersion and transport from offshore emission sources to receptors located on land or water. It is a steady-state Gaussian model with enhancements that consider the differences between over water and over land dispersion characteristics, and platform aerodynamic effects" (DiCristofaro and Hanna 1989).

Considering the offshore location of the proposed project and its significant distance from land, as well as the unique nature of the jack-up drill rig structure's downwash (as described below), the OCD model is the most appropriate short-range GAQM model for this ambient air quality impact analysis.

3.1 Dispersion Environment

As noted above, the proposed project will be located at least 110 km off the coast of Alaska. As such, the modeling domain is completely over water and a model that has the ability to characterize over water dispersion is necessary. This is because the over water variation in boundary layer stability, both diurnally and annually, is completely unrelated to that observed over land. This is primarily a result of the greater heat capacity of water compared to that of land which in turn moderates the over water air temperature due to the heat flux from the open ocean. Therefore, boundary layer stability over water cannot be parameterized using the same factors as that over land, and it is critical to use a model that can parameterize the over water stability properly. The OCD model can properly parameterize over water stability and is the USEPA GAQM short-range dispersion model recommended for applications involving over water sources and plume transport/dispersion.

3.2 Building Downwash Considerations

The wake and eddy effects from structures on plumes from stacks located near structures (i.e., building downwash effects) must be considered in order to predict near-field impacts. This is particularly complex for a jack-up drill rig which has many porous structures, and airflow under the rig superstructure. Fortunately, the OCD model has specialized algorithms to deal with this unique environment. As required by OCD for downwash computations, for each stack, a maximum building height and width, and the mean height of the platform base above the water surface, 12.5 meters (m), was input to the model.

It should be noted that consideration was given as to whether or not it was appropriate to utilize a dispersion model that incorporates the PRIME downwash algorithms. However, PRIME downwash algorithms were not developed nor evaluated for offshore platform type of structures where there is air flow between the water surface and the bottom of the structure; therefore, it is not appropriate for simulating a jack-up drill rig. A wind

tunnel and model algorithm development study specifically designed for the OCD model was completed by Petersen (1986) and the results were incorporated into OCD.

It is clear that for purposes of characterizing the over water dispersion environment as well as the structure downwash peculiar to offshore platform structures, OCD is the most appropriate model to use for the proposed project.

4.0 Meteorological Data for Use in the Model

To appropriately characterize the project area dispersion environment, the OCD model requires two surface meteorological data bases:

- Over Water - Hourly surface meteorological data observations from an over water station such as a buoy or vessel, or a representative coastal station; and
- Over Land - Data from a land-based station to represent over land dispersion.

In addition, OCD also requires upper air data in the form of mixing heights.

Long-term over water databases are not available in the project location and are difficult to obtain in the absence of a permanent offshore structure such as a drill rig or man-made island since ice is a limiting factor in the Chukchi Sea. However, as described further below, in this case it is perfectly acceptable to conduct dispersion modeling using data from a coastal station because meteorological conditions along the shore of the Chukchi Sea at the NWS in Wainwright are representative of those over water in the project location due to minimal terrain, the general lack of surface heating at high northern latitudes, and lack of sea breeze effects during most of the year. In order to demonstrate that it is perfectly acceptable to conduct dispersion modeling using data from a coastal station, for comparison, surface meteorological data are also available for several months (available from the end of July through the beginning of November of 2008) from two research vessels, the Bluefin and the Norseman.

Based on these data sources, two data bases were developed for input to the OCD model and separate modeling was conducted using each data base:

- Five years of recent meteorological data (1999, 2002, 2004, 2005, and 2006) from the Wainwright NWS station fulfilling both over water and over land data requirements coupled with concurrent mixing heights from Barrow; and
- Several months (late July through early November 2008; overlaps the planned exploratory drilling period) of "onsite" over water data recorded by research vessels in the project area fulfilling the over water data requirement, concurrent over land data measured at Wainwright NWS data fulfilling the over land data requirement, and concurrent mixing heights from Barrow.

These two data sets were processed separately to develop two databases. Each database was applied with OCD in separate model iterations. As discussed further in Chapter 6.0 and 8.0, the results of both the significance modeling and cumulative modeling, were from modeling conducted with the 5-year Wainwright NWS as the over water data source.

The following documents the specific parameters that were used to develop the two OCD over water meteorological databases.

<u>Five Years of Hourly Coastal NWS Data from 1999, 2002, and 2004 – 2006:</u>

This near-shore data consisted of representative NWS meteorological data collected at Wainwright, Alaska during calendar years 1999, 2002, 2004, 2005, and 2006. Model sensitively analyses were used to develop representative over water-specific parameters that are not measured at Wainwright. The following notes the source of each of the OCD required meteorological inputs for this over water database:

- Wind speed and direction – NWS station at Wainwright, Alaska;
- Ambient temperature – NWS station at Wainwright, Alaska;

- Relative humidity – set to 80%, based on OCD User's Guide recommendations and sensitivity analyses described in Section 4.2.1;
- Ambient air minus sea surface temperature – set to -5 degrees, based on sensitivity analyses described in Section 4.2.1, climatic information, and analysis of the research vessel data collected by the Bluefin; and
- Over water mixing heights - Barrow upper air station.

On-site Over Water Data from July 27– November 03, 2008:

The onsite over water meteorological data consists of data collected in the project area from instrumentation mounted on two research vessels, the Bluefin and the Norseman, that recorded all OCD required inputs, except mixing heights, from late July to early November 2008. The following notes the source of the each of the OCD required meteorological inputs for this over water database:

- Wind speed and direction – research vessels (Bluefin and Norseman);
- Ambient temperature – research vessels (Bluefin and Norseman);
- Relative humidity – research vessels (Bluefin and Norseman);
- Ambient air minus sea surface temperature – research vessel (Bluefin only); and
- Over water mixing heights – Barrow upper air station.

4.1 Meteorological Data Sources

The remote project location and lack of prior development could lead to the conclusion that the area is sparse in meteorological data necessary to execute the OCD model; however, the contrary is true. The presence of the military along this coast since World War II, the focus on the area as a climate change bellwether, and the upper air station in Barrow, results in a region rich with long-term meteorological and sophisticated oceanographic data sets. Combine this with data collected recently by CP research vessels in the Chukchi Sea and it is easily concluded that this region is better characterized than many parts of the contiguous 48 States.

The following is a detailed description of the datasets used in this ambient air quality impact analysis:

- Surface Data from National Weather Service Station in Wainwright. This station is the nearest source of long-term hourly meteorological data and is located onshore 150 km east of the project location (see **Figure 1-1**) and less than 1 km inland from the coast. This station has been active since World War II. In 1998, the site was converted to Automated Surface Observing System (ASOS) station and data recovery rates significantly increased. The end result is a long-term maritime wind and temperature climatology adjacent to the Chukchi Sea. The ASOS station at Wainwright reports hourly measurements of wind direction, wind speed, temperature, cloud cover, and ceiling height. **Figure 4-1** shows the location of the NWS meteorological tower in Wainwright.

  Meteorological data for the years 1999 through 2008 from the Wainwright ASOS station were reviewed to identify five years with acceptable data capture for the period from July 1 through November 30 when it is assumed the drill rig will operate. Therefore, data capture at Wainwright was evaluated only for the period of July through November for each year. **Table 4-1** summarizes data capture statistics. Data for the period of July through November from the years 1999, 2002, and 2004 through 2006 were selected for modeling analysis since these data represent the five most recent years with the highest data capture.

- Upper Air Data from the Barrow Upper Air Station. The project area lies 300 km from the long-term, upper air station operated by the NWS at Barrow. This places the project as close to an upper air station as many projects permitted throughout the US including parts of southwestern Montana and

northeastern Oregon. Furthermore, the Barrow station is uniquely situated on the coast on a point of land well exposed to maritime air masses from a horizontal arc of over 270° and includes the predominate wind directions. With respect to the continental US, only the Miami, Florida upper air station is equally suited for sampling maritime air masses. Mixing height data are recorded twice daily at the Barrow station. Mixing height data for the years 1999, 2002, and 2004 through 2006 and the period contemporaneous with the Wainwright NWS surface data and data collected by research vessels in 2008 were used in the modeling analysis.

- ConocoPhillips Summer 2008 Chukchi Sea Research Vessels. From July 27 through November 3, 2008 (i.e., nearly the entire drilling season), CP collected data from two research vessels, the Bluefin and the Norseman, in the Devil's Paw and Burger prospects (reference **Figure 1-1**). These vessels collected months of sub-hourly meteorological, oceanographic, and zoological data in the project impact area. This vessel data provides the most recent measurements of over water wind and sea surface temperature data for dispersion modeling. Though this is a relatively short-term data set, it is coincidental with the period of the year when project drilling activities will occur. In addition, it provides the best correlation of onshore to offshore measurements, which was used to increase confidence for using the onshore NWS data discussed above for dispersion modeling in the project area.

- Chukchi Sea OCS Climatic Atlas (NCDC 1988). In 1988, a project was conducted to consolidate information collected primarily by the NWS (National Oceanographic and Atmospheric Administration), the Federal Aviation Administration, the US Navy, and the US Air Force into a detailed climatic atlas of the maritime and coastal regions of the Chukchi and Beaufort Seas. Statistics presented in the atlas come from over 4.5 million surface maritime observations and 8.5 million observations for 66 coastal and island stations within the Chukchi and Beaufort Sea region. In terms of dispersion modeling, this atlas provides a valuable resource for characterizing offshore wind climatology, and sea surface temperature difference as well as important information on the influence of sea currents on weather.

The approach used to select the meteorological data used in the modeling analysis centered on using as much of the aforementioned data to develop the longest-term, most representative data set possible for conducting dispersion modeling in the project area with the OCD model. The long-term nature of these data are important because the more representative data that can be brought to bear on an ambient air quality impact analysis, the more confidence one can have that impacts are predicted across the widest range of possible atmospheric conditions and properly account for inter-annual variability consistent with the GAQM recommendations. The availability of all of the aforementioned data leads to the conclusion that a screening approach to dispersion modeling of the project is unnecessary and refined dispersion modeling with the OCD model was most appropriate.

Table 4-1 Data Capture Statistics for Wainwright NWS Meteorological Station

Year	July – November, % Complete		
	Temperature	Wind Direction	Wind Speed
1999	**90.2**	**91.4**	**91.5**
2000	86.9	86.4	86.5
2001	74.2	71.6	72.0
2002	**91.3**	**91.2**	**91.5**
2003	68.7	70.5	70.8
2004	**89.4**	**90.0**	**90.0**
2005	**93.7**	**93.5**	**93.7**
2006	**89.7**	**89.6**	**89.8**
2007	76.5	76.4	76.6
2008	80.5	80.5	80.5

Representativeness of the Wainwright and Barrow Data for Over Water and Over Land Dispersion Modeling Applications

As stated above, to characterize the over water dispersion environment, the OCD model requires hourly surface meteorological data observations representative of over water conditions. However, long-term over water databases are not currently available in the project area. For the following reasons, it is sound to use the NWS data recorded at the shoreline as part of the over water database required by OCD as representative for determining ambient air quality impacts. A comparison of recent concurrent data collected at the Wainwright NWS and by research vessels in the project area, provided in detail in **Appendix I** and summarized below, demonstrates the representativeness of the Wainwright data for over water applications.

Wind Direction –The wind direction climatology measured at an onshore location may be different than that over water due to the influences of terrain, surface roughness length, and sea breezes. However, given the near-shore location of the Wainwright NWS, lack of terrain features and generally low surface roughness features, theory suggests differences between wind directions at Wainwright NWS and the project area will exist but will not be significant. Consistent with this, and discussed further in **Appendix I**, comparison of concurrent data collected in the project area by the research vessels and the NWS data shows a similar dominant northerly through easterly wind pattern with the exception that the Wainwright data exhibit predominant easterlies while the vessel data indicate predominant northeasterly winds. As discussed in Section 4.2.1, this could be explained by clockwise veering of the winds associated with land friction affects. Also discussed in Section 4.2.1, this difference in wind patterns will not affect the ability of the OCD model to predict representative impacts.

Wind Speed – Theory indicates the wind speed measured onshore will be different than that over water due to the influence of surface roughness. Based on theory, since the Wainwright station is within 1 km of the coast, wind speeds measured at Wainwright should generally be lower than those measured over water within the project area because of slightly higher surface roughness of the near-shore NWS station location compared to the project location. This is confirmed by comparison of concurrent data collected over water by the research vessels and at the NWS station presented in **Appendix I**, which shows wind speeds measured over land are generally lower than over water. Note that modeling with lower wind speeds leads to lower plume dilution, and

therefore, generally results in higher modeled impacts (i.e., adds conservatism to the modeling). This is consistent with the modeling results discussed in Chapter 8.0 that shows the maximum impacts modeled with the NWS database are higher than the maximum impacts modeled with the vessel meteorological database.

Ambient Temperature – Theory indicates the air temperature measured onshore will exhibit some differences compared to those over water due to the influence of surface heating. However, due to the close proximity of Wainwright to the coast, and the general the lack of surface heating at high northern latitudes, the temperature measured at Wainwright should be similar to that over water in the project area with the exception that the over water area should exhibit less diurnal variability due to the moderating effects of the open ocean. This suppressed variability can be explained by the greater heat capacity of water over that of land which in turn moderates the overlying air temperature due to the heat flux from the open ocean. This is confirmed by time series comparison plots of vessel temperature versus Wainwright NWS temperature discussed further in **Appendix I**. Since the ambient temperature only affects plume buoyancy estimates, model predicted impacts are not sensitive to small uncertainties in the ambient temperature when modeled stack exit temperatures are well above ambient conditions as they are for this project.

Air - Sea Temperature Difference – Sensitivity analyses discussed in Section 4.2.1 show that this parameter can be conservatively handled by using a constant -5 °C. Sensitivity modeling demonstrates that the OCD model is primarily sensitive to whether the water is warmer or cooler than the air, and not sensitive to how much warmer or cooler. Sensitivity modeling also indicates that OCD predicts higher values when the water is warmer than the air, since those conditions result in more rapid mixing of elevated plumes to the water surface. Historical measurements in the Chukchi Sea show that the air is usually warmer than the water in July and August and the water is usually warmer than the air during September through November (NCDC 1988). Consistent with this, and detailed in **Appendix I**, data collected by the Bluefin research vessel shows that the water is usually warmer than the air for most of the period late July through October (the period of collection for this parameter). Note that this parameter was not collected by the Norseman research vessel. Therefore, a fixed negative value was assumed in the OCD model for the air minus sea temperature parameter which ensures that model-predicted impacts are representative or, even more likely, conservative.

Mixing Height – Due to the exposure of the Barrow upper air monitoring station to maritime air masses, its proximity to the ocean and the project area, and the general lack of surface heating at high northern latitudes, as discussed in Section 4.2.1, it was concluded that mixing heights measured at Barrow are representative of the project area. It should be noted that, OCD is rarely run, if ever, with measurements of mixing height over water because they generally don't exist, and that the data from the Barrow upper air station is sufficiently close to the project area to be representative for modeling according to Appendix C of Volume II of the OCD User's Guide (DiCristofaro and Hanna 1989).

As detailed in **Appendix J**, it should be noted that the interpolation of the Barrow mixing heights at sounding times (twice daily) to hourly mixing heights for use in the OCD model using the Holzworth interpolation method, as was done for this analysis, can introduce occasional very low mixing heights into the modeling analysis that are an artifact of the method and are not representative and produce unrealistically high model predicted impacts. Regardless, these mixing heights were used unaltered to be conservative.

The summary above which concludes that Wainwright NWS and Barrow upper air data are representative of over water locations are not only based on understanding the theoretical differences that might exist between the onshore measurements and the offshore climatology, but also on a comprehensive analysis of the sensitivity of model predicted impacts to the various input parameters, a comparison of available concurrent offshore and onshore data sets, and a review of available literature. This detailed analysis is presented in Section 4.2.1.

4.1.1 Over Water Application of the Wainwright and Barrow Data

Over water data required by the OCD model include:

- Over water wind direction and wind speed;
- Over water air temperature;
- Water surface temperature or the air-water temperature difference;
- Over water mixing height; and
- Over water humidity, wet bulb temperature, or dew point temperature.

As discussed, these inputs were satisfied by a partial year of representative over water meteorological data collected from research vessels (the Bluefin and the Norseman) and 5 partial years of nearby shoreline NWS meteorological data. The discussion below describes the representativeness of the required OCD model meteorological inputs that were used in the analysis.

Representativeness of Wainwright NWS Wind Data for Over Water Applications

As noted above, long-term over water data are not available in the project area. Although several months of 2008 vessel data are available and were used in the OCD modeling analysis, modeling with OCD was also conducted with the nearest long-term source of hourly wind and air temperature data, which is recorded onshore at Wainwright. While meteorological conditions over land can sometimes differ from those over water, we do not believe this to be the case along the shore of the Chukchi Sea due to minimal terrain and the proximity of the airport to the coast. The following effects were considered in determining whether Wainwright NWS data were appropriate to use as over water meteorology for dispersion modeling in the offshore project area:

1. **Friction created by surface roughness of the land can slow winds**. When compared to nearby over water locations, over land winds can be lower and wind directions turned due to the influence of increased friction encountered by air transported over land. This influence is not obvious at the land sea interface but does increase in strength the further the air is transported over land and changes as the boundary layer develops. These effects will be more pronounced and develop more quickly in the presence of topography and high onshore surface roughness length because of increased turbulence in the boundary layer. Because there is very low surface roughness in the vicinity of Wainwright (i.e., <0.02 m), there is very little terrain in the vicinity of Wainwright, and there is less than 1 km of land from the edge of the water to the meteorological station, wind data collected at the Wainwright station will exhibit minimal turning compared to that collected offshore. Theory indicates the difference expected will result in onshore winds that are lower, and rotated slightly clockwise.

   As shown further in **Appendix I**, consistent with theory, a comparison of the vessel data (over water) and NWS data (over land) indicate predominance of easterlies in the NWS data compared to northeasterly winds in the vessel data; i.e. indicating possible clockwise turning of the winds onshore. The **Appendix I** comparisons also indicate lower wind speeds experienced at the NWS site compared to the vessel measurements as expected based on theory. These observations can be attributed in part to the frictional affect and in part to natural variation in wind measurements from site-to-site as is common when making any such comparison of measurements at two nearby locations. These differences should not affect the model's ability to predict representative impacts because the model will over predict concentrations since lower wind speeds lead to less dispersion and higher concentrations.

   It should be noted that the OCD model contains an algorithm to adjust over land wind speed data so that it can be used for missing over water data to account for the effects of winds modified by friction as they encounter land. If the over water wind speed is missing, the OCD model will estimate it using the following relationship, devised by Hsu (1981):

   $$(\text{Over Water Wind Speed}) = 3 * (\text{Over Land Wind Speed})^{(2/3)}$$

This formulation is based on data collected from several outer continental shelf regions, and would suggest that the mean wind speed measured at Wainwright should be increased by over 3 m/s if it were used for over water modeling. Though the model option exists for correcting Wainwright wind speed data to represent over water wind conditions (by increasing them) it was not used; however, it supports the conclusion that over water winds are typically higher than those over land.

2. **Significant terrain can steer winds.** As shown in **Figure 4-1**, there is no significant terrain in the vicinity of Wainwright that would cause winds measured offshore to be significantly different than those measured at Wainwright**.**

3. **Surface heating of the land can create sea breezes.** During periods without strong synoptic forcing, land surface heating can induce an onshore component to the mesoscale flow that increases in strength moving from over water to near-shore locations (land-sea breeze effect). If it exists, this effect could cause wind directions to be slightly different at Wainwright than what might be encountered offshore. Though a monthly wind analysis does suggest that turning of the winds by this mechanism does occur (reference **Appendix B**), it is a slight effect and only noticeable in July and August. During these months, the wind climatology is still dominated by east-northeasterly and easterly winds; however, a slight increase (i.e., less than 10 percent) in south-southwesterly and westerly winds is evident as well as a more distributed wind rose. As expected, the land-sea breeze effect is small at Wainwright because, sun angles are too low at this latitude to cause significant surface heating, and the surface is dotted with many lakes and lagoons leaving less land to heat. Furthermore, strong synoptic forcing is present most of the time, dominating this land-sea effect.

With respect to wind direction differences that exist between over water and over land wind data, these will not affect the ability of the OCD model to predict representative air quality impacts. The modeling conducted indicates that maximum project-related impacts are in the near-field and are affected by structure downwash which is not direction-specific in the OCD model. In addition, since the modeling domain is completely over water, there were no impacts on elevated terrain, which is highly dependent on source/terrain/wind direction relationships. Therefore, the maximum model predicted impacts are not sensitive to wind direction differences.

For the reasons discussed above, for the purposes of dispersion modeling with OCD, wind data recorded at Wainwright are representative of the proposed project area. Furthermore, the use of 5 years of data ensures that a large range of meteorological conditions were evaluated. To help demonstrate that conducting modeling with 5 years of Wainwright data produces representative model predicted impacts, several months of vessel-based over water meteorological data were also modeled with OCD to add to the robustness of the evaluation and provide a reference to understand the differences between impacts predicted using data collected at Wainwright and data collected over water in the project area. These results are discussed in Chapter 8.0.

Representativeness of the Wainwright NWS Temperature Data for Over Water Applications

Due to the close proximity of the Wainwright NWS to the coast, and the general lack of surface heating at high northern latitudes, the temperature measured at Wainwright should be similar to that over water in the project area with the exception that locations over water should exhibit less diurnal variability due to the moderating effects of the open ocean. This suppressed variability can be explained by the greater heat capacity of water over that of land which in turn moderates the overlying air due to the heat flux from the open ocean. This is confirmed by time series comparison plots of vessel temperature versus Wainwright temperature discussed further in **Appendix I** which show the temperature characteristics are similar with the exception of the diurnal pattern exhibited over land. In any case, there is not enough difference to affect plume buoyancy, particularly because the sources being modeled have high exhaust temperatures. The excess temperature makes the calculation of the plume buoyancy relatively insensitive to small uncertainties in the ambient temperature values. Therefore, for the purposes of dispersion modeling, air temperature data recorded at Wainwright are representative of the project area.

Figure 4-1 Aerial Photo of Wainwright, Alaska

Selection of a Representative Air Minus Water Temperature Database when Modeling with Wainwright NWS Data

The stability of the marine boundary layer is primarily determined by the amount of sensible and latent heat released to the atmosphere from the water surface. To parameterize this flux and determine the over water stability, OCD requires air minus water temperature data. However, the OCD model is only sensitive to sign of the temperature difference (i.e., whether the water is warmer or cooler than the air, not how much warmer or cooler) (DiCristofaro and Hanna 1989). Therefore, it is not necessary to know the magnitude of the difference between the temperatures on an hour-by-hour basis in order to predict conservatively representative ambient air quality impacts.

Information on the air-water temperature difference for the Chukchi Sea is available from the Chukchi Sea climatic atlas (NCDC 1988). Excerpts from that climatic atlas, which are shown in **Appendix A**, indicate that the air minus sea temperature values generally range from -3°C to 3°C from July through September for Marine Area B where the project being permitted will be located. During October and November the air minus sea temperature values generally are less than -3°C (i.e., the water is usually several degrees warmer than the air). Based on the possible range of values indicated in the climatic atlas and from data collected by one of the research vessels (reference **Appendix I**), air minus sea temperature values ranging from -10°C to 10°C, which covers the range of observed differences, were selected for conducting project-specific sensitivity modeling to show that model predicted impacts are not sensitive to changes in this parameter. This sensitivity modeling was conducted for the project drill rig sources. In each model run, the air minus sea temperature value was assumed to be constant from July through November. The results of these modeling runs shown in **Table 4-2** indicate that model predicted impacts are not sensitive to the magnitude of this parameter, but are sensitive to the sign (i.e., the model is only sensitive to whether the water is warmer or cooler than the air, and not by how much warmer or cooler) as expected based on discussions in the OCD User's Guide. The exception to this is slight sensitivity of model predicted annual impacts to the magnitude of the air minus sea temperature value; however, this effect is less than significant impact levels and too small to be meaningful to a compliance demonstration. Generally, predicted impacts reach a maximum plateau for values of 0°C and lower, which is why the OCD User's Guide recommends using a value of 0°C for this parameter if it is not known.

Actual values of air-water temperature differences were available from one of the 2008 research vessel meteorological databases but were not available for the 5-year Wainwright NWS database. Therefore, a representative value had to be determined for use with the Wainwright NWS data. As stated above, modeled impacts are not sensitive to the magnitude of this parameter; however, **Table 4-2** shows that lower values tend to increase annual impacts slightly. Aside from a few anomalous measurements, the lower limit of the actual measurements of air minus sea temperature values from the research vessel Bluefin was -5 °C as shown in **Appendix I**. Therefore, a single value of -5 °C was assumed for this parameter for every hour in the 5-year Wainwright database.

Representativeness of Barrow Mixing Heights to Over Water Modeling Applications

According to the OCD Model User's Guide, the mixing height is "impractical to measure offshore" and thus is rarely measured over water (DiCristofaro and Hanna 1989). In every regulatory application of the OCD model reviewed, none ever used mixing heights measured over water, and instead relied on: 1) data from the nearest upper air station; 2) data from an onshore acoustic sounder; or 3) a constant value of 500 m, which is the default suggested in the OCD User's Guide.

The upper air station at Barrow, Alaska is the nearest upper air station to the project area and records upper air soundings twice daily from which mixing heights are computed. Data collected at this station is representative of over water locations because the station is located less than 1 km inland, and is well exposed to maritime air masses transported to the site from a horizontal arc of over 270°, which includes the

predominate wind directions. Furthermore, surface heating and turbulence effects, which typically lead to differences between data collected at an over land station and an over water station, will be insignificant at Barrow. These effects are insignificant at Barrow due to low sun angles at this latitude leading to a lack of surface heating, and because the tundra land surface at Barrow, which is dominated by water features, does not absorb heat to the extent that dry land does. Therefore, it is reasonable to use mixing heights derived from the Barrow station upper air data in the modeling analysis, and more realistic than using a fixed, constant value used in some screening techniques, and the OCD User's Guide default approach which suggests using a fixed value of 500 m.

The assertion that Barrow experiences a general lack of surface heating as compared to an over water location is supported by comparing over water temperatures measured by the Bluefin and Norseman research vessels in 2008 and concurrent measurements of air temperature from the Wainwright NWS. As discussed in **Appendix I**, vessel air temperatures are comparable to Wainwright temperatures temporally and differ by about 1 to 3°C for much of the data record, which includes much of the drilling season. Because the Barrow upper air station is equally or better exposed to maritime influences than Wainwright, it is reasonable to assume that the difference between temperatures at Barrow and those over water would be smaller than those shown at Wainwright demonstrating a general lack of surface heating at Barrow as compared to an over water location.

The conclusion that Barrow upper air data is representative of over water locations is also supported by comparing mixing heights derived from the Barrow upper air data to mixing height data collected over water during two independent studies in the Baltic Sea area. These studies, which are described in **Appendix J**, demonstrate that over water mixing heights during the late summer and fall range from 250 to just over 1,000 m, with an average between 500 and 800 m. This is similar to the range of morning and afternoon mixing heights observed in the Barrow mixing height data for the July to November period for the years 1999, 2002, and 2004 through 2006, which are shown in **Figure 4-2**. With the exception of some very low mixing heights observed in the Barrow database, **Figure 4-2** shows Barrow mixing heights vary from about 100 to 1,500 m with an average of approximately 500 m.

The very low mixing heights observed in the Barrow mixing height database are likely an artifact of the methodology used to derive mixing heights from the Barrow station upper air data. OCD requires hourly mixing height data; therefore, it was necessary to derive the hourly values from twice daily sounding data for input to the OCD model using the Holzworth mixing height interpolation method. However, as explained in **Appendix J,** the use of the Barrow upper air data with the Holzworth mixing height interpolation method can introduce several hours with very low mixing heights. Independent studies noted in **Appendix J**, including data obtained from radiosondes launched from small islands in the Baltic Sea area conclude that the over water mixing height does not vary much diurnally and it rarely drops below about 250 m. This is especially true for areas such as the project site that are so far away from land masses that it is very unlikely that a warm air mass heated by the land could be advected to the project area unchanged and create a low-level inversion in the area during ice-free periods. Therefore, the low mixing heights that occur in the Barrow mixing height database used in this ambient air quality impact analysis are likely an artifact of the Holzworth method and not realistic based on a comparison to available field data.

Though the unrealistically low mixing heights that occur in the Barrow mixing height database used for this analysis are likely an artifact of the methodology used to derive the mixing heights, they were not eliminated from the database prior to conducting modeling even though they are known to produce unrealistically high model predicted impacts. Use of the occasional very low hourly mixing heights can result in simulated plume trapping or the mixing downward to the surface of an elevated plume at great distances from the project site. For some conditions, this can result in an OCD simulation of very distant peak impacts that are counterintuitive.

To understand the effect unrealistically low mixing heights have on model predicted impacts, project-specific modeling for the drill rig sources was conducted to determine the sensitivity of project predicted impacts to

mixing height. **Table 4-3** shows the maximum modeled impacts from the project source inventory assuming various mixing heights persist throughout the July through November period. As shown in **Table 4-3**, project-specific short-term model predicted impacts are sensitive to mixing height, and they are particularly sensitive to mixing heights equivalent to simulated source plume heights as would be expected based on model algorithms (i.e., between 30 and 100 m in this case). As shown in **Figure 4-2**, histograms of Barrow mixing height data for the July to November period, for the years 1999, 2002, and 2004 through 2006 indicate the range of mixing heights leading to high project-specific model predicted impacts occur approximately 10% of the time in the Barrow mixing height database used in the modeling analysis.

It has been concluded that mixing heights less than 100 m are unrealistic for an over water location, and are likely an artifact of the methodology used to derive mixing heights from the Barrow upper air data. It has also been shown that including these low mixing heights in the model meteorological input data will lead to unrealistically elevated short-term impacts. Regardless, for conservatism, the unrealistically low mixing heights were retained in the model meteorological input database even though they produce elevated impacts.

Selection of a Representative Humidity Database when Modeling with Wainwright NWS Data

Over water humidity is also used by the OCD model to determine over water plume transport and dispersion. Relative humidity measurements were available for the 2008 research vessel meteorological database, but were not available for the 5-year Wainwright NWS database. Modeling runs for the project drill rig sources were conducted to determine the level of sensitivity this parameter has on modeling results. **Table 4-4** shows the maximum model predicted impacts assuming various over water humidity values. Each humidity level was assumed to be constant throughout the July through November period. As shown in the table, the modeling results are not sensitive to this parameter. Furthermore, the OCD User's Guide states "Sensitivity tests have shown that the humidity variable is of lesser importance than the other required overwater input data". Therefore, the default value recommended by the User's Guide, 80 percent, was assumed for the 5-year Wainwright database in the OCD modeling.

4.1.2 Representativeness of the Wainwright NWS Data for Over Land Applications

The OCD model requires over land meteorological data to characterize the land-sea interface at the coast as well as to calculate shoreline fumigation. The over land data consisted of surface observations from Wainwright, Alaska as well as mixing height data from Barrow, Alaska, for the years 1999, 2002, 2004, 2005, 2006, and 2008. Missing data were filled in with a combination of interpolation and backup data from Barrow since OCD requires 100 percent data capture. The procedures for filling in missing data are documented in **Appendix H**.

Table 4-2 OCD Sensitivity Results for Air-Sea Temperature Difference

Air minus Sea Temperature	Overall Maximum Concentration (μg/m^3)				
	-10 deg	-2 deg	0 deg (OCD Default)	+2 deg	+10 deg
1-Hour	34.1	34.1	33.4	21.9	21.4
3-Hour	23.9	24.2	24.0	15.1	15.1
8-Hour	18.9	18.9	18.8	10.4	10.4
24-Hour	14.8	14.8	14.4	6.8	6.8
Annual	1.9	1.8	1.6	1.2	0.8

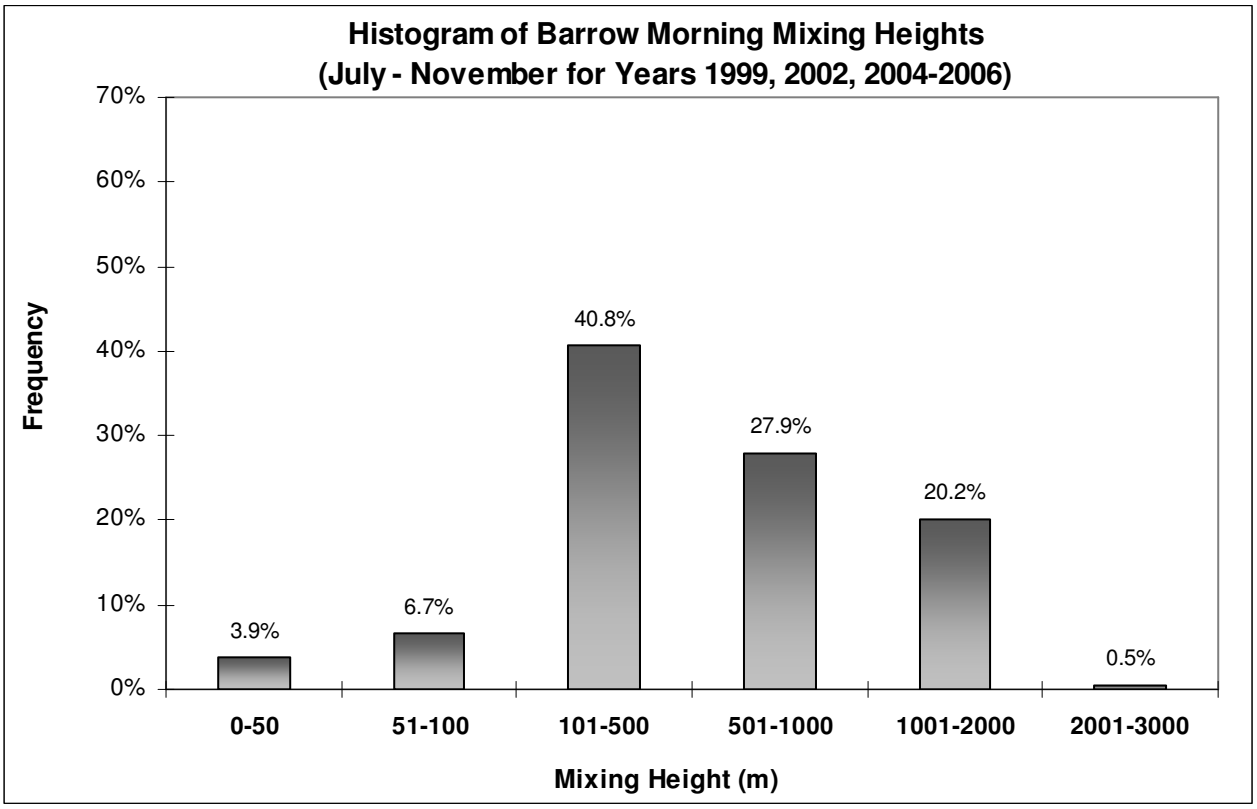
Table 4-3 OCD Sensitivity Results for Mixing Height

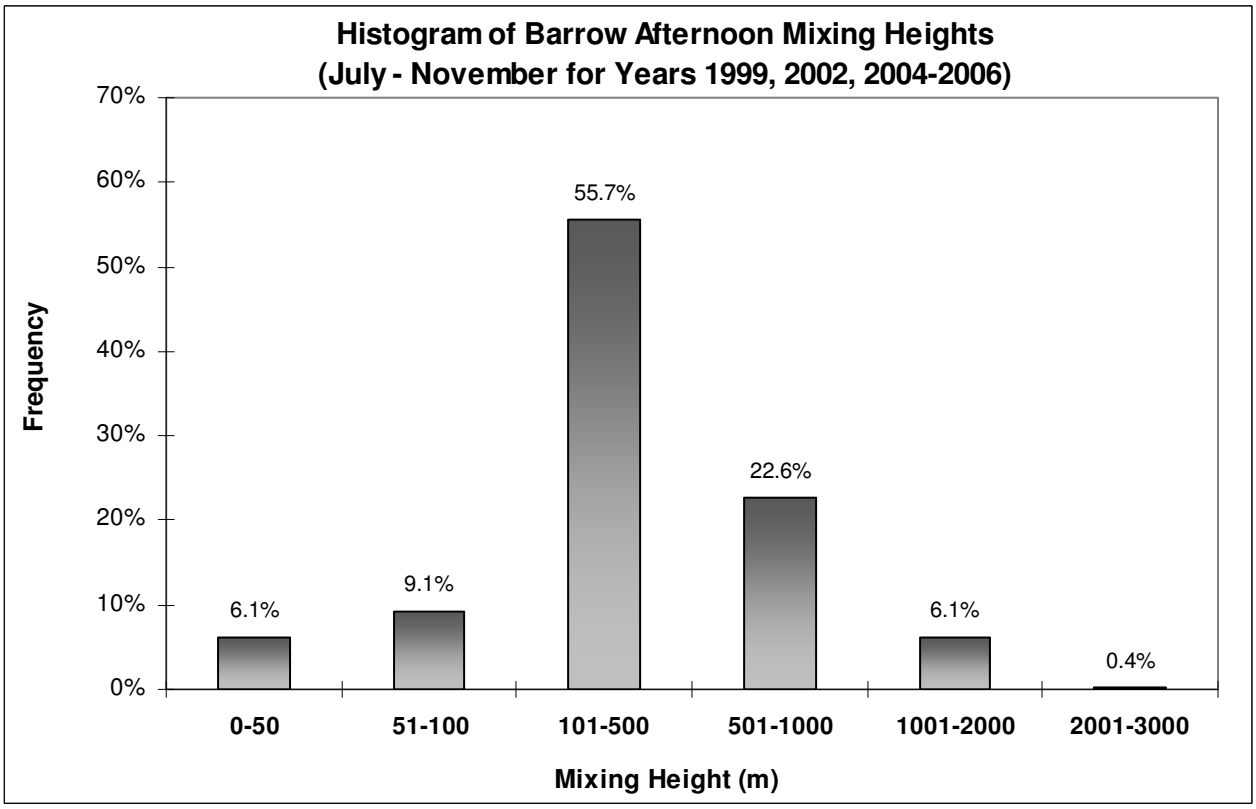
Mixing Height	Overall Maximum Concentration (μg/m^3)							
	10 m	20 m	30 m	40 m	50 m	100 m	500 m (OCD Default)	1,000 m
1-Hour	27.3	27.3	27.3	27.3	31.6	27.3	27.3	27.3
3-Hour	22.7	22.7	22.7	22.7	26.0	24.0	23.9	23.9
8-Hour	12.1	12.1	12.4	14.2	18.3	18.8	18.9	18.6
24-Hour	8.1	8.1	8.5	9.4	10.3	14.8	14.8	14.3
Annual	1.6	1.6	1.7	1.7	1.7	1.9	2.0	2.0

Table 4-4 OCD Sensitivity Results for Relative Humidity

Relative Humidity	Overall Maximum Concentration (μg/m^3)		
	50%	80% (OCD Default)	95%
1-Hour	34.1	34.1	34.1
3-Hour	23.9	23.9	23.9
8-Hour	18.9	18.9	18.9
24-Hour	14.8	14.8	14.8
Annual	1.8	1.8	1.8

Figure 4-2 Histograms of Barrow Mixing Height Data





4.2 Meteorological Data Processing

Based on the available data sources discussed above, two databases were developed for input to the OCD modeling:

- Several months (late July through early November 2008; overlapping the planned exploratory drilling period) of "onsite" over water data recorded by research vessels (Bluefin and Norseman) in the project area fulfilling the over water data requirement, concurrent Wainwright NWS data fulfilling the over land data requirement, and concurrent mixing heights from Barrow; and
- Five years of recent meteorological data (1999, 2002, 2004, 2005, and 2006) from the Wainwright NWS station fulfilling both over water and the over land data requirements coupled with concurrent mixing heights from Barrow.

As required by OCD, to create the required over water meteorological input files for each of the two databases, over water wind and temperature data were combined with the air-sea temperature difference, Barrow mixing height, and over water humidity data into a free-format ASCII text file for use in the OCD model. To create the OCD required over land meteorological input file, over land data consisting of surface observations from Wainwright, Alaska, and twice daily mixing heights from Barrow, Alaska, were processed with USEPA's PCRAMMET processor to format the data for use in the OCD model.

In both cases, OCD must have a complete data set for each parameter included in the meteorological input files in order to execute successfully. The proposed meteorological datasets did contain some missing hours; therefore, data were filled according to the procedures outlined in **Appendix H** to make them 100 percent complete. Guidance provided by USEPA (USEPA, 1992) was followed for filling missing data. It should be noted that USEPA guidelines do not require 100 percent complete meteorological data sets. However, data were filled completely because the OCD model cannot execute successfully with any missing data.

5.0 Application of the OCD Model

The first step in the ambient air quality analysis was to model project potential emissions to predict impacts for comparison to the SILs. Cumulative modeling was then conducted for the pollutants/averaging periods where the SIL was exceeded (Chapter 8.0). The following criteria pollutants and averaging periods were modeled to estimate the maximum air quality impacts from the proposed project:

- CO – 1-hour and 8-hour averaging periods;
- NO_2 – Annual averaging period;
- SO_2 – 3-hour, 24-hour, and annual averaging periods;
- PM_{10} – 24-hour averaging period; and
- $PM_{2.5}$ – 24-hour and annual averaging periods.

As recommended in GAQM Section 5.2.4c, annual NO_2 impacts were computed assuming a 75% conversion rate of NO_X to NO_2.

OCD model options were set to regulatory defaults outlined in Section 8 of the GAQM as they apply to the current modeling effort. Those model options are as follows:

- Included stack-tip downwash;
- Excluded calculation of gradual plume rise; and
- Included buoyancy induced dispersion in initial plume calculations.

5.1 Drill Rig Orientation and Location

The proposed drill rig could be located in any of CP's lease holdings within the Devil's Paw Prospect. Therefore, for the purposes of dispersion modeling, the drill rig was located such that both project-related and cumulative air quality impacts were maximized. The following considerations were given in locating the rig to maximize modeled impacts: 1) the location nearest the shore, 2) the potential interaction with onshore sources, and 3) the potential interaction with other permitted OCS sources that could be operating near the project area (i.e., exploratory drilling conducted by Shell). Given the great distance between the closest potential location of the drill rig to the shore, 110 km, the location relative to other permitted OCS sources was given more consideration than potential shoreline impacts or the potential interaction of onshore sources with the project sources. Therefore, potential project locations were evaluated in a sensitivity modeling analysis (refer to **Appendix L**) to maximize the cumulative impacts of the project combined with other permitted OCS sources (i.e., exploratory drilling conducted by Shell). As discussed further in Section 8.2 and detailed in **Appendix L**, based on the sensitivity modeling analysis the project drill rig location was assumed to be at a latitude and longitude of 70° 56'N, 165° 43' W which is shown on **Figure 1-1**.

During drilling, an attempt is made to orient the drill rig with the living quarters positioned at 90 degrees to the prevailing wind direction that occurs during the drilling season. As shown by the wind roses provided in **Appendix B**, the predominant wind direction of the meteorological data set used for dispersion modeling during the drilling season is generally easterly. Therefore, all modeling was conducted with the drill rig positioned as shown in **Figure 2-2** to orient the living quarters north-south.

5.2 Source Simulation in the Model

Emission sources associated with CP's exploratory drilling program were modeled as a combination of point and area sources. All of the drill rig sources as well sources on vessels modeled within a mile of the rig were modeled explicitly as point sources, which included simulation of structure downwash in the OCD model. The remainder of the vessel sources will generally be mobile and located beyond 1 mile from the rig. As such, it was appropriate to represent them in the model as either area sources or volume sources. The OCD model does not have the same capability to model volume sources that other refined models such as AERMOD or ISCST3 have. Therefore, mobile vessel sources associated with the project were represented by area sources, the size of which was determined by the nature of the mobile vessel source's activities. To simplify the model simulation, and to increase conservatism, several sources were co-located and their emissions combined. Those sources that were co-located are noted below.

The following non-emergency activities that are part of the exploratory drilling program were evaluated in the modeling analysis:

- Normal rig drilling;
- Rig construction, repositioning, and demobilization;
- Resupply of the drill rig by an Offshore Supply Vessel (OSV) or ware vessel;
- Regular Oil Spill Response Vessel (OSRV) operation;
- OSRV activities including:
    - Regular OSRV operations,
    - OSRV operations during fuel transfer, and
    - MMS simulated spill response exercises;
- Ice management; and
- Research vessel activity.

These activities and their simulation in the OCD model are discussed further below. **Figures 5-1, 5-2**, and **5-3** depict the modeled locations of the activities and their associated sources.

Complete documentation supporting calculations of emissions and stack exhaust characteristics for all modeled sources, as well as the selection of point source stack parameters and area source parameters used in the model can be found in **Appendix E** and **Appendix G**.

5.2.1 Normal Rig Drilling

This activity will include the operation of all emission units located on the drill rig. This activity includes all rig potential emissions while it is an OCS Source whether it is drilling exploratory wells or sitting mostly idle while it is being prepared to drill or prepared to demobilize. All stacks were modeled as point sources at fixed locations on the rig as shown in **Figure 5-1**. Unlike other GAQM steady state dispersion models, OCD has the capability of simulating horizontal emission releases; therefore, no special techniques were required to simulate these types of releases.

This activity also implicitly includes a scenario when the drill rig main engine SCR NO_x control units are inoperable for a limited number of hours per year. This scenario did not need to be modeled explicitly because NO_x impacts were only predicted for comparison to an annual standard. Therefore, as long as the annual modeled emission rate includes the increase in emissions from this scenario, which it does, the scenario does note need to be modeled explicitly.

The main drill rig engines dominate the drill rig air quality impacts, not only because they make up a majority of the total emissions, but also because these units exhaust horizontally near the boundary with ambient air. Therefore, a worst-case load analysis was conducted for the main drill rig engines only. The results of the load analysis are documented in **Appendix K**. As shown in **Appendix K**, 100% load is the worst-case for SO_2, CO, and NO_2 while 50% load is the worst-case for PM_{10} and $PM_{2.5}$. Therefore, all subsequent modeling of project sources included the main drill rig engines at these pollutant-specific worst-case loads.

5.2.2 Rig Construction, Repositioning, and Demobilization

There will be a short period of time on either side of active drilling operations when the drill rig is either being prepared for drilling or being prepared to demobilize from the project area. During this time, an Anchor Handling Supply Tug (AHST) may operate within 25 miles of the drill rig. An AHST will be used to position the drill rig as it is being erected on the sea floor prior to it becoming an OCS Source. After the drill rig is positioned on the sea floor and erected and becomes an OCS Source, the AHST will remain within 25 miles of the drill rig cruising for up to 20 hours per event (with 3 events or 60 hours cruising per year). The AHST remains within 25 miles of the drill rig to make sure the drill rig footings do not sink and the rig's position is stable. The AHST will be cruising in a 1 km area located 1 mile from the rig, in the event it needs to be dispatched to the rig for repositioning. Emissions from the cruising AHST were modeled as a circular area source, 1 km in diameter, located 1 mile east of the rig. The alignment of the area source with respect to the drill rig is based on sensitivity modeling described in Section 5.2.8.

5.2.3 Resupply of the Drill Rig with a Ware Vessel

A ware vessel will potentially be used to transport large amounts of supplies (i.e., fuel, drilling fluids, pipe, etc.) and manpower to the drill rig. This vessel will only operate within 25 miles of the drill rig while in transit to the drill rig for the purpose of transferring supplies to the drill rig. In addition, the ware vessel also will operate for a short time afterwards while leaving the area. In the case of poor weather the ware vessel may idle within 25 miles of the drill rig waiting for proper conditions to transfer supplies.

A ware vessel will operate under its own power and will utilize dynamic positioning to sit stationary next to the drill rig without being tied to it (dynamic positioning mode). When transferring supplies at the drill rig, the ware vessel will be maintained adjacent to the rig by dynamic positioning and there will be no physical attachment between the ware vessel and the rig except for a fuel line during refueling activities.

A ware vessel will take up to 3 hours to travel one-way to the drill rig (cruising mode). As permitted, a ware vessel will make an average of 4 resupply trips per week over 14 weeks (50 trips) between the edge of the 25 mile radius and the rig. In reality, this vessel only needs to make one trip every two weeks and is being permitted this way in case a smaller vessel, which would have to make more trips per week, were used in place of the ware vessel. Unloading the vessel to the rig will take up to 300 hours (in dynamic positioning mode) each season. The vessel will be dynamically positioned next to the rig for a maximum of 6 hours for each fuel transfer event, and less than 6 hours for transfer of other supplies. Open-water idling of the vessel due to poor weather may take place for up to 100 hours per season within a 25 mile radius of the drill rig.

As noted in Chapter 2.0, resupply of the rig will be provided by <u>either</u> an OSV or ware vessel. Therefore, a sensitivity analysis was performed to determine whether use of an OSV or ware vessel would produce higher air quality impacts. **Appendix L** documents this analysis and indicates that use of an OSV yields higher impacts than use of a ware vessel. Therefore, the significance and cumulative modeling analyses incorporated OSV activities, and ware vessel activities were not given further consideration in the ambient air quality analysis.

5.2.4 Resupply of the Drill Rig with Offshore Supply Vessel (OSV)

OSVs are smaller than ware vessels and are used to shuttle supplies and manpower to the drill rig from a supply barge located beyond 25 miles from the drill rig. Two OSVs will be used to support the proposed

exploratory drilling activities. However, at one time only one vessel will operate within 25 miles of the drill rig while in transit to the drill rig, transferring supplies, and for a short time afterwards in departing the area. When transferring supplies, the OSV will be maintained adjacent to the rig by dynamic positioning (dynamic positioning mode) and there will be no physical attachment between the OSV and the drill rig except for a fuel line during refueling activities. In the case of poor weather this vessel may idle within 25 miles of the drill rig waiting for proper conditions to transfer supplies.

An OSV will take up to 3 hours to travel one-way to the drill rig (cruising mode). The OSV will make approximately 4 resupply trips per week over 14 weeks for a total of 60 trips between the supply barge and the drill rig. Unloading the OSV to the rig will take up to 360 hours (in dynamic positioning mode) each season. The vessel will be dynamically positioned next to the rig for a maximum of 6 hours for each fuel transfer event and less than 6 hours for transfer of other supplies. Open-water idling of the vessel due to poor weather may take place for up to 100 hours per season within the 25 mile radius.

As noted in Chapter 2.0, resupply of the rig will be provided by <u>either</u> an OSV or ware vessel. A sensitivity analysis was performed to determine whether use of an OSV or ware vessel would produce higher air quality impacts. **Appendix L** documents this analysis and indicates that use of an OSV yields higher impacts than use of a ware vessel. Therefore, the significance and cumulative modeling analyses incorporated OSV activities, and ware vessel activities were not given further consideration in the ambient air quality analysis.

All OSV emissions that occur within 1 mile of the rig were modeled as point sources, at a fixed location adjacent to the rig. This includes emissions from the OSV when dynamically positioned next to the rig while offloading, as well as a portion (1/25th) of the emissions occurring while the vessel is in transit within 1 mile of the rig. **Appendix L** documents sensitivity modeling that was conducted which determined that the worst-case position of the OSV while adjacent to the drill rig is on the south side of the rig (refer to **Figure 5-1**). Therefore, all subsequent modeling of project sources included the OSV vessel located on the south side of the drill rig.

The OSV transit emissions that occur between 1 and 25 miles from the rig were also modeled as point sources at a fixed position 1 mile east of the rig. This is a conservative approach since the majority of these emissions will occur farther than 1 mile from the rig.

Emissions that may occur as a result of open water idling due to poor weather were modeled as a circular area source, 1 km in diameter (consistent with the turn radius of the vessel), even though the actual size the activity will occupy is likely larger. The area source was modeled 1 mile east of the rig, which represents the closest distance this activity will take place. Assuming that the area source is smaller and closer to the rig than will actually be the case reduces the amount of initial dispersion of the emissions and maximizes the potential interaction between the OSV sources and the drill rig sources. This will in turn maximize modeled impacts.

Note that short-term (≤ 24 hours) activities for the OSV include travel to/from the rig and unloading supplies <u>OR</u> idling in open water due to poor weather, but not both simultaneously. The OSV produces much higher emissions while traveling to/from the rig and unloading supplies than while idling in open water. Therefore, that worst-case short-term emission scenario was modeled and short-term emissions during open water idling did not need to be explicitly modeled. However, annual emissions due to open water idling were included as described above.

Though the OSV could approach the rig from any direction, or open water idling could take place at any azimuth from the drill rig, these sources were modeled east of the drill rig, based on sensitivity modeling described further below.

5.2.5 Oil Spill Response Vessel (OSRV) Activities

A dedicated OSRV will be staged near the project area for various spill response related activities. The OSRV will carry two work boats that can be deployed as needed. This dedicated OSRV will operate in cruising mode

or will be anchored/moored within 25 miles of, but no closer than 10 miles to the drill rig (regular OSRV operations) for up to 2,352 hours per year. This same OSRV will be one of the OSRVs that participate in mandated simulated spill response exercises discussed below for up to 48 hours per year. In addition, this OSRV will provide spill coverage in the event of a spill during fuel and supply transfer at the drill rig (OSRV Operation During Fuel Transfer) for up to 48 hours per year. Weather permitting, fuel transfer coverage could instead be handled by a work boat deployed by the OSRV. These three activities that the OSRV will perform are described further below.

A second OSRV, with work boats, will be maintained further than 25 miles from the drill rig except as needed for spill response and mandated spill response exercises.

Regular Oil Spill Response Vessel (OSRV) Operations

The Regular OSRV Operations will consist of 1,500 hours per year anchored/moored and 852 hours per year cruising while within 25 miles of the drill rig. Emissions from regular OSRV operations were modeled as a circular area source, 1 km in diameter (consistent with the turn radius of the vessel), even though the actual size the activity will occupy is likely to be larger. The area source was modeled 10 miles east of the rig, which represents the closest distance this activity will take place. Assuming that the area source is smaller and closer to the rig than the actual operation will likely occupy reduces the amount of initial dispersion of the emissions and maximize the potential interaction between the OSRV vessel sources and drill rig sources. This in turn will maximize modeled impacts.

Deciding to simulate this source east of the drill rig was based on sensitivity modeling described in Section 8.2, even though it could be located anywhere outside 10 miles from the rig. It will be assumed this activity can take place for up to 24 hours per day.

OSRV Operation During Fuel Transfer

Either a single OSRV or a single work boat will be staged in the vicinity of the drill rig to deploy spill response boom and provide standby spill prevention support while fuel is being transferred to the drill rig. This activity is part of regular OSRV operations and will not require a second OSRV to be dispatched within 25 miles of the drill rig. Depending on the weather conditions during fuel transfer at the drill rig either the OSRV or one of its work boats will operate near the drill rig for spill coverage. During this activity the OSRV or the small work boat will lay spill response boom. Once the boom is deployed, the OSRV or work boat will idle ¼ mile from the drill rig. Once the fuel transfer at the rig is complete, the OSRV or work boat will retrieve the spill response boom and return to regular duties beyond 10 miles from the drill rig.

An OSRV is a larger vessel and produces higher emissions than a work boat. As such, it was assumed that using an OSRV for this activity would produce higher air quality impacts than a work boat. Therefore, for dispersion modeling purposes, this activity was simulated using an OSRV even though either an OSRV or a work boat may be used to support fuel transfer operations.

The first aspect of the supply transfer operation which involves boom laying activities during fuel transfer (up to 6 fuel transfers per year) will last one hour for both laying and retrieving the boom. Emissions during this activity will be modeled as point sources at a fixed location adjacent to the drill rig. To maximize air quality impacts, it was assumed that the worst-case location for the OSRV would be next to the OSV, adjacent to the south side of the rig. See **Figure 5-1** for source layout details. This location maximizes the potential interaction with point sources located on both the rig and OSV.

The second aspect of the supply transfer operation assumes that the OSRV will be idling during, 1) fuel transfer, 2) after boom deployment and 3) before boom retrieval, for up to 6 hours per event with up to 6 events per year. These emissions were modeled as point sources located ¼ mile east of the rig. The position of this source with respect to the rig was determined through sensitivity modeling described further below.

Mandated MMS Simulated Spill Response Exercises

An oil spill response fleet will participate in simulated spill response exercises mandated by the Mineral Management Services (MMS). The oil spill response fleet will consist of two OSRVs, 4 work boats, which are normally stored on board the OSRVs, but are deployed during practice exercises, and a spill response tanker. These activities will take place for 48 hours during the drilling season. For the purposes of dispersion modeling, it was assumed the OSRVs can operate up to 24 hours per day. One of the OSRVs that participates in the practices exercises normally operates within 25 miles of the drill rig and its normal operation was previously discussed. The other OSRV is normally maintained beyond 25 miles of the drill rig.

Emissions from the two OSRVs, as well as the 4 work boats, were modeled as circular area sources, 1 km in diameter (consistent with the turn radius of an OSRV), even though the actual area that these mobile vessels will occupy is likely larger. The area sources were collocated and modeled 1 mile east of the rig which represents the closest distance these vessels are expected to be to the rig. Assuming that the area sources are smaller and closer to the rig than the actual operation will likely occupy is conservative and reduces the amount of initial dispersion of the emissions. This will in turn maximize the potential interaction between the sources on the vessels and the drill rig sources, which in turn maximizes modeled impacts.

Even though the oil spill response fleet may conduct practice exercises anywhere beyond 1 mile from the rig, the area sources were located 1 mile east of the rig in the dispersion model based on sensitivity modeling described in Section 5.2.8. These area sources were collocated with the AHST area source and OSV open-water idling area source mentioned above.

5.2.6 Ice Management

Two ice management vessels will be staged within 25 miles of the drill rig for up to 675 hours per season to manage ice sheets that may break loose and drift toward the drilling operation. However, for conservatism, this activity was modeled as occurring up to 700 hours per season. These vessels generally will be operated well upwind of the drilling operation and will operate a significant amount of the time further than 25 miles from the drill rig. If ice moves to within approximately 10 miles of the drill rig, a decision will be made whether to begin shutting down the drill rig. If ice were to come within 5 miles of the drill rig, steps would be taken to remove the drill rig from the sea floor (i.e., the drill rig would no longer be an OCS Source); therefore, the icebreakers will not be operating within 5 miles of the rig when it is an OCS Source.

Emissions from these vessels were modeled as a circular area source, 2 km in diameter (which is consistent with the turn radius of the vessel), even though the actual size the activity will occupy is likely to be larger. The area source will be modeled at a distance of 5 miles from the drill rig, which represents the closest distance an icebreaker will operate to the drill rig, as previously discussed. These assumptions will reduce the amount of initial dispersion of the emissions and maximize the potential interaction between the sources on the vessels and the sources on the drill rig, which will in turn maximize modeled impacts. The modeled emission rate represents the total amount of emissions occurring within 25 miles of the rig, even though the greatest portion of the emissions are likely to occur much farther away from the modeled location (i.e., any ice to be managed will be managed long before it gets to within 5 miles of the drill rig). It will be assumed that ice management vessels can operate up to 24 hours per day.

While ice management may take place anywhere beyond 5 miles from the rig, the area source was located east of the rig in the dispersion model based on sensitivity modeling described in Section 5.2.8.

5.2.7 Research Vessel Activity

A single vessel used to conduct biological, climatological, and oceanographic research, and evaluate environmental impacts of the drilling operation may cruise within 25 miles of the drill rig. The vessel may operate up to 600 hours per year and up to 24 hours per day while within 25 miles of the rig.

Emissions from the vessel were modeled as a circular area source, 1 km in diameter, even though the actual area that the mobile vessel will occupy is likely larger. The area source was modeled 1 mile east of the rig, which represents the closest distance the vessel is expected to operate to the rig. Assuming that the area source is smaller and closer to the rig than the actual operation will occupy is conservative and will reduce the amount of initial dispersion of the emissions and maximize the potential interaction between the vessel sources and the sources on the drill rig, which will in turn maximize modeled impacts. Furthermore, it should be noted that the vessel will be mobile, transecting the entire the project area as it collects data. Limiting the activity to occur only within a circle that is 1 km wide in the dispersion model is conservative as it concentrates emissions that will realistically be spread across a much larger space.

While research vessel activity may take place in any direction from the rig, the area source was located east of the rig in the dispersion model based on sensitivity modeling described in Section 5.2.8.

5.2.8 Alignment of Vessels Relative to the Drill Rig

Because the position of all of the vessels described above in relation to the drill rig will not be fixed, a sensitivity modeling analysis was conducted to determine the alignment of these sources relative to the drill rig position that would maximize project air quality impacts. The sensitivity analysis, which is documented in **Appendix L**, demonstrated that the worst-case alignment of these sources was to place them east of the drill rig, consistent with the predominant easterly wind direction of the modeled meteorological input data.

5.3 Modeling Scenario

Table 5-1 lists all individual activities and shows which are potentially contemporaneous. To be conservative, modeling of short-term (≤ 24-hours) averaging periods included emissions from all activities described above, even if the activities cannot occur simultaneously. For example, as shown in **Table 5-1** and previously discussed, the three types of activities that the dedicated OSRV can participate in cannot occur simultaneously because they are being conducted by the same vessel; however to be conservative, they were modeled as occurring contemporaneously.

Since all activities associated with the proposed exploratory drilling program will occur at some point throughout the duration of the drilling season, permitted annual emissions associated with all activities were included in a single annual modeling scenario when predicting annual average impacts.

Figure 5-1 depicts the near-field sources associated with the modeling scenario. **Figure 5-3** shows the far-field sources included in the modeling scenario.

5.4 Receptor Grid and Ambient Air Boundary

As discussed above, the drill rig will be located in close proximity to the shoreline; therefore, all modeling receptors were placed over water. A Cartesian receptor grid centered on the worst-case well location (i.e., well location = 473,600 East, 7,869,600 North, Zone 3, NAD 83) was generated based on UTM coordinates system with the following density:

- 25 m receptor spacing along the ambient air quality boundary;
- 25 m resolution extending from the ambient air quality boundary out to a distance of 1 km;
- 100 m receptor spacing beyond 1 km out to a distance of 2 km;
- 500 m resolution extending from the 2 km out to 5 km;
- 1,000 m resolution extending from 5 km to 20 km; and
- 2,000 m resolution extending from 20 km to 50 km.

Furthermore, additional receptors, spaced at 100 m intervals, were placed in the vicinity of sources located greater than 2 km from the rig where receptor spacing would otherwise have been greater than 100 m. The ambient air quality boundary for all project emissions was defined by the rail of the OCS Source, which is the rail of the drill rig.

The near-field receptor grid is shown in **Figure 5-1**, and the far-field receptor grid is shown in **Figure 5-3**.

For cumulative modeling, the receptor grid was refined to only include receptors within the significant impact area, and in all cases, refined modeling (25 m resolution) was conducted to resolve the maximum impacts if they were not modeled in the aforementioned 25 m grid. In addition, note that the receptor locations (as well as all source locations) used in significance and cumulative modeling were referenced to the same UTM coordinate system (Zone 3, NAD 83).

Table 5-1 Activities Associated with the Proposed Exploratory Drilling Program

	Normal Rig Drilling	**Rig Construction, Repositioning, and Demobilization**	**Resupply by OSV or Ware Vessel**	**Regular OSRV Operations**	**OSRV Operating During Fuel Transfer**	**Simulated Spill Response Exercises**	**Ice Management**	**Research Vessel Activity**
Normal Rig Drilling		X	X	X	X	X	X	X
Rig Const., Repos., and Demob.	X		X	X	X	X	X	X
Resupply by OSV or Ware Vessel	X	X		X	X	X	X	X
Regular OSRV Operations	X	X	X		**O**	**O**	X	X
OSRV Operation During Fuel Transfer	X	X	X	**O**		**O**	X	X
Simulated Spill Response Exercises	X	X	X	**O**	**O**		X	X
Ice Management	X	X	X	X	X	X		X
Research Vessel Activity	X	X	X	X	X	X	X	

O = Cannot occur simultaneously
X = Can occur simultaneously

Figure 5-1 Location of Near-Field Receptors and Sources

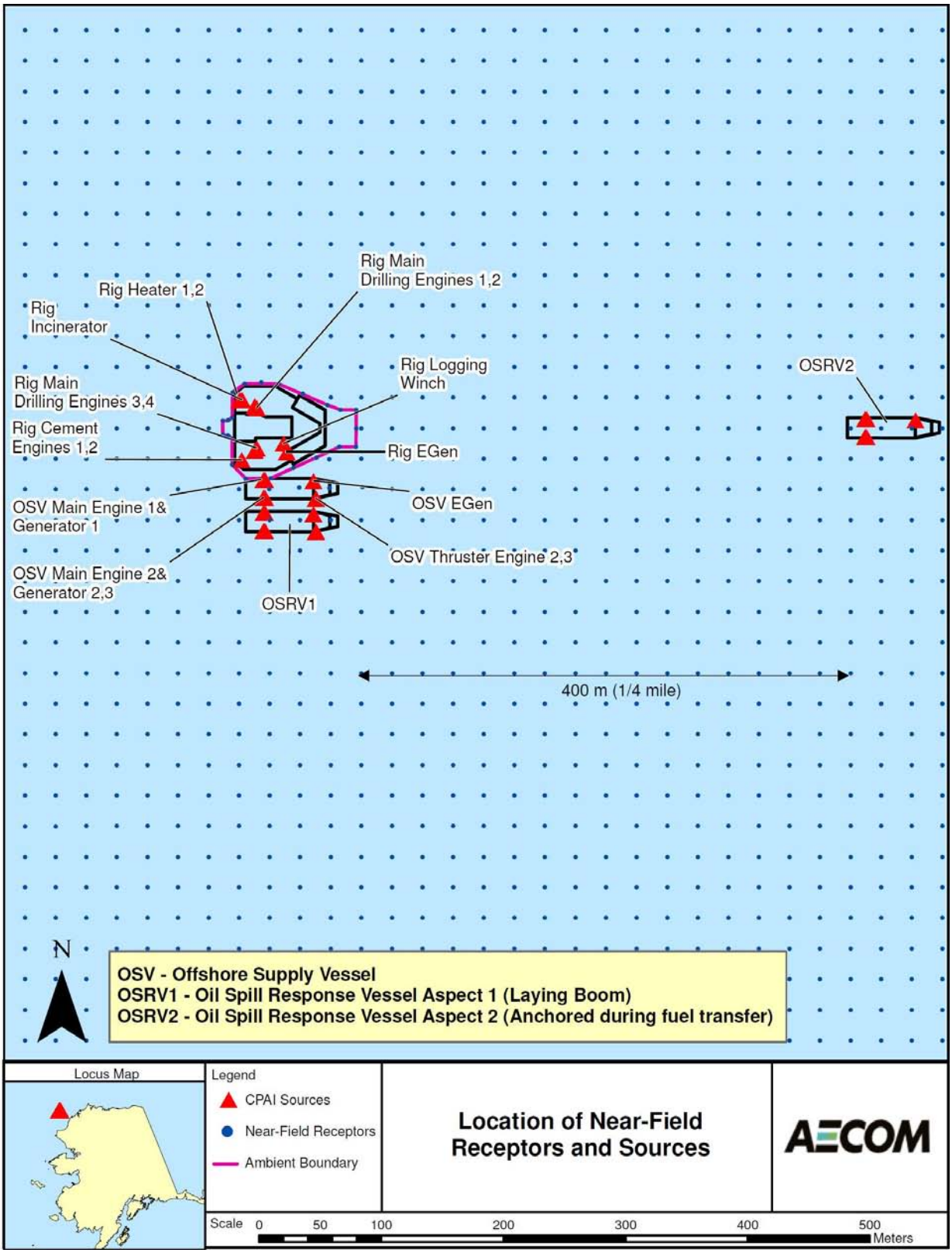


Figure 5-2 Location of Far-Field Receptors and Sources (out to ~17 km)

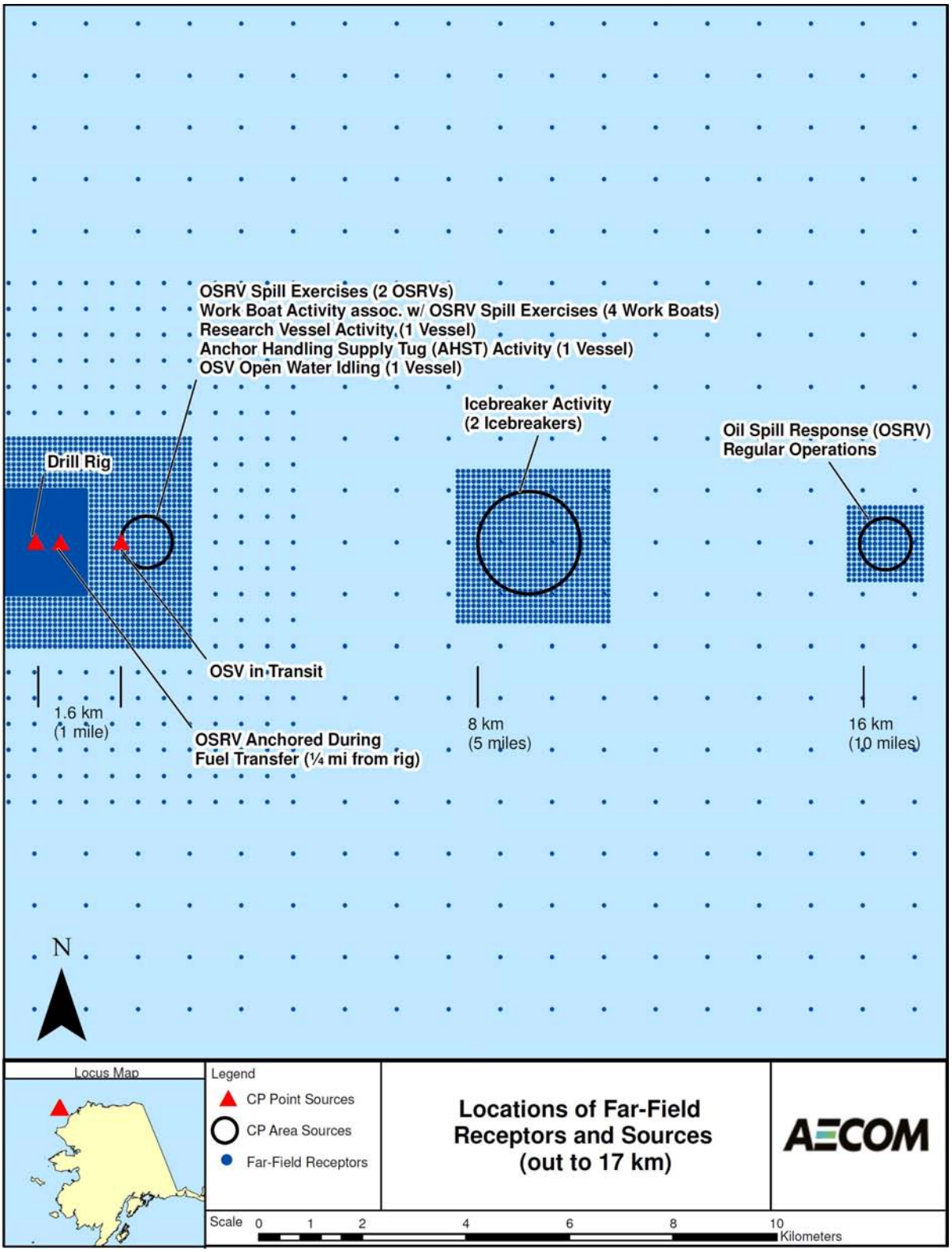
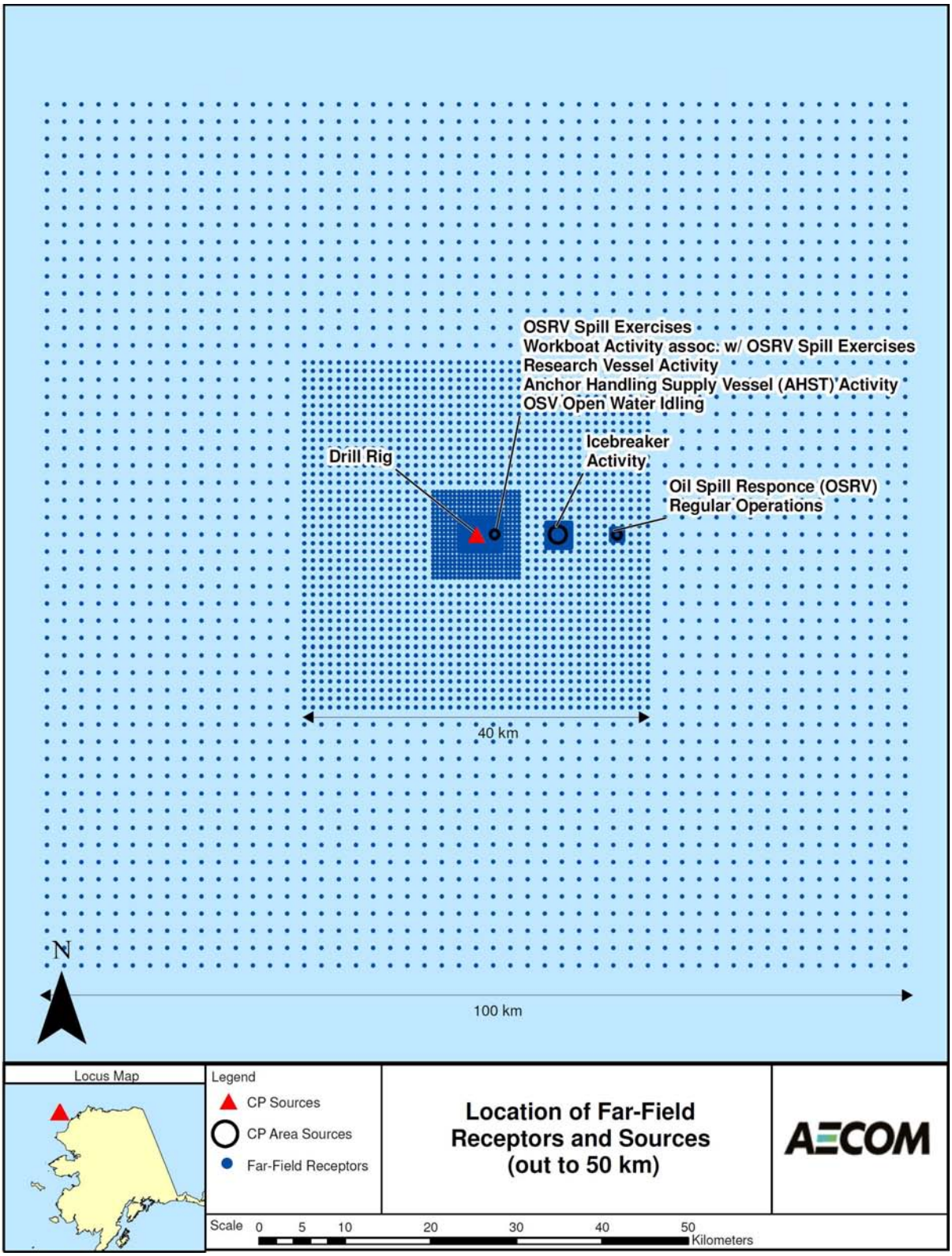


Figure 5-3 Location of Far-Field Receptors and Sources (out to 50 km)



6.0 Significant Impact Analysis

6.1 Modeling Methodology

The first step in the modeling to demonstrate compliance with the NAAQS was to determine maximum ambient air quality impacts due to emissions from the project sources for comparison to the USEPA significant impact levels (SILs). According to 40 CFR 55.2, the OCS Source is the drill rig and any vessels physically and operationally attached to it. For conservatism in the analysis, the modeling of the project included the OCS Source as well as all vessels associated with the project, including those vessels not physically attached to the rig but operating within 25 miles of the drill rig.

Based on standard modeling practice, the modeling results for the air emissions associated with the proposed project alone were first compared to the SILs (see **Table 6-1**). Note that there are no established SILs for $PM_{2.5}$. Therefore, this analysis used the lowest of the thresholds proposed by USEPA (USEPA 2007), as shown in **Table 6-1**. For pollutants and averaging periods where the modeled project impacts are below SILs, no further analysis is required and compliance with the NAAQS is demonstrated. For pollutants and averaging periods where the project modeled impacts are greater than the SILs, compliance with the NAAQS is based on cumulative modeling of project sources, existing stationary sources, plus a representative background concentration component to represent sources not explicitly modeled.

6.2 Significance Modeling Results

Maximum air quality impacts due to emissions from the project sources are summarized in **Table 6-2**. As shown in the table, predicted impacts are less than the SILs for 3-hour, 24-hour, and annual SO_2. This is an expected outcome from combusting only Ultra-Low Sulfur Diesel fuel. Therefore, no further analysis was required for 3-hour, 24-hour, and annual SO_2 and compliance was demonstrated with the NAAQS for these pollutants and averaging periods.

Modeling results exceeded the SILs for 1-hour and 8-hour CO, 24-hour and annual $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2. Therefore, a cumulative modeling analysis was conducted for these pollutants and averaging periods to demonstrate compliance with the NAAQS.

Table 6-2 also shows the Significant Impact Area (SIA) that was determined for each significant pollutant and averaging period. The SIA was defined as the radius from the drill rig well center to the farthest distance to the proposed project's impact above the SIL. As discussed above, these impacts represent those from CP sources only. **Table 6-2** indicates that the SIA for PM_{10} is less than <80 km. The furthest receptors in the receptor grid for the SIA modeling extended to 70 km where the maximum 24-hour impacts associated with the project sources was 5.4 $\mu g/m^3$ versus the PM_{10} SIL of 5 $\mu g/m^3$. This modeled impact at the edge of the receptor grid rounds to 5 $\mu g/m^3$, which is equivalent to the SIL indicating resolution of the SIA to be about 70 km. However, it was also estimated that at a distance of 80 km the project modeled impacts would be less than the 5 $\mu g/m^3$ SIL. Therefore, the SIA was conservatively estimated to be 80 km. A SIL has not yet been established by USEPA for $PM_{2.5}$. Based on the range of draft SILs proposed by USEPA (USEPA, 2007), the lowest proposed SIL is 1.2 $\mu g/m^3$. Based on this proposed SIL, the SIA would exceed 80 km. However, the SIA was not further investigated for $PM_{2.5}$ because: 1) it was clear that cumulative modeling was necessary and 2) a $PM_{2.5}$ SIL has not been defined by USEPA.

Table 6-1 Applicable Air Quality Standards

Pollutant	Averaging Period	Class II Significant Impact Level (SIL) [1] ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
CO	1-hour	2,000	40,000 [1]
	8-hour	500	10,000 [1]
NO_2	Annual	1	100 [2]
PM_{10}	24-hour	5	150 [3]
$PM_{2.5}$	24-hour	1.2 [4]	35 [5]
	Annual	0.3 [4]	15 [1]
SO_2	3-hour	25	1,300 [2]
	24-hour	5	365 [2]
	Annual	1	80 [1]

[1] Standard compared to the highest-second-high model predicted impact.

[2] Standard compared to the highest-first-high model predicted impact.

[3] Standard compared to the highest-sixth-high model predicted impact when modeling with 5 years of meteorological data.

[4] Lowest proposed value (USEPA 2007).

[5] Standard compared to the highest of the 5-year average eighth-highest model predicted impact at each receptor when modeling with 5 years of meteorological data.

Table 6-2 Significance Modeling Results – ConocoPhillips Project Sources Only – Maximum concentrations (μg/m^3)

Pollutant	Averaging Period	Wainwright NWS Met Data					Vessel Met Data	Overall Maximum Impact	SIL (μg/m^3)	SIA (km)
		1999	2002	2004	2005	2006	2008			
CO	1-hr	1,808	1,952	2,086	1,690	2,075	2,075	2,086	2,000	0.1
	8-hr	1,155	1,064	1,280	1,091	1,190	1,190	1,280	500	0.8
NO_2[1]	Annual	9.6	7.4	8.2	12.0	9.2	6.4	12.0	1	4
$PM_{2.5}$	24-hr	15.5	15.4	16.8	18.1	15.2	11.0	18.1	1.2	>80
	Annual	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3
PM_{10}	24-hr	15.5	15.4	16.8	18.1	15.2	11.0	18.1	5	<80
SO_2	3-hr	0.3	0.2	0.2	0.3	0.3	0.2	0.3	1	N/A
	24-hr	4.7	4.0	4.3	4.3	4.2	4.4	4.7	25	N/A
	Annual	2.3	2.0	1.9	2.1	1.6	2.0	2.3	5	N/A

[1] Includes the 75% NO_x to NO_2 conversion.

7.0 Regional Background Concentrations

To demonstrate compliance with the NAAQS, for those pollutants where the maximum modeled project impacts were greater than the SILs, the cumulative modeled impacts of the proposed project sources and significant off-site sources were added to a regional background concentration which represents sources not explicitly modeled. It should be noted that the background concentrations proposed below are based on data collected at a monitoring station located onshore, where pollutant concentrations will be much higher than in the project area due to the monitors' proximity to onshore sources. Therefore, the background concentrations are conservative representations of the ambient background concentrations in the project area.

7.1 CO and NO_2 Background Concentrations

Maximum concentrations recorded as part the Wainwright Near-Term Ambient Air Quality Monitoring Program (Wainwright Monitoring Program) were used as background data to demonstrate compliance with the NAAQS for CO and NO_2. **Figure 4-1** shows the location of the ambient monitor in Wainwright. As noted above, the influence of local combustion sources, while they impact the measured background concentrations, would not extend to the vicinity of the proposed project impact area, and therefore, ambient background concentrations in the project impact area will be much less than what is measured at Wainwright for these pollutants. **Table 7-1** presents the concentrations recorded at Wainwright from November 2008 through October 2009 for CO and NO_2.

Table 7-1 CO and NO_2 Background Concentrations

Pollutant	Averaging Period	Maximum Measured Concentration	
		ppm	µg/m^3
CO	1-hour	0.918	1050
	8-hour [1]	0.826	945
NO_2	Annual	0.001	1.7

[1] Period average calculated from non-overlapping blocks starting at midnight standard time each day.

7.2 $PM_{2.5}$ and PM_{10} Background Concentrations

Particulate concentrations (PM_{10} and $PM_{2.5}$) measured as part of the Wainwright Monitoring Program include, and are dominated by, the contribution from local fugitive dust sources that are not representative of the offshore project area which is located more than 100 km from the nearest fugitive dust source. Therefore, simply adding particulate concentrations measured at Wainwright to model predicted concentrations would not be representative of over water locations.

To determine representative 24-hour $PM_{2.5}$ and PM_{10} background concentrations over water the following two components were summed:

- A regional background concentration including contributions from sea spray, and Wainwright community fugitive dust and combustion sources; and
- A concentration determined through modeling which represented the effect of the dominant Wainwright fugitive dust sources in the project area.

The regional background concentration was determined by finding the highest 24-hour measured particulate concentration determined from among all days dominated by winds blowing from the sea and community sources towards the Wainwright monitor. Therefore, the resulting 24-hour $PM_{2.5}$ and PM_{10} measured concentrations included the influence of Wainwright community combustion and fugitive dust sources as well as sea salt particulate from the Chukchi Sea.

Dispersion modeling was then used to account for potential air quality impacts in the project area due to the fugitive dust from the Wainwright Airport. The emission rate for the modeled fugitive dust source was based on the maximum particulate impacts measured at the Wainwright monitor.

The regional background concentration was added to the modeled concentration due to fugitive dust from disturbed areas associated with the airport to determine the representative background concentration over water that was then used in the cumulative analysis detailed in Chapter 8.0. **Appendix M** provides details of the development of each of the two components comprising the 24-hour $PM_{2.5}$ and PM_{10} representative background concentrations that are summarized in **Table 7-2**.

Though a similar procedure of separately accounting for the influence of local fugitive dust impacts on measured concentrations could have been applied when determining the annual background particulate concentration, it was not conducted because the exercise would have had very little effect on the annual average particulate concentration determined because the annual measured $PM_{2.5}$ concentration is very low to begin with. The annual $PM_{2.5}$ background concentration listed in **Table 7-2** represents the average concentration over the 8 months of available data from the Wainwright Monitoring Program. While this is less than the 1 year of $PM_{2.5}$ data typically desired, the 8 months of available data span the drilling season and represent the highest concentrations expected to be measured during a 12 month period. This is because the data is collected in an area where particulate emissions are dominated by fugitive dust, and the 8 month timeframe encompasses the warmest and driest portion of the year, when local fugitive dust sources are exposed, no longer frozen and/or snow covered, and will be the most productive.

Table 7-2 $PM_{2.5}$ and PM_{10} Background Concentrations

Pollutant	Averaging Period	Maximum Representative Concentration ($\mu g/m^3$)
$PM_{2.5}$	24-hour	10
	Annual	3
PM_{10}	24-hour	49

8.0 Cumulative Impact Analysis

8.1 Modeling Methodology

As presented in Chapter 6.0, maximum project impacts exceeded the SILs for 1-hour and 8-hour CO, 24-hour and annual $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2. Therefore a cumulative modeling analysis was conducted to demonstrate compliance with the NAAQS for these pollutants and averaging periods. The cumulative modeling involved assessing the cumulative air quality impacts of 1) proposed project sources; 2) nearby off-site sources not related to the project; and 3) impacts from minor and naturally occurring sources not modeled represented by the background ambient air quality.

Following guidance provided in the GAQM (i.e., Section 8.2.3b), all sources expected to cause a significant concentration gradient in the vicinity of project sources were included in the cumulative modeling analysis. Therefore, the cumulative impact analysis included dispersion modeling of the proposed project's potential emissions as well as background source inventory discussed below.

To demonstrate compliance with the NAAQS, a representative regional background component (described in Chapter 7.0) was added to maximum modeled impacts and the total concentration was compared to the standards.

8.2 Off-site Inventory

An inventory of off-site sources not related to the project was considered for inclusion in the cumulative analysis as described below.

The off-site inventory included: 1) existing stationary sources, 2) stationary sources which have received PSD permits but have not yet began to operate, as well as 3) emissions from any proposed stationary source for which a complete PSD application exists but for which a permit has not yet been issued.

8.2.1 Shell Gulf of Mexico Inc. (Shell)

Shell has submitted a complete PSD permit application and has been issued a draft permit for exploration activities to be located near the project area. Shell's exploration plan for the next year indicates that this source could be potentially located northeast of the Devil's Paw Prospect in the Burger Prospect, due north of the Cracker Jack Prospect, or west of the project area in the SW Shoebill Prospect (see **Figure 1-1**). None of these locations are clearly worst-case in terms of producing maximum impacts in the project area. Therefore, a separate OCD modeling analysis was conducted to determine where to locate the Shell OCS Source to maximize impacts within the project area. **Appendix L** details the OCD analysis.

Note that the analysis conducted to determine the worst-case placement for the Shell OCS Source was developed by considering all of the Shell lease holdings, not just the specific prospects noted above that Shell details in its Exploration Plan for the first year of drilling.

Figure 8-1 depicts the worst-case Shell OCS Source location with respect to the CP OCS Source that was determined through a worst-case modeling analysis and was subsequently used in the cumulative analysis. This worst-case location is on the southern edge of the Cracker Jack Prospect (see **Figure 1-1** for location of Cracker Jack Prospect). **Figure 8-2** depicts the near-field configuration of the Shell OCS Source used in the cumulative analysis. The Shell OCS Source was modeled using locations, emissions, and stack parameter data found in Shell's revised Chukchi Sea air permit application submitted on December 22, 2009 as detailed in **Appendix L**.

Figure 8-1 Modeled Location of the Shell OCS Source Relative to ConocoPhillips Drill Rig

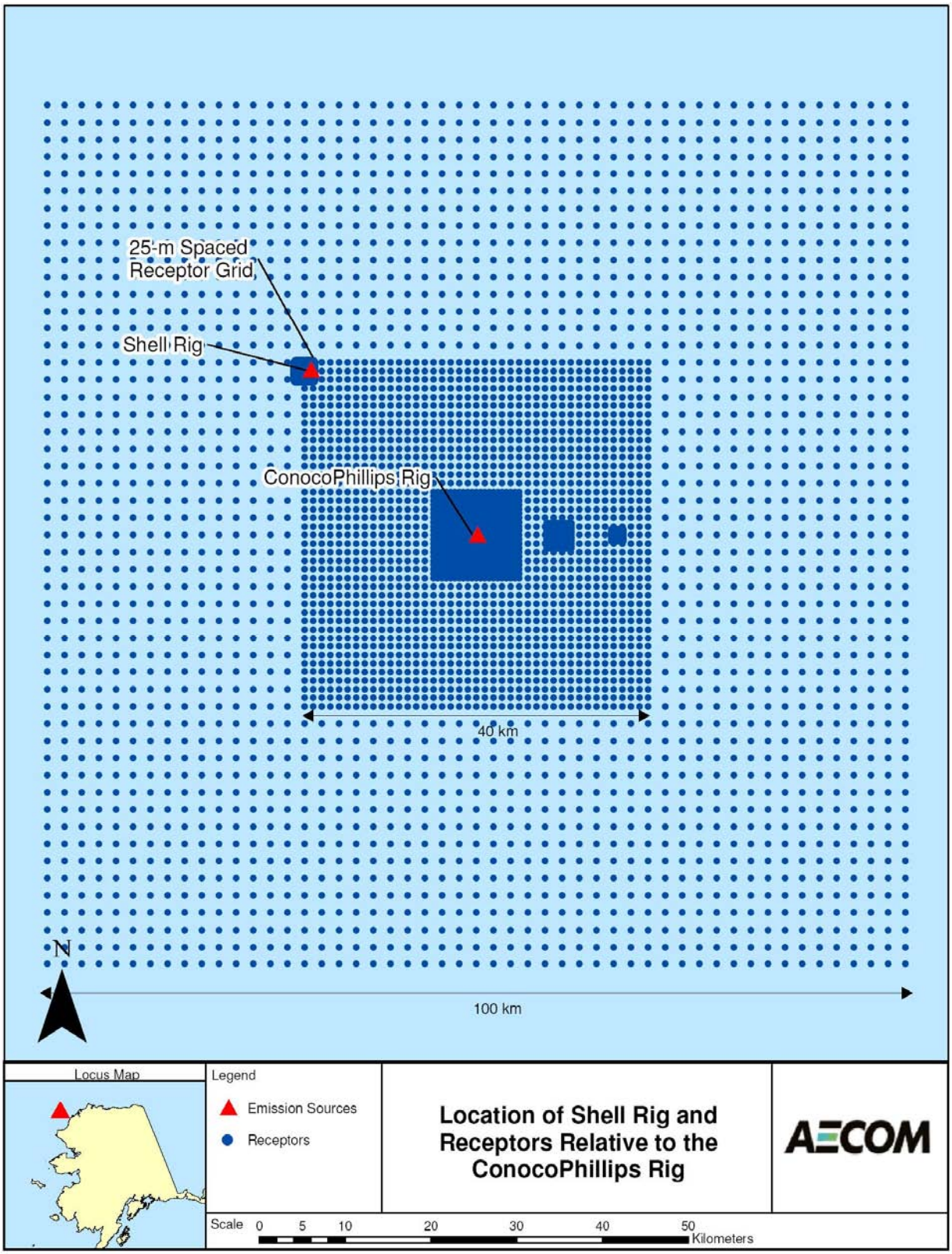
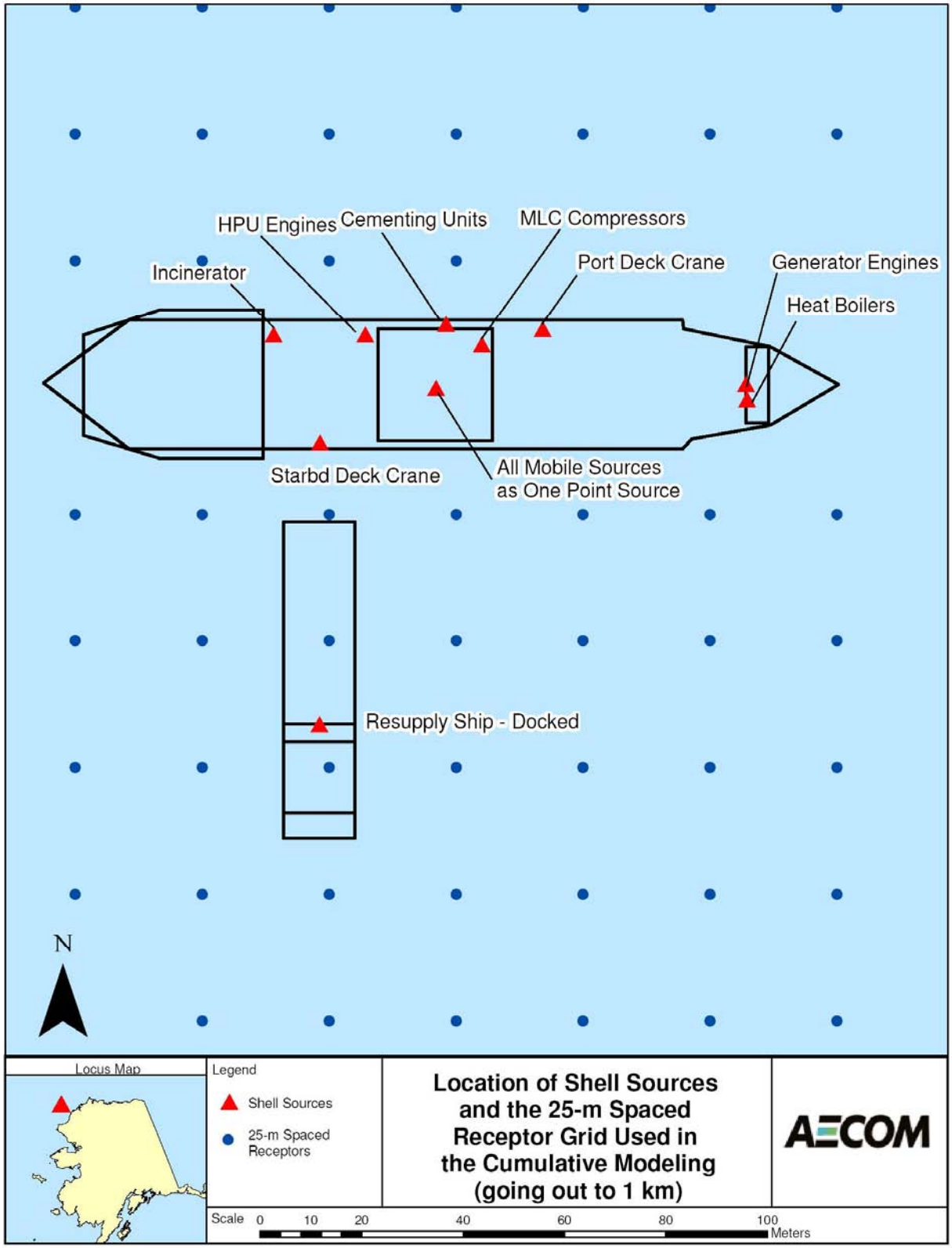


Figure 8-2 Modeled Near-Field Locations of Shell's Emissions Source Inventory



8.2.2 Existing Stationary Sources

Onshore stationary sources such as power plant combustion engines as well as residential and commercial heating sources from the following onshore communities were considered for possible inclusion in the cumulative analysis:

- Wainwright, AK – emission sources located approximately 170 km from the closest potential project location;
- Point Lay, AK – emission sources located approximately 120 km from the closest potential project location; and
- Barrow, AK – emission sources located approximately 300 km from the closest potential project location.

It was not necessary to include these sources in the cumulative modeling analysis because they are located too far away from the proposed project to cause a significant concentration gradient in the vicinity of project sources. Note that regional background concentrations which are included in the cumulative impact analysis (described in Chapter 7.0) already include the influence of the local sources associated with a typical coastal community; therefore, it would be inappropriate to include them in the cumulative modeling since it would be accounting for the impacts from these sources twice.

8.2.3 Mobile Sources

Non-project mobile vessels such as cruise ships, supply vessels bound for Barrow and Prudhoe Bay, etc. could transit the project area. Therefore, a separate analysis was conducted to evaluate if their inclusion within the cumulative impact analysis was necessary. The analysis consisted of modeling a single large vessel travelling through the CP modeling domain. Because results indicated that impacts were orders of magnitude below the SILs, it is assumed that vessels transiting the area will not cause a significant concentration gradient in the project impact area, and according to GAQM Section 8.2.3 do not need to be included in the cumulative analysis. **Appendix N** describes this analysis in further detail.

It should be noted that mobile support vessels associated with the Shell OCS Source <u>were</u> included as part of Shell's inventory that was explicitly modeled as part of the cumulative impact analysis.

8.3 Cumulative Modeling Results

Results of the cumulative impact analysis are summarized in **Table 8-1** which lists all modeled concentrations, ambient background concentrations, as well as total concentrations for comparison to the NAAQS. Maximum modeled impacts shown in the table were found using receptors that were resolved to 25 m spacing. **Table 8-1** clearly demonstrates that model predicted cumulative air quality impacts are less than the NAAQS for all pollutant and averaging periods evaluated.

8.3.1 Description of Model Predicted Short-Term Impacts

<u>CO Impacts</u>

Maximum short-term CO modeled impacts were found to be located 100 to 200 m from the drill rig. The receptors in this area are spaced 25 m apart; therefore, the overall maximum 1-hour and 8-hour CO impacts were captured.

As shown in **Table 8-1,** culpability analyses indicate that CP project sources contribute 100% of the maximum modeled impact. Additional analyses indicate that emission units located on the OSV and the OSRV laying boom during fuel transfer as the most culpable project sources. These impacts were driven by a combination of drill rig structure downwash and low mixing heights which are likely an artifact of the procedure used to derive the mixing heights from the Barrow upper air data as discussed in Section 4.2.1 and **Appendix J**.

Table 8-1 Cumulative Analysis Results (Concentrations in μg/m^3)

Pollutant	Avg Period	Impacts Predicted with Wainwright NWS Meteorological Data					Overall Maximum Impact	CP Contribution to Overall Maximum Impact	Bkgrnd. Conc.	Total	NAAQS
		1999	2002	2004	2005	2006					
CO	1-hr	1,926	1,823	1,740	1,921	2,075	2,075	2,075	1,050	3,125	40,000[1]
	8-hr	1,094	1,008	1,008	1,073	1,089	1,094	1,094	945	2,039	10,000[1]
NO_2[1]	Annual	9.7	7.6	10.4	12.1	9.3	12.1	12.0	2	14.1	100[2]
$PM_{2.5}$	24-hr	17.9					17.9	0	10	28.1	17.9
	Annual	1.7	1.4	1.9	2.3	1.7	2.3	0	3	5.3	15[1]
PM_{10}	24-hr	22.4	20.4	37.2	24.8	23.2	37.2	0	49	86.3	150[3]

[1] Standard compared to the highest-second-high model predicted impact.

[2] Standard compared to the highest-first-high model predicted impact.

[3] Standard compared to the highest-sixth-high model predicted impact when modeling with 5 years of meteorological data.

[4] Standard compared to the highest of the 5-year average of the eighth-highest model predicted impact at each receptor when modeling with 5 years of meteorological data.

$PM_{2.5}$ and PM_{10} Impacts

Maximum 24-hour $PM_{2.5}$ and PM_{10} modeled impacts occur 27 km northeast of the drill rig, near the modeled Shell OCS Source. This location is in the portion of the receptor grid with 2 km spacing. Therefore, additional receptors spaced 25 m apart were then developed and included in the modeling to ensure the highest impacts were captured. **Table 8-1** reflects impacts found within the 25 m spaced fine grid of receptors.

Culpability analyses show that CP project sources do not contribute to the maximum modeled impact. This is because the maximum particulate concentrations are found at a large distance from the CP project sources and in close proximity to the Shell OCS Source. Note that the modeling of the Shell OCS Source was based on information provided in the December 2009 permit application for the Shell project. There might be room for refinement of the Shell impacts if the Shell modeling parameters were investigated further. In addition, based on the following, the cumulative $PM_{10}/PM_{2.5}$ impacts controlled by Shell are likely conservative:

- Review of the maximum cumulative impacts controlled by Shell indicates the modeled results were associated with very low mixing heights which are likely an artifact of the procedure used to derive the mixing heights from the Barrow upper air data discussed in Section 4.2.1 and **Appendix J**. If the conservatism was removed from the analysis by refining the mixing heights, the maximum cumulative impact would likely decrease.
- As discussed in the Shell permit application, the Shell OCS Source must be oriented into the wind as was simulated in the screening modeling used to support that application. This limitation on the Shell OCS Source could not be incorporated in the refined OCD modeling. Therefore, the fixed Shell source orientation represented in the cumulative modeling may result in overly conservatively impacts by allowing for plume overlap that would not occur if the Shell OCS Source could be oriented into the wind for every hour of the modeling.
- To simplify the analysis, the entire Shell mobile vessel fleet was modeled at a single point in the center of the Shell drill ship. This is more conservative and produces higher impacts than if the mobile vessel fleet were spread out over hundreds of meters as simulated in the ambient air quality impacts analysis conducted by Shell.

Therefore, the maximum model predicted cumulative short term $PM_{10}/PM_{2.5}$ impact, which is entirely the result of the Shell OCS Source, could be reduced if there was concern about an impact that CP project sources do not significantly contribute to.

8.3.2 Description of Model Predicted Annual Impacts

NO_2 Impacts

As reflected in **Table 8-1,** culpability analyses indicate that CP project sources contribute 100% of the maximum annual cumulative NO_2 impact (i.e., 12 µg/m^3). The overall maximum annual NO_2 modeled impacts were located 40 m south-southeast of the project's well center. This is shown in **Figure 8-3** that illustrates the maximum annual NO_2 modeled concentrations relative to the CP source locations. Note that the model receptors in the areas adjacent to project sources are spaced 25 m apart; therefore, the overall maximum annual NO_2 impacts were captured. **Table 8-2** provides the culpability of specific CP project sources to the maximum modeled impact. The culpability analysis indicates that the emission units located on the OSV, which is located adjacent to the drill rig, contribute the most to the maximum impact (i.e., 10.9 µg/m^3). These modeled impacts were largely driven by structure downwash of the drill rig.

Figure 8-3 also indicates that the impacts adjacent to the ice breakers and OSRV regular operations are low; i.e., less than 1 µg/m^3.

The total maximum project impact plus background is 14 µg/m^3, or only 14% of the NAAQS (100 µg/m^3). Therefore, the modeling indicates a wide margin for compliance based on the proposed NO_x emission rates.

Given this wide compliance margin, and the fact that impacts from the drill rig and support vessel activity are very low in comparison to the NAAQS, a shift in the distribution of annual emissions amongst the support vessels and drill rig would not affect NAAQS compliance.

Table 8-2 Project Source Culpability for the NO_2 Annual Maximum Concentration

Source Group	NO_2 Annual Impact at the Max Location (µg/m^3)
Drill Rig Emission Units	
Main Engines	0.00
Emergency Generator	0.00
Cement Units	0.01
Logging Winch	0.02
Heaters	0.03
Incinerator	0.00
Total from the Drill Rig	**0.1**
Supply Vessel (OSV)	
Main Engines	0.2
Thruster Engines	8.4
Generators	2.3
Total from the OSV	**10.9**
Oil Spill Response Vessel (OSRV) Laying Boom During Fuel Transfer	
Main Engines	0.1
Thruster Engines	0.1
Generators	0.0
Total from the OSRV	**0.3**
All Other Sources Associated with the Project	~0.8
Total Concentration from All Sources	**12.0**

$PM_{2.5}$ Impacts

The overall maximum annual $PM_{2.5}$ modeled impacts were initially found to occur 27 km from the project's well center, near the modeled Shell OCS Source. This location is in the portion of the receptor grid with 2 km spacing. Therefore, additional receptors spaced 25 m apart were then developed and included in the modeling to ensure the highest impacts were captured. **Table 8-1** reflects impacts found within the 25 m spaced fine grid of receptors. Culpability analyses show that CP project sources do not contribute to the maximum modeled impact. This is because the maximum particulate concentrations are found at quite a distance from the proposed project sources and in close proximity to the Shell OCS Source. As shown in **Table 8-1**, the total maximum modeled concentration (2.3 µg/m^3) plus background (3 µg/m^3) is only 20% of the NAAQS (i.e., 5.3 µg/m^3 versus 15 µg/m^3). Given this wide compliance margin, a shift in the distribution of annual emissions amongst the support vessels and the drill rig would not affect NAAQS compliance.

8.3.3 Discussion of the Model Predicted $PM_{2.5}$ Impacts Dominated by the CP OCS Source

As discussed in Section 8.3.1, the maximum short-term cumulative $PM_{2.5}$ concentration was modeled at receptors adjacent to the Shell OCS Source and there was no contribution to the maximum modeled concentration from CP sources. This impact, which is known to be conservative due to the simplistic way the Shell OCS Source was simulated, does not warrant attention as compared to the maximum short-term $PM_{2.5}$ impact that the CP OCS Source contributes significantly to. Therefore, additional analysis of the $PM_{2.5}$ results was conducted to understand the maximum short-term $PM_{2.5}$ impacts associated with the CP project sources in terms of location and source culpability. In support of the analysis, contour plots of maximum modeled concentrations were developed as shown in **Figure 8-4** and **Figure 8-5**. **Figure 8-4**, shows the far-field view of modeled concentrations relative to all CP project sources and clearly shows that maximum concentrations resulting from project sources were found adjacent to the drill rig. **Figure 8-5** shows a zoomed in view of the maximum concentrations adjacent to the rig and shows a primary impact area where the maximum concentration due to CP source emissions was predicted to the north of the rig (i.e., 18.1 µg/m^3) and an secondary impact area to the northwest of the rig (i.e., secondary max of 16.9 µg/m^3).

A breakdown of the source culpability for the primary maximum and secondary maximum concentrations is provided in **Table 8-3**. As shown in **Table 8-3**, drill rig sources account for most of the modeled concentrations with the main engines accounting for approximately half of the impacts at both the primary and secondary maximum impact areas identified (i.e., 8.9/18.1 = 47%) at the primary maximum impact area, and 41% (6.9/16.9 = 41 %) at the secondary maximum impact area). **Table 8-3** also indicates that the project $PM_{2.5}$ impacts associated with the supply vessel (2.3 µg/m^3), OSRV (1.1 µg/m^3), and "other" sources associated with the project (0.3 µg/m^3) are all very low compared to 24-hour $PM_{2.5}$ NAAQS (35 µg/m^3).

Given that the Shell OCS Source does not have a significant impact in the vicinity of the CP OCS Source, a cumulative impact can be estimated by ignoring the Shell OCS Source and simply summing the maximum project impacts with background. Using this approach, the overall maximum cumulative impact dominated by CP sources is 28.1 µg/m^3 (i.e., a project impact of 18.1 µg/m^3 plus a background of 10 µg/m^3). Note that this total concentration is based on the highest modeled concentration associated with the project and not the 98th percentile that is used for compliance with the $PM_{2.5}$ NAAQS. Therefore, the margin of compliance is greater than indicated by this simple calculation. Nonetheless, there is still ample room for compliance demonstrating that short-term emission limits for CP project sources are not necessary to ensure that ambient air quality impacts resulting from the CP OCS Source remain below the NAAQS.

Figure 8-3 Far-Field Contour Plot of NO_2 Annual Impacts from Project Sources

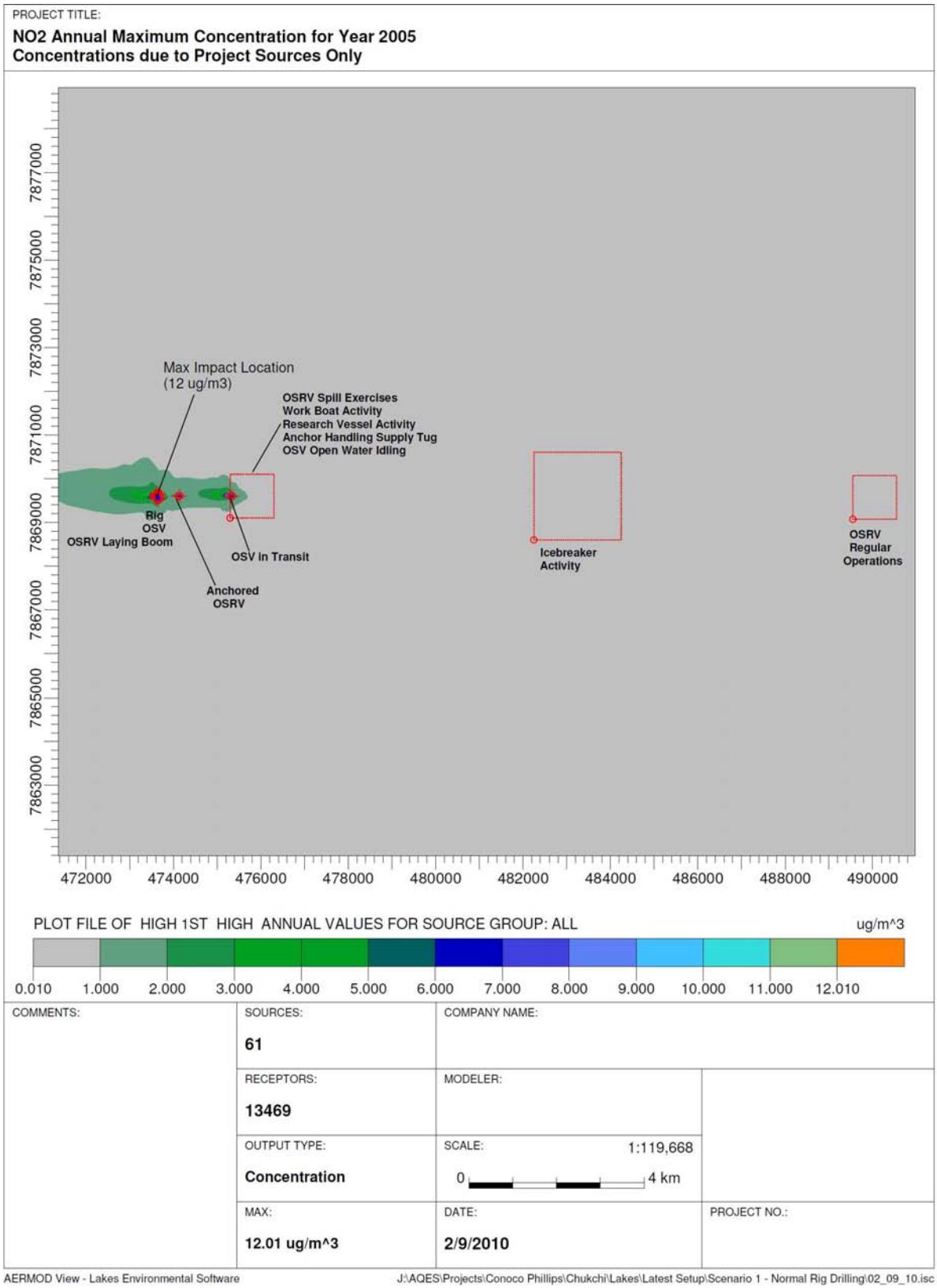


Figure 8-4 Far-Field Contour Plot of $PM_{2.5}$ 24-hour Impacts from Project Sources

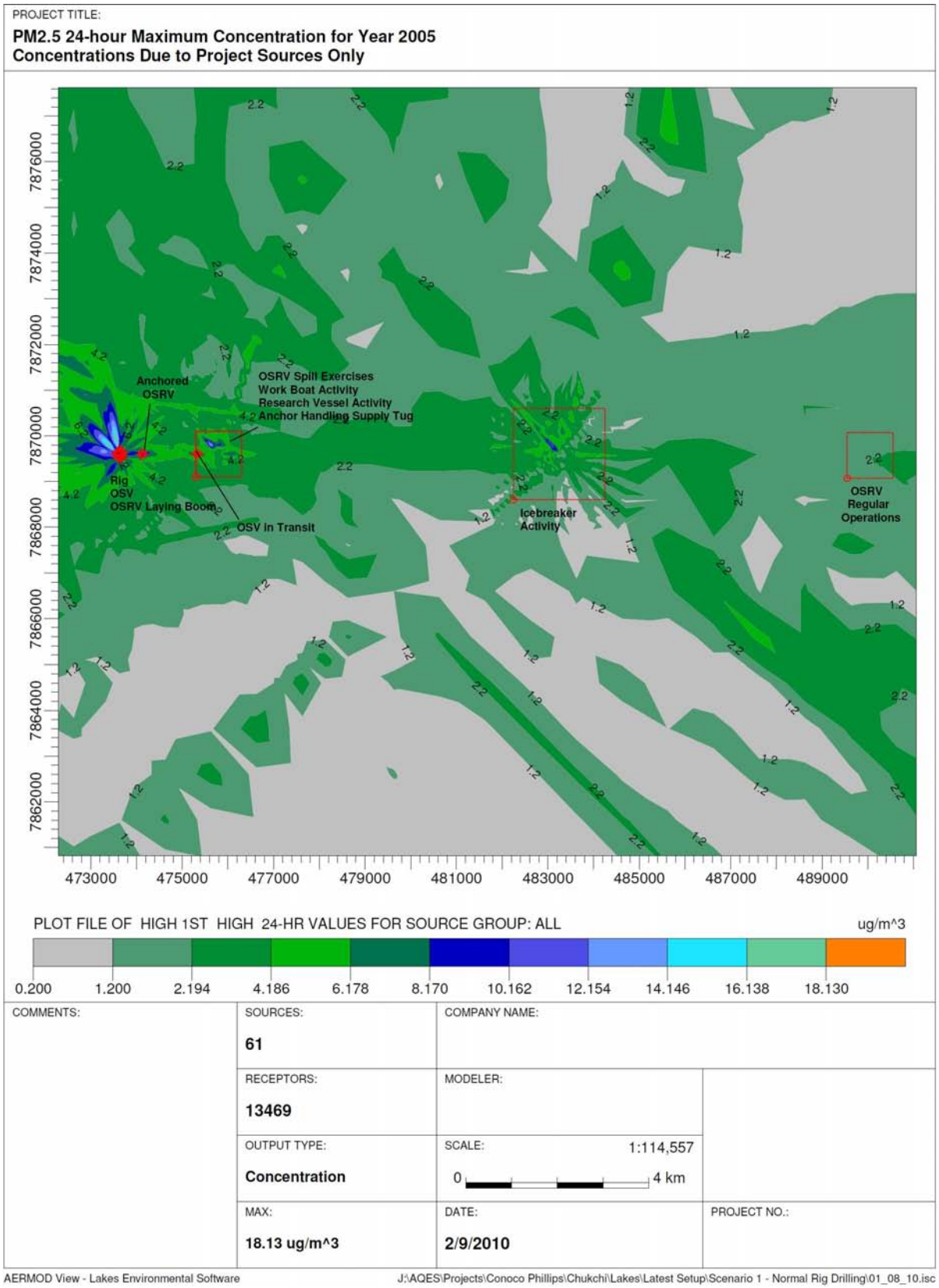


Figure 8-5 Near-Field Contour Plot of $PM_{2.5}$ 24-hour Impacts from Project Sources

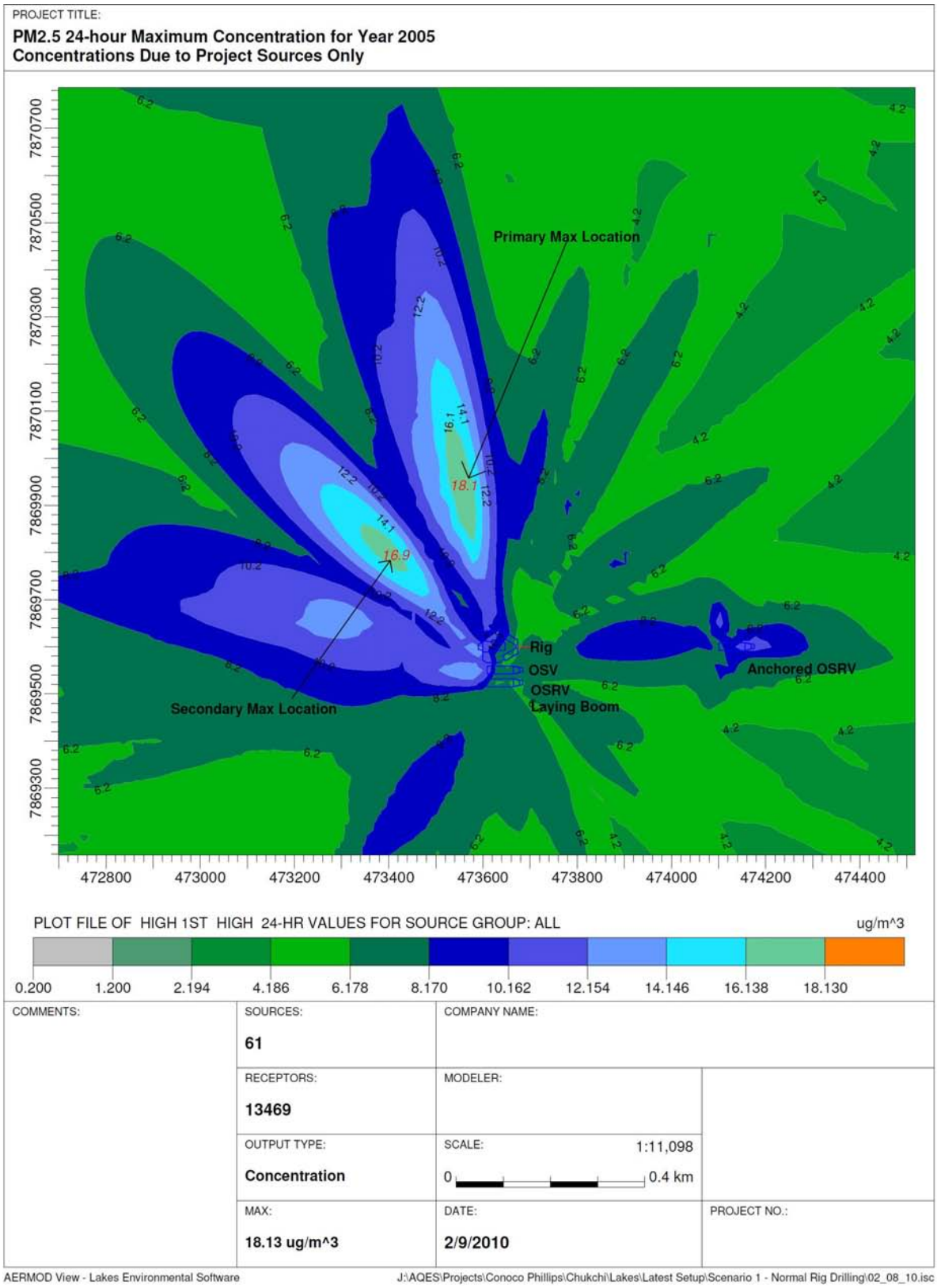


Table 8-3 $PM_{2.5}$ 24-hour Project Source Culpability for the Primary Maximum and Secondary Maximum Concentrations

Source Group	$PM_{2.5}$ 24-hr Impact at the Primary Maximum Location (µg/m^3)	$PM_{2.5}$ 24-hr Impact at the Secondary Maximum Location (µg/m^3)
Drill Rig Emission Units		
Main Engines	8.5	6.9
Emergency Generator	1.0	1.1
Cement Units	1.7	1.8
Logging Winch	0.5	0.5
Heaters	0.1	0.2
Incinerator	2.9	2.9
Total from the Drill Rig	**14.7**	**13.4**
Supply Vessel (OSV)		
Main Engines	0.1	0.1
Thruster Engines	1.4	1.5
Generators	0.8	0.7
Total from the OSV	**2.2**	**2.3**
Oil Spill Response Vessel (OSRV) Laying Boom During Fuel Transfer		
Main Engines	0.4	0.3
Thruster Engines	0.5	0.4
Generators	0.2	0.2
Total from the OSRV	**1.1**	**0.9**
All Other Sources Associated with the Proposed Project	~0.1	~0.3
Total Concentration from All Sources	**18.1**	**16.9**

8.3.4 Comparison of Impacts Predicted with the Wainwright NWS Data Compared to Onsite Vessel Data

While the significance and cumulative modeling analyses included the determination of impacts using onsite meteorological data collected by the research vessel, it should be noted that those impacts were not used for comparison to air quality thresholds such as the SILs or NAAQS. Modeled impacts found using the onsite vessel meteorological data have been included in these air quality impact analyses for comparison to impacts found using the Wainwright NWS 5-year data set to reinforce that:

- Conducting modeling with the Wainwright NWS data produces impacts representative of those predicted with over water meteorological data; and
- When possible, basing an ambient air quality impact analysis on a representative long-term metrological database produces a more robust analysis than basing impacts in a single year of data.

Table 8-4 shows the comparison of maximum modeled impacts between the two meteorological datasets, indicating that predicted impacts are comparable. For all pollutants and averaging periods with the exception of 8-hour CO, Wainwright NWS data produces the highest modeled concentrations, and the vessel met data results fall within the range of the 5-years of Wainwright NWS model concentrations. This supports the conclusion that the Wainwright NWS is representative for modeling the project impacts, and in all cases with the exception of 8-hour CO (which is not a controlling pollutant for NAAQS compliance) the results using Wainwright NWS data are more conservative for this analysis.

The variability of the impacts year-to-year shown in **Table 8-4** clearly shows that the more robust compliance demonstration relies on modeling conducted with the longest-term data available by properly accounting for the natural inter-annual variability that leads to both elevated and low impacts. This conclusion is supported by GAQM Section 8.3.1.2 which recommends that modeling should be conducted with a long-term data record to ensure that worst-case meteorological conditions are adequately represented in the model results.

Table 8-4 Maximum Modeled Concentrations for Sources Included in the Cumulative Analysis

Pollutant	Averaging Period	Wainwright NWS Met Data					Vessel Met Data	Overall Maximum Impact
		1999	2002	2004	2005	2006	2008	
CO	1-hr	2,089	2,056	2,137	2,676	2,163	2,252	2,676
CO	8-hr	1,155	1,064	1,280	1,128	1,190	1,375	1,375
NO_2[1]	Annual	9.7	7.6	10.4	12.1	9.3	6.6	12.1
$PM_{2.5}$	24-hr	17.6	19.2	35.5	18.1	26.0	27.5	35.5
	Annual	1.0	0.7	1.3	0.8	0.9	0.8	1.3
PM_{10}	24-hr	17.6	19.2	35.5	18.1	26.0	27.5	35.5

9.0 Digital Record

A digital record was compiled and provided to USEPA Region 10. The digital record contains pertinent information supporting the ambient air quality analysis described herein. The contents of the digital record are as follows:

- Spreadsheets supporting emissions and stack flow calculations;
- Spreadsheets demonstrating the procedures used to fill meteorological data;
- All input and output files used to create the meteorological databases used as input to the modeling;
- All OCD modeling files supporting all sensitivity analyses;
- All OCD modeling files supporting the significance and cumulative modeling analyses;
- Data from the Wainwright Monitoring Program used to develop background concentrations used in the cumulative modeling analyses;
- All AERMOD modeling files supporting the development of representative short-term particulate background concentrations; and
- An electronic copy of this report and all appendices.

10.0 References

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