Shell Exploration & Production

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David Johnston, Regional Supervisor
Office of Leasing and Plans
Alaska OCS Region
U.S. Department of Interior
Bureau of Ocean Energy Management
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503-5823

December 20, 2013

Re: Shell Gulf of Mexico Inc. – Responses to Requests for Additional Information for Chukchi Sea Exploration Plan Revision 2

Dear Mr. Johnston:

Shell Gulf of Mexico Inc. (Shell) hereby submits responses to requests for additional information (RFAI) from the Bureau of Ocean Energy Management regarding Shell's Chukchi Sea Exploration Plan Revision 2 received on November 29, 2013. Attached are two documents listing the RFAIs and Shell's responses. In some cases these responses do not fit into the document format and so are included as separate files on the accompanying compact disks.

If there are any questions or comments please contact me at (907) 646-7112 or at Susan.Childs@Shell.com.

Sincerely,

Susan Childs
AK Venture Support Integrator, Manager

Attachments:

RFAI response document (Operational and Environmental)
RFAI response document (Air Quality)
3 compact disks (two public and one proprietary)

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OPERATIONAL

RFAI No. 1 (Section 1.0, Page 1-1, Paragraph 1)

Provide information on any modifications that Shell performed to the Noble Discoverer to make it Arctic-ready, and provide documentation that Shell has addressed and corrected all non-compliance deficiencies cited by the U.S. Coast Guard and EPA following exploration drilling by the Noble Discoverer in 2012.

Section 2.2 of the IOP, pages (15-18) detailed the preparation of the *Discoverer* for Arctic service in 2014.

Marine vessels chartered by Shell are subject to stringent U.S. Coast Guard inspection requirements contained in the Code of Federal Regulations. Various certificates and documents are issued by the Coast Guard to the vessel owner/operator to demonstrate compliance with the regulations. Shell will request these certifications and documents from the appropriate vessel operator so Shell can provide to BSEE any such certifications and documents required by their regulations (subject to appropriate confidentiality limitations, if any). Shell will provide copies of any such certifications and documents to BOEM.

RFAI No. 2 (Section 1.0)

Provide confirmation of the completion of the third party management system review (as required by the 60-Day Report) or, if not yet complete, Shell's plans and schedule for completing the third party review.

On December 9, 2013 Shell submitted a Safety and Environmental Management Systems (SEMS) and Shell Alaska Management System Audit document to the Bureau of Safety and Environmental Enforcement. This document outlines Shell’s plans and schedule for completing the third party review as recommended in the Department of the Interior report. This document is under review by BSEE. A final version will be submitted to BOEM when available.

RFAI No. 3 (Section 1.0, Page 1-1)

EP Rev 2 proposes adjusting the BOP test frequency from once every 7 days to once every 14 days. In its 2012 Chukchi Sea EP, Shell stated "[t]he blowout prevention program will be enhanced through ...increased frequency of BOP performance tests from 14 to 7 days ...” Provide the rationale behind Shell's decision now to reduce the frequency of BOP tests to 14 days. Also, provide clarification for the doubling of the barrels of well fluids to be discharged because of BOP re-testing, if the BOP system is now proposed to be tested half as often (i.e., every 14 days as opposed to 7 days).

Shell has adopted the current industry practice from the Gulf of Mexico: a pressure test every 14 days and a function test every 7 days, so the control systems would still be tested every 7 days. Standardizing the frequency of the pressure test to concur with the Gulf of Mexico will reduce wear on the BOP sealing elements, enhancing rather than degrading BOP reliability. Fluids discharged will not be reduced, since the function test is still being conducted every 7 days. The BOP discharge fluid was doubled to allow contingency for re-test.

Section 12 of EP Revision 2 will be modified to include the preceding explanation.

RFAI No. 4 (Section 1.0, Page 1-1, Footnote)

Correction: BOEM was enjoined from taking action on the May document. Once the injunction was lifted, Shell submitted its Revised draft EP, dated October11, 2011.

Comment noted.

RFAI No. 5 (Section 1.0, Page 1-7, Figure 1.b-7)

The anchor radius of the Burger S well is projected to extend outside of lease block 6762 and would require a right of use easement per 30 CFR 550.160. This should be reflected within the EP narrative, within Table 1-1, and other applicable sections of the EP Rev 2.

Under 30 CFR 550.160 Shell will apply for a right-of-use and easement authorization to place one or more anchors on an adjacent lease when Shell submits an Application for Permit to Drill to BSEE. Text addressing this request has been included in the EP Revision 2 on page 12-1.

RFAI No. 6 (Section 2.0, Page 2-1, Table 2.a-1)

Permits and certifications associated with the relief drilling rig operations in the Chukchi Sea need to be identified in this table. Submittal of copies of the permits listed in this table would be helpful.

Shell does not plan to have the Polar Pioneer enter the Chukchi Sea as a primary drilling vessel. The Polar Pioneer will remain in Dutch Harbor on standby while the Discoverer is drilling in the Chukchi Sea. Therefore, there are no permits or authorizations under 30 CFR 550.213(a) for the Polar Pioneer as a drilling vessel in the Chukchi Sea, and Table 2.a-1 of the EP Revision 2 will not be modified.

RFAI No. 7 (Section 2.0 & 6.0, Tables 2.b-1, 6.1-1, 6.a-2, 6.a-3, 6.a-4, 6.a-5)

Provide clarification of the differences between volumes provided in Table 2.b-1 and the well specific tables within Section 6.0 regarding estimated discharge volumes once the riser is set. Provide example of calculations.

Using the Burger F drill site as an example, it is estimated that 7,188 bbl of drilling fluid will be used to drill the well to total depth (Table 2.b-1). The corresponding discharge volume in Table 6.a-2 (WBM drilling fluids and cuttings with adhered WBM) is 6,731 bbl. 6,731 bbl includes 5,688 bbl of drilling fluids and 1,043 bbl of cuttings. 5,688 bbl of drilling fluid added to 1,500 bbl of reserve pit WBM totals 7,188 bbl. A clarifying footnote has been added to Table 2.b-1 on page 2-2 of the EP Revision 2 and text has been added to Tables 6.a-1 through -6 clarifying the drilling fluid and cuttings volumes for each planned well.

RFAI No. 8 (Section 2.0, Page 2-2)

Provide information and documentation (i.e. certification and approvals) to verify that the well capping stack and containment system are ready and available for Arctic OCS conditions.

Section 2.12 (Surface Intervention – Capping and Containment (If Necessary)) and 2.13 (ACS Dome Component Improvements) of the IOP provides information that the capping stack and containment system are ready and available for Arctic OCS conditions.

Marine vessels chartered by Shell are subject to stringent U.S. Coast Guard inspection requirements contained in the Code of Federal Regulations. Various certificates and documents are issued by the Coast Guard to the vessel owner/operator to demonstrate compliance with the regulations. Shell will request these certifications and documents from the appropriate vessel operator so Shell can provide to BSEE any such certifications and documents required by their regulations (subject to appropriate confidentiality limitations, if any). Shell will provide copies of any such certifications and documents to BOEM.

RFAI No. 9 (Section 2.0, Page 2-2)

For drilling a relief well, provide for the Polar Pioneer:

- ***mobilization time (supported by speed of towing vessel, distance, weather factors, time to anchor, etc.), and proposed drilling schedule; • notifications that Shell will issue before moving the Polar Pioneer; and***
- ***assets (availability and logistics of support vessels/equipment) moving with the Polar Pioneer***

The following table outlines the schedule for the Polar Pioneer and her support vessels to mobilize to the Burger Prospect and drill a relief well.

Activity	Unmooring at Dutch	Tow from Dutch to Burger	Mooring at Burger	Drilling to intercept point
Timing	1.0 days	7.5 days	1.5 days	28 days
Comments	Based on pulling and racking anchors and commencing tow. Rig will be fully crewed with TransOcean staff keeping equipment in a state of readiness	Built around 6 knots travel speed based on previous average tows with Polar Pioneer incorporating a variety of weather conditions and one active tug. In this case two tugs and a contingency anchor handle are available.	Based on 2 anchor handlers and past anchoring times.	Base time of 23 days from original estimate with logging, MLC and P&A operations removed. Adds in ranging runs. Nominal estimate of NPT at 20% takes estimate to 28 days. Additional information will be provided in the APD as required.

RFAI No. 10 (Section 3.0)

The EP Rev 1 proprietary Section 3.0 was written prior to the drilling program in 2012. The drilling program at the Burger Site A included the excavation of a mudline cellar approximately 21 feet in diameter by 40 feet deep and drilling a pilot hole to approximately 1,500 feet below the sea level that was continuously logged while drilling. Shell interpreted the proprietary well log data, concluding that no permafrost is present in the subsurface at Burger Site A and that cooled muds would not be required when drilling to TD. These conclusions are asserted on pages 12-1 and xiv (App. E) in EP Rev 2, but the logs nor their analysis are not included. Provide an updated proprietary Section 3.0 with geological descriptions and associated data (specifically log data) obtained from the 2012 drilling field season, and Shell's analysis to support changes in the exploration drilling program.

The response to this request contains proprietary information and is attached as a separate document under separate cover labeled RFAI 10 Proprietary Section 3. Changes to this section are noted with red font.

RFAI No. 11 (Section 4.0)

Submit the recent H2S Contingency Plan that was submitted to BSEE on July 18, 2013. The revised H2S plan should be referenced in the EP Rev. 2 and changes are needed to Section 4.0 to reflect this new plan. Also, confirm that all emergency contact phone numbers are valid. Provide information on how any changes will be provided to relevant agencies.

The most recent H2S plan was submitted to BSEE on July 18, 2012. The changes included minor administrative changes such as naming the attending vessel and updating the contact list. A copy of the H2S is attached as the RFAI 11 document.

The H2S plan has only been provided to BOEM and BSEE; each agency now has an updated copy.

RFAI No. 12 (Section 6.0)

Within Table 1-1 Shell has indicated that drilling fluids will not be cooled. Provide the rationale for the change, with supporting documentation, including any associated changes this will have on permitted actions and environmental impacts.

The purpose of cooling drilling fluids is to prevent the melting and subsequent washout of permafrost/hydrate zones in shallow hole sections. The LWD logs from our pilot hole, which were provided to BSEE, did not show any evidence of permafrost, hydrates, shallow hydrocarbons or any other shallow hazard. This is consistent with our expectations and well-site clearance letters. BSEE also concurred with our assessment of the absence of shallow hazards by allowing us to open the hole for 20" casing. Absent permafrost or hydrates, there is no reason to cool drilling fluids during operations.

Section 12 of EP Revision 2 will be modified to note why Shell deems it is not necessary to cool drilling fluids.

RFAI No. 13 (Section 9.0)

The Well Control Plan in the EP Rev 1 included two topics that are not addressed in Appendix L, EP Rev 2, specifically: Blowout Well Ignition and Blowout Well Intervention. Identify and discuss any changes of assets and/or procedures to the referenced methods/practices for these two topics.

Blowout Well Ignition and Blowout Well Intervention remain options available during blowout response which could be executed with the named support fleet. Placing human safety as the highest priority, Shell would consider the feasibility of igniting the blowout and the benefits this may bring to personnel and assets supporting capping and containment work. Any action taken to ignite the blowout would be a product of careful planning, repositioning of the fleet, and concurrence from the Unified Command. Blowout Well Intervention is considered an opportunity which would always be evaluated dependent on the wellbore condition and blowout scenario. Either rig is capable of intervening back into a blowout well either after successful activation of the BOP, wellbore depletion, or the well bridging over. Wells commonly do bridge over sometimes within 24-48 hours of first blowing out.

Appendix L was revised in Revision 2 of the EP to focus on the elements of the Well Control Plan which requires the most comprehensive planning to execute: Well Planning, Secondary Well Control, and Well Containment and Response. Several contingent operations, such as Blowout Well Ignition and Blowout Well Intervention, exist and would be evaluated during a response.

RFAI No. 14 (Section 10.0, Page 10-1)

Discuss the Hanna Shoal Walrus Use Area (HSWUA) and Shell's proposed mitigations, specifically for the months of June through September since Figure 13.e-1 and Figure 13.e-2 and identify operational/logistical activities (i.e. ice management, vessel, aircraft travel, etc.) within the HSWUA.

Shell is currently in discussion with US Fish & Wildlife Service (USFWS) with respect to the approach to operations that may occur in and around the HSWUA during and related to drilling activities in 2014. The details of the monitoring and mitigation measures that are to be utilized in relation to the HSWUA will be fully documented in the Letter of Authorization (LOA) and any variances under the HSWUA that Shell receives from the USFWS. The Bureau of Ocean Energy Management will be copied on these requests, when made, and any variances, when they are received.

Section 10 of EP Revision 2 will be modified to note Shell's plans regarding operations in the HSWUA.

RFAI No. 15 (Section 11.0, Page 11-1)

Provide decision criteria for when a sound source verification of the drillship and support vessels would not be necessary.

Shell plans to conduct sound source verification (SSV) on the vessels which did not have a SSV during the 2012 exploration drilling season. Since sound levels generated by drilling operations do not exceed sound levels where mitigation measures are required, the utility of SSVs, which are normally used to verify and adjust mitigation distances, is limited. Shell is also utilizing distributed arrays around the drilling location to measure cumulative sound impacts throughout the drilling process. These arrays are generating more useful information than individual SSVs.

Section 11 of EP Revision 2 will be modified to note Shell's plans regarding SSVs.

RFAI No. 16 (Section 12.0, Page 12-1)

Provide performance and capability information (i.e., drill unit specifications) for the Polar Pioneer. BOEM expects information similar to what is provided for the primary drilling unit within EP Rev 1. At minimum, include: station keeping capabilities; drilling capabilities; and, Arctic-readiness modifications and capabilities. Also revise Table 2.a-1 to include any permits or certifications associated with the Polar Pioneer's ability to operate in the Chukchi Sea under Alaska OCS conditions.

The Polar Pioneer is specially designed and constructed to operate in cold, harsh, sub-zero environments. All structural components have a design temperature of -20 degrees Celsius as defined by DNV for unrestricted service. All areas other than the pipe deck and riser deck are fully enclosed from the environment. There is heat tracing on all the deck and walkways as well as all the piping. See the following table for the Polar Pioneer specifications. Shell does not plan to have the Polar Pioneer enter the Chukchi Sea as a primary drilling vessel. The Polar Pioneer will remain in Dutch Harbor on standby while the Discoverer is drilling in the Chukchi Sea. Therefore, there are no permits or authorizations under 30 CFR 550.213(a) for the Polar Pioneer as a drilling vessel in the Chukchi Sea, and Table 2.a-1 of the EP Revision 2 will not be modified.

POLAR PIONEER SPECIFICATIONS	
TYPE-DESIGN	Sonar Polar / Hitachi design
SHAPE	Harsh Environment Semi-Submersible
SHIP BUILDERS & YEAR	Hitachi Zosen, Ariake, Japan
YEAR OF HULL CONSTRUCTION	1985/1994/1999
DATE OF LAST DRY-DOCKING	No Dry dock since Hitachi Zosen shipyard 1983-1985
POLAR PIONEER DIMENSIONS	
MIN HULL LENGTH X WIDTH	Upper hull length x width: 85 x 71 m
LENGTH OF PONTOONS	116 m
MAX HEIGHT (ABOVE THRUSTERS)	102.15 m
HEIGHT OF DERRICK ABOVE RIG FLOOR	51.80 m
POLAR PIONEER MOORING EQUIPMENT	
MOORING CLASS	Posmoor-ATA
ANCHOR WINCHES	8 x Maritime Pusnes Model 750 double winches
ANCHORS	8 x 15 MT Stevpris anchors
ANCHOR LINES	Combined line and chain
SIZE/GRADE	K-4, 84 mm chain
LENGTH OF USABLE WIRE AND CHAIN PER ANCHOR	1969 - 2035 m per line
THRUSTER ASSIST	Both manual and automatic. APM 3000 installed.

POLAR PIONEER OPERATING WATER DEPTH	
MAX WATER DEPTH	450 m
MAX DRILLING DEPTH	6500 m
POLAR PIONEER DRILLING PACKAGE	
DRAW WORKS	Continental Emsco C3; 3,000 hp
ROTARY	Continental Emsco T4950-65 with 49½in opening
MUD PUMPS	3 x Continental Emsco FB 1600, triplex pumps
DERRICK	Maritime Hydraulics 50 x 12 x 12m;
PIPE RACKING	MH type NH 1147-50
DRILL STRING COMPENSATOR	Maritime Hydraulics (Aker Kvae) - Model AHC 25-270
RISER TENSIONERS	8 x 44 mt tensioners, 7.62 m stroke - Wicham A/S Model 100k
CROWN BLOCK	Maritime Hydraulics (Aker Kvae) - Model MH 1068-20
TRAVELING BLOCK	Maritime Hydraulics (Aker Kvae) - Model MH 1142 650 st
BOP	2 x Hydril 18¾in 15,000 psi double rams / 1 x10,000 psi GX Hydril annular
RISER	Hughes 21" riser - Model HMF
TOP DRIVE	Maritime Hydraulics DDM-650-HY
BOP HANDLING	BOP crane: Kita overhead crane 2 x 110 mt main hoists. Trolley 1 x BOP maritime Hydraulic 220 mt, 1 x 220 mt BOP.
POLAR PIONEER DISPLACEMENT	
SURVIVAL	43312 mt
DRILLING	46440 mt
POLAR PIONEER DRAFT	
DRAFT AT LOAD LINE	23 m
TRANSIT	9.15 m
DRILLING	23 m
POLAR PIONEER HELIDECK	
MAXIMUM HELICOPTER SIZE	Sikorsky S61N, Super Puma or similar helicopter
FUEL STORAGE ON HELIDECK	10 m3
POLAR PIONEER ACCOMODATIONS	
NUMBER OF BEDS	110
SEWAGE TREATMENT UNIT	Fredrikstad Sewage treatment plant Model CP 65

POLAR PIONEER PROPULSION EQUIPMENT	
THRUSTERS	4 each Rolls-Royce, Liaaen with adju azimuth and pitch
POWER CONSUMPTION EACH [kW]	thruster power consumption: 2400 kW each
TRANSIT SPEED	N/A, NON-SELF PROPELLED - Historically towed at 4-6 knots
GENERAL STORAGE CAPACITIES	
SACK STORAGE AREA	145 m^2
BULK STORAGE	
Bulk Bentonite (column/surface)	98 / 14 m^3
Bulk Barite (column/surface)	389 / 58 m^3
Bulk Cement (column/surface)	300 / 59 m^3
LIQUID MUD	
Active	199 m3 (active), 228 m3(reserve main deck)
Reserve	365 m3
Total Mud storage	792 m3
POTABLE WATER	4843 bbl
DRILL WATER	11140 bbl
FUEL OIL	11290 bbl
ARCTIC READINESS MODIFICATIONS	
RIG FLOOR	Fully enclosed
DERRICK	Fully enclosed
CEMENT AND FLUID SYSTEMS	Heat Traced
PIPEWORK	Heat Traced
CRANES	
DRILLING SYSTEMS	Heat Traced
ADDITIONAL INFORMATION	The installation is specially designed and constructed to operate in cold, harsh, sub-zero environments. All structural components have a design temperature of -20 degrees Celsius as defined by DNV for unrestricted service. All areas other than the pipe deck and riser deck are fully enclosed from the environment. There is heat tracing on all the deck and walkways as well as all the piping.

RFAI No. 17 (Section 13.0, Page 13-1)

Identify and incorporate the relief drilling rig and support vessel(s) within this section.

30 CFR 550.224(a) requires the listing of vessels "… you will use to support your exploration activities." The Polar Pioneer and support vessels will be stationed in Dutch Harbor and are not part of the exploration drilling support fleet so Shell has determined that these vessels do not belong in Table 13.a-1.

	Polar Pioneer	Tugs (X2)[1]	Anchor Handler[2]	Barge and Tug	
				Barge[3]	Tug[4]
Length	279ft (85m)	146ft (44.4m)	274ft (83.7m)	400ft (122m)	150ft (45.7m)
Width	233ft (71m)	46ft (14m)	59.0ft (18.0m)	99.5ft (30.3m)	40ft (12.2m)
Draft	30ft (9m)	25ft (7.6m)	19.7ft (6.0m)	19.3ft (5.9m)	18.5ft (5.6m)
Accommodations	100	13	64		11
Maximum Speed		16kts (30kph)	16kts (30kph)		12kts (22kph)
Fuel Storage	11290bbl (1794m3)	5585bbl (888m3)	1190m3	390bbl (62m3)	1786bbl (284m3)
Liquid Storage	6180bbl (982m3)			76900bbl (1226m3)	

[1] specifications based on Crowley Ocean Class tug
[2] specifications based on the Tor Viking
[3] specifications based on the Tuuq
[4] specifications based on the Lauren Foss

RFAI No. 18 (Section 13.0, Page 13-1)

Provide a description of how the assets in Section 13-1 are designed and built or modified for the Alaska OCS Conditions (i.e., extreme cold, freezing spray, snow, extended periods of low light, strong winds, dense fog, sea ice, strong currents, and dangerous sea states). Explain how Shell will manage all assets within the EP drilling program. If Shell believes all or some of this information is included in the Integrated Operations Plan, submitted November 26, Shell may respond by citing the IOP page number referencing the responsive information.

The explanation must address:

- ***how contractor safety practices are aligned with Shell safety principles and standards;***

Shell Management of Contractors is defined in Section 5.0, of the IOP, pages 37-45.

- ***documentation of your integrated risk management approach for contractor management and oversight from mobilization through to demobilization;***

Shell Management of Contractors is defined in Section 5.0, of the IOP, pages 37-45.

- ***a schedule of your exploration program, including contractor work on critical components, and plans to tailor your management and oversight programs to Alaska OCS Conditions;***

The exploration program summary is outlined in the IOP Section1, pages 3 - 14. Information regarding contractor work on critical components and plans to tailor management and oversight programs to Alaska OCS conditions are found in Section 2, pages 15 – 23.

- ***documentation of Health, Safety, Security, and Environmental (HSSE) elements and risk management capabilities tailored for the risks and challenges of operating in the Alaska OCS;***

HSSE Risk Management approach is outlined in Section 5.2 of the IOP page 38.

- ***documentation about how vessels and equipment will be (or have been) designed, built, and/or modified to handle the Alaska OCS Conditions;***

Section 1.1 of the IOP, Vessel Operation, page 4, and Section 5.6 Alaska Maritime Assurance Process pages 42-44 defines the requirements for Winterization and Ice classification of assets working in the OCS

- ***drilling program objectives and timelines for each objective, including contingency plans for temporary abandonment of its well(s);***

Drilling Program Objectives and season timelines can be referenced in the IOP Section 1.0. Temporary abandonment of a wellbore for any reason will be done via the BSEE APM process and satisfy the requirements of 30 CFR 250.1721.

- ***documentation of mobilization and demobilization operations, including tow plans applicable within Alaska OCS Conditions, as well as anticipated maintenance plans;***

Asset Maritime Assurance processes, including mobilization and towing requirements are included Section 5.6 of the IOP pages 42-44.

- ***documentation of any resource sharing agreements for assets or mutual aid in the event of an emergency;***

Reference Shell's *Chukchi Sea Regional Exploration Program Oil Spill Response Plan* (OSRP) to identify additional Tier III resources, or those that go beyond that scaled to meet the WCD. Please reference the OSRP Appendix C, Out-of-Region Resources for a discussion of Shell's plans for accessing these resources. The OSRP Appendix B may also be referenced for Shell's Certification of Memberships and Contractual Agreements which includes OSRO memberships (Alaska Clean Seas and Marine Spill Response Corporation) and response contracts (ASRC Energy Services – Response Operations and UIC Arctic Response Services). Part 2 of the OSRP provides a comprehensive description of Shell's Emergency Action Plan.

Tier III resources may be accessed through multiple venues, inclusive of:

1. OSRO memberships (e.g., ACS) ACS as a member of the Association of Petroleum Industry Co-op Managers (APICOM) (Reference Appendix C, Figure C-4, ACS Tactic L-10, Accessing Non-Obligated Resources)
2. direct contract with vendors and logistical support / supply contractors (Appendix G)
3. Shell Americas Response Team

- ***information regarding Shell's preparation and plans for staging spill response and cleanup assets;***

Reference Shell's Chukchi Sea Regional Exploration Program Oil Spill Response Plan (OSRP) for information regarding Shell's staged spill response and cleanup assets. Appendix C identifies those resources scaled to meet the WCD with specific discussion of recovery capacity. Offshore and nearshore oil spill response assets are scaled to demonstrate sufficient EDRC to meet the WCD. Based upon a conservative transit speed, these vessel-based assets are positioned and staged to respond within a specific time frame (as opposed to assignment to a specific location). Shore-based assets are also identified within Appendix C with further discussion of the scaled response provided in Part 2 (Specifically, Sections 2.4 and 2.7). OSR equipment will be staged based upon a defined transit speed and associated transit time as identified within Table C-3.

Appendix A, Table A-2 of the OSRP provides a summary of the major Shell-chartered and contracted equipment that is scaled to meet the WCD. This summary also identifies the equipment assigned to each Task Force and the distance to the projected response location.

- ***weather and ice forecasting capability for all phase of the exploration program, including transportation to and from the Alaska OCS, and plan for managing ice hazards and responding to extreme weather events;***

Weather and Ice forecasting capability is outlined in Section 1.4 of the IOP, page 9-11.

- ***accountability and auditing of the implementation of plans and oversight of contractors; and, benchmarks for determining successful implementation***

Oversight of contractors is outlined in Section 5 of the IOP pages 37-45.

RFAI No. 19 (Section 13.0, Page 13-1 & 13-2)

The following vessels are identified as available when needed: an ice management vessel, M/V Nordica; an anchor handling vessel, M/V Aiviq; a resupply tug and barge, such as M/V Lauren Foss and/or Tuuq; an additional tug, similar to the M/V Ocean Wave; a science research vessel; an additional third offshore supply vessel; and an oil storage tanker, Affinity. Some of these vessels were listed in the Shell Camden Bay Exploration Plan. To ensure that the Chukchi Sea EP Rev 2 will be a stand-alone document, provide the same detail for each of these vessels as was provided for the Camden Bay EP: information where the support vessels are to be stationed when they are not in direct support of the drilling activities; and provide clarification of when and how these assets will be utilized and managed on a daily basis.

The M/V Nordica (or similar) is listed in the Camden Bay EP as the primary ice management vessel. For this Chukchi Sea EP Revision 2 it will be used on an occasional or as needed basis to help with ice management or other duties. It is likely that the Nordica will be in the lease sale area during the drilling season in case it is needed. Specifications for the Nordica that were provided for the Camden Bay EP are now provided for the "Ice Management Vessel" listed in Table 13.a-1 of the EP Revision 2.

The M/V Aiviq (or similar) is listed in the Camden Bay as an anchor handler. (At that time, the Aiviq was not yet named and was listed as Hull 247 in the Camden Bay EP). For this Chukchi Sea EP Revision 2, it will be used on an occasional or as needed basis to help with anchor handling duties with either the drilling vessel and/or the containment barge. The Aiviq (or similar) will be located near the drilling vessel, or near the containment barge outside the lease sale area in Kotzebue Sound depending on where it is needed. The Aiviq will be utilized as a vessel of opportunity skimming system in the event of a well control incident. Specifications for the Aiviq are provided for the "Anchor Handler" listed in Table 13.a-1 of the EP Revision 2.

The tug M/V Lauren Foss and Tuuq barge (or similar vessels) were not listed in either the Camden Bay EP or Chukchi Sea EP Revision 1. The tug and barge will provide general resupply support for the exploration drilling operations. It will remain in the Chukchi Sea most of the time, but may make trips to Dutch Harbor. When not in use, the tug and barge may be moored outside the lease sale area in Kotzebue Sound. Specifications for the Lauren Foss and Tuuq are provided for the "Tug and Barge" listed in Table 13.a-1 of the EP Revision 2.

An additional tug, the M/V Ocean Wave (or similar) was not listed in either the Camden Bay EP or the Chukchi Sea EP Revision 1. It will be available for use when needed. It will remain outside the Lease sale area, possibly moored in Kotzebue Sound, when not in use. Specifications for the Ocean Wave are provided for the "Tug" listed in Table 13.a-1 of the EP Revision 2.

The science (oceanographic research) vessel was not listed in either the Camden Bay EP or the Chukchi Sea EP Revision 1. It is planned that the science (oceanographic research) vessel will remain near the drilling unit throughout the drilling season to monitor waste stream discharges for compliance with the NPDES General Permit AKG-28-8100. Specifications for the science (oceanographic research) vessel are available in Table 13.a-1 of the EP Revision 2.

An additional OSV will be added to the existing two OSVs in order to bolster resupply to and from the drilling vessel. The OSVs will make several trips between the drilling unit and Dutch Harbor. Specifications for the OSV are available in Table 13.a-1 of the EP Revision 2.

The OST Affinity (or similar) is mentioned as an OST in the Camden Bay EP and the Chukchi Sea EP Revision 1. Rather than being centrally located between the Chukchi and Beaufort Sea as was described in the EP Revision 1, it will now be positioned closer to the drilling unit. The OST is not an added vessel, but is mentioned because of change of location during drilling.

RFAI No. 20 (Section 13.0, Page 13-1)

The Aiviq suffered four engine failures during the towing of the Kulluk in 2012. Provide information about the cause of the failure of the four engines on the Aiviq in 2012 and what steps or procedures has Shell adopted to prevent a reoccurrence.

Marine vessels chartered by Shell are subject to stringent U.S. Coast Guard inspection requirements contained in the Code of Federal Regulations. Various certificates and documents are issued by the Coast Guard to the vessel owner/operator to demonstrate compliance with the regulations. Shell will request these certifications and documents from the appropriate vessel operator so Shell can provide to BSEE any such certifications and documents required by their regulations (subject to appropriate confidentiality limitations, if any). Shell will provide copies of any such certifications and documents to BOEM..

RFAI No. 21 (Section 13.0, Page 13-2)

Provide additional information and clarification of assets and activities associated with the Goodhope Bay in Kotzebue Sound. Clarify what operational activities are planned; and if there will be any on-shore based activities/facilities associated with exploration drilling activities.

Shell plans limited support operations at Goodhope Bay in Kotzebue Sound. Up to three temporary mooring buoys may be established proximate to the DI-04-01 site identified in the Northwest Arctic Subarea Contingency Plan – Potential Places of Refuge (PPOR) – supplements the Alaska Federal/State Preparedness Plan for Response to Oil and Hazardous Substance Discharges/Release (Unified Plan). These temporary moorings may support the seasonal location of up to three tug/barge combinations. Moored activity would be minimal and consisting of routine machinery and equipment readiness checks and exercises, routine logistics support and other ancillary activities. Seasonal location of the tug/barge combinations in the vicinity of exploration activity, but not at the exploration site described elsewhere in this EP is thought to be safer for tug crews, as well as be more efficient and minimize risk exposures operationally and logistically. Support for the moored barges is expected via a support landing craft (or similar) staging from a dock or terminal in the City of Kotzebue.

Section 13 a) of EP Revision 2 will be modified to reflect Shell's support operations in Goodhope Bay, Kotzebue Sound.

RFAI No. 22 (Section 13.0, Page 13-2)

Provide more information on activities (staging, fueling, duration, etc.) associated with landing craft operations.

The landing craft is intended to be used for primarily for crew transfers for vessels located in Kotzebue Sound. A secondary mission is transport of materials within the fleet if required. The vessel will transit with the fleet from Dutch Harbor at commencement of the season and will be refueled as required at Kotzebue marine terminal or at sea in accordance with the fuel transfer plan. The vessel will return to Dutch Harbor with the rest of the fleet on completion of the drilling season.

Section 13 a) of EP Revision 2 will be modified to include additional information on the landing craft operations.

RFAI No. 23 (Section 14.0, Page 14-1)

Shell proposes to increase its man camp capacity in Barrow from 75 beds to approximately 200 beds. Provide the information required by 30 CFR 550.225(a)(2); as well as any changes in existing permits that will be required for the expansion and operations of the camp. Any changes in permits and/or authorization should also be identified within Table 2.a-1; and identified and discussed within other applicable sections of EP Rev 2.

EP Revision 2 states that Shell would, move the existing Barrow man camp from its current location near NARL to a location near the airport, expand these facilities to accommodate 200 persons, and add a kitchen dining area. This plan has been modified. Shell now plans to: 1) maintain the existing 75-person man camp; 2) add a kitchen/dining/recreation (K/D/R) area to this existing 75-person man camp – the KDR unit would adjoin the existing facilities and be located on the same pad; and 3) lease / utilize additional accommodations at the existing 40-person Ukpeaġvik Iñupiat Corporation (UIC) modular construction camp which is at the UIC storage location in Barrow and will relocated to its new location on the existing UIC pad (see the location figure under RFAI No.1 EAI 2.3, Page 2.9).

30 CFR 550.225(a)(2) requires the following information be provided with regard to onshore support facilities:

"(2) If the onshore support facilities are, or will be, located in areas not adjacent to the Western GOM, provide a timetable for acquiring lands (including rights-of-way and easements) and constructing or expanding the facilities. Describe any State or Federal permits or approvals (dredging, filling, etc.) that would be required for constructing or expanding them."

An Administrative Approval (development permit) was obtained the North Slope Borough (NSB) by UIC for the development of the existing 75-person man camp. The K/D/R will be permitted by the SOA Fire Marshall and the existing development permit with the NSB will be revised to show the addition of the K/D/R unit to the pad with the 75-person man camp. No State or Federal permits were required so no additional information is required for Table 2.a-1.

The planned 40-person construction camp will be installed on a similar sand pad constructed by the U.S. Navy in 1940's. These existing modular accommodations, owned by UIC, are currently reside in Barrow and will be moved to the pad and installed on through pad pilings. Permitting of this facility is the owner's responsibility; the facilities are not Shell's. Shell will only be leasing the use of these facilities which are being constructed regardless of Shell's intentions.

Section 14 a) of EP revision 2 will be modified to reflect the added information regarding the Barrow man camp.

RFAI No. 24 (Appendix A, Rev. 1)

With changes to proposed anchor radii, updated OCS Plan Information forms should be submitted with the EP Rev 2 (see section of form entitled "Anchor Locations for Drilling Rig or Construction Barge").

See the attached RFAI 24 document for the revised page 2 from form BOEM-137 for drill sites Burger F, J, R, S and V. Note of Clarification: Required well location coordinates include Lambert X-Y coordinates, but currently there is no standard used for Lambert projection in the Alaska OCS. In place of the Lambert coordinates, Universal Transverse Mercator (UTM) coordinates have been substituted.

RFAI No. 25 (Appendix L)

Provide specifics regarding blowout well ignition and blowout well intervention. BOEM expects that safety principles and standards; accountability for implementations and auditing; and, benchmarks for determining successful implementation, etc. will be fully incorporated into the discussions regarding:

- *the schedule of blowout well intervention (including contractor work on critical program components);*
- *discrete and amalgamated timeline(s);*
- *descriptions of mobilization and demobilization operations;*
- *general maintenance schedule for vessels and equipment;*
- *description of the primary and secondary (if applicable) mission and corresponding work designated for each vessel (including all contracted operations and contractors)*

The following table is also included in the response to the preceding RFAI #9. The table lists the schedule and timeline regarding mobilization to the Burger Prospect and finishing a relief well and provides a description of the duties of those vessels supporting the Polar Pioneer.

Activity	Unmooring at Dutch	Tow from Dutch to Burger	Mooring at Burger	Drilling to intercept point
Timing	1.0 days	7.5 days	1.5 days	28 days
Comments	Based on pulling and racking anchors and commencing tow. Rig will be fully crewed with TransOcean staff keeping equipment in a state of readiness	Built around 6 knots travel speed based on previous average tows with Polar Pioneer incorporating a variety of weather conditions and one active tug. In this case two tugs and a contingency anchor handle are available.	Based on 2 anchor handlers and past anchoring times.	Base time of 23 days from original estimate with logging, MLC and P&A operations removed. Adds in ranging runs. Nominal estimate of NPT at 20% takes estimate to 28 days. Additional information will be provided in the APD as required.

ENVIRONMENTAL

EFH

RFAI No. 1 (Section: EIA Fish and EFH, Page 4-5)

Seafloor Disturbance is addressed for the drilling sites in the EIA, Table 4.5-4. Provide similar information (e.g. the number of anchors, the surface area disturbed per anchor, the volume displaced per anchor, and the total seafloor area disturbed) for vessels moored in Kotzebue Sound--Opilio crab EFH will now be part of the analysis.

The EIA stated that Shell may install 2-4 mooring buoys in the Goodhope Bay area of Kotzebue Sound. At this time it appears most likely number that three will be installed; therefore, this analysis is based on installation of three buoys. These buoys would be installed annually. The mooring buoys will be of two different designs; both types will be moored with conventional drag embedment anchors – at this time we believe they will be 20,000 lb stockless anchors. One design (A) requires three such anchors; the other design (B) utilizes a single anchor (Table 4.1.5-1). Utilizing the anchor dimensions and drag lengths we estimate that the setting of each anchors during installation of the mooring buoys may disturb about 0.4 ac (1,449 m2) of seafloor and displace about 1,049 cu yd (802 m3) annually (Tables 4.1.5-1, 4.1.5-2, and 4.1.5-3).

Table 4.1.5-1: Estimated Area of Seafloor Disturbed Annually by Installation of a Mooring Buoy

Buoy Type	Anchors [1]	Anchor Scar Area [2]		Anchor Cable [3]		Total Disturbance Area / Buoy	
		ft^2	m^2	ft^2	m^2	ft^2	m^2
A	3	725	67	1,324	123	6,157	572
B	1	725	67	2,562	238	3,283	305

[1] Number of anchors associated with the buoy type
[2] Seafloor area disturbed by single anchor only during setting; based on a drag length 5x anchor length includes a 1.0 m area around scar where sediment would be bermed
[3] Assumes 1,620 ft anchor cable or chain on the seafloor with 0.8 ft wide disturbance; includes 1,500 ft caternary tow line for Type B

Table 4.1.5-2: Estimated Volumes of Seafloor Sediments Displaced by Installation of a Mooring Buoy

Buoy Type	Anchors	Anchor Scar Volume [1]		Anchor Cable Volume [2]		Total Volume of Seafloor Sediment Displaced / Buoy	
		ft^3	m^3	ft^3	m^3	ft^3	m^3
A	3	2,815	80	1,088	572	11,724	332
B	1	2,815	80	2,097	572	4,909	139

[1] Sediments disturbed by anchor only; based on a drag length 5x anchor length, anchor width, and anchor depth; does not include the 1.0 m area around scar where sediment would be bermed
[2] Assumes a 1,620 ft anchor cable or chain on the seafloor with 0.8 ft wide x 0.8 ft deep disturbance; includes 1,500 ft caternary tow line for Type B

Table 4.1.5-3: Estimated Annual Seafloor Disturbance and Sediment Displacement by Installation of All Mooring Buoy

Buoy	Anchors	Total Annual Seafloor Disturbance		Total Seafloor Sediments Displaced Annually	
		ft^2	m^2	yd^3	m^3
1	3	2,052	572	434	332
2	3	2,052	572	434	332
3	1	3,282	305	182	139
All	7	15,595	1,449	1,049	802

The seafloor disturbance associated with the moorings in Kotzebue Sound will occur within areas designated as essential fish habitat (EFH) for the snow or opilio crab. These impacts will be negligible given that the impacts would be temporary and would be limited to a very small portion of the opilio crab EFH in the Chukchi Sea. Generally, all waters less than 328 ft (100 m) in the Chukchi Sea south of Cape Lisburne are designated as opilio crab EFH.

Section 4.1.5 of the EIA for EP Revision 2 will be modified by adding the above information and tables. Section 4.1.6, Impact of Vessel Traffic on Fish and EFH will be modified to provide an analysis of the effects of the moorings on opilio crab EFH.

Sociocultural/Subsistence

RFAI No. 1 (Section: EIA 2.3, Page 2-9)

Provide full details regarding man-camps in Barrow and Wainwright. Provide maps and a detailed description to fully address the expansion (and new location) of the man camp from 75 to 200 persons in Barrow, to include precise location of the camp and changes in footprint to accommodate expansion. Also, describe the disposal of wastes (wastewater and solid waste handling) in terms of amounts and methods of disposal (impacts on NSB services) and provide associated permits.

EP Revision 2 states that Shell would, move the existing Barrow man camp from its current location near NARL to a location near the airport, expand these facilities to accommodate 200 persons, and add a kitchen dining area. This plan has been modified. Shell now plans to: 1) maintain the existing 75-person man camp; 2) add a kitchen/dining/recreation (K/D/R) area to this existing 75-person man camp – the KDR unit would adjoin the existing facilities and be located on the same pad; and 3) lease / utilize additional accommodations at the existing 40-person Ukpeaġvik Iñupiat Corporation (UIC) construction camp. Passenger processing facility expansion and hangar repairs are planned for the Barrow airport area at this time. Additional blocks of hotel rooms may also be reserved at either the new Top of the World Hotel, or the old Top of the World Hotel if refurbished since the fire in the adjacent restaurant. The two pads where the 75-person and 40-person camps are/will be located are in the NARL area approximately 4.0 mi from the center of Barrow, and are located approximately 0.75 mi from each other. The pad locations are indicated in the attached Figure 2.3-2.

Shell's existing 75-person man camp consists of skid-mounted modular buildings. The planned K/D/R unit is approximately 166 ft long by 64 ft wide and will be installed on the existing pad at the southwest corner of the existing accommodations. The K/D/R unit will be placed on mats and dunnage on the existing pad material (sand/gravel). After the K/D/R unit is set, gravel will be hauled in and mixed with the beach sand in the driveway area of the pad along the back and end of the K/D/R over 14,375 sq ft (0.33 ac) of the existing pad to stabilize the new driving area (Figure 2.3-3). The K/D/R would service both man camps and overflow facilities.

The existing camp has been permitted with the North Slope Borough (NSB) with a Development Permit and a fill permit. The K/D/R will be permitted by the SOA Fire Marshall and the existing Development Permit with the NSB will be revised to show the addition of the 200-Man K/D/R to the pad with the 75-person man camp. No State or Federal permits were required.

The UIC 40-person construction camp will be relocated from its existing location in Barrow to a similar sand pad constructed by the U.S. Navy in 1940's as indicated in Figure 2.3-2. The modular accommodations owned by UIC are currently unused and reside in Barrow. They would be moved to the pad and installed on through pad pilings. Permitting of this facility is not Shell's responsibility as the facilities are not Shell's; Shell will only lease the facilities once installed at the new location.

Blackwater (sewage) and graywater (showers, kitchen) from the two camps will be held in holding tanks at each site. Based on an average camp occupancy of 50 percent of capacity, and average per capita waste generation factors provided by the local utility, Shell expects to generate about 1,000 gal of combined blackwater and graywater wastes per day. These wastes will be picked up by the NSB with their routine service and treated in their waste water plant. These wastes generated by camps with temporary population of 40-115 persons, will not tax Barrow's municipal wastewater treatment system, which accommodates a population of over 4,000 people, and consists of a series of large water treatment lagoons.

Household trash from the camps will be stored in bear proof containers for all locations. These household wastes will be set up for collection by NSB's regular dumpster service, and will be disposed of at the NSB Landfill. Shell estimates, based on 2012 Barrow operations and accounting for the additional planned camp accommodations, that the two man camps may generate up to 200 cu yd of household trash per season, which represents less than 0.75 percent of the average annual volumes disposed of at the landfill.

Non-household waste generated at the camps will be stored in a 20-ft shipping container set up as a waste accumulation area located behind the primary camp. The accumulation area will hold any hazardous, non-hazardous and liquid wastes. All of Shell's Barrow facilities are operated as a Conditionally Exempt Small Quantity Generators of Hazardous waste by the EPA, and therefore a permit is not required and hold times do not apply. These wastes will be transported out of the Arctic and disposed of at licensed facilities as indicated in the EP Revision 1.

Expansion of the existing passenger processing facility (Figure 2.3-4) utilized by Shell in 2012 at the Barrow airport is also planned. The expansion would consist of four buildings totaling approximately 2,200 sq ft (204 m2). The expansion would adjoin the existing passenger processing facility (Figure 2.3-5) and would occur on previously developed lands adjacent to the airport and controlled by the FAA. The facilities will be constructed and operated by UIC and leased by Shell. No State or Federal permits are required. The expansion will be permitted with the NSB .

Shell reserves rooms at the existing Olgoonik Oil Field Services Camp in Wainwright. Shell's oil spill response group will be housed and fed at these facilities. EP Revision 2 states that Shell may utilize a larger camp of up to 55 accommodations to accommodate certain contingencies such as Shell conducting crew changes through Wainwright, or onshore environmental studies in the area. At this time this would involve only the potential reservation of additional rooms. Construction of new facilities or expansion of existing facilities is not planned at this time.

With the exception of food waste from the camp kitchen, all wastes generated at the Wainwright camp (Figure 2.3-6) will be containerized and transported to either Oxbow Landfill in Deadhorse or the Anchorage Landfill in Anchorage, depending on the availability of barges. Food wastes from the kitchen will be disposed in the Wainwright landfill. These actions taken by Shell with respect to waste handling will minimize the impact to the community, including the landfill. Based on water usage information provided by the ADEC website, it is estimated that the response group will generate less than 200 gallons of black and gray water per day on average. This equates to approximately 2% of the estimated average generation rate for the entire village, based on a 2012 population of 575.

Section 2.3 of the EIA for EP revision 2 will be modified to include the above information and the following figures.

Figure 2.3-2 Barrow Man Camp Locations

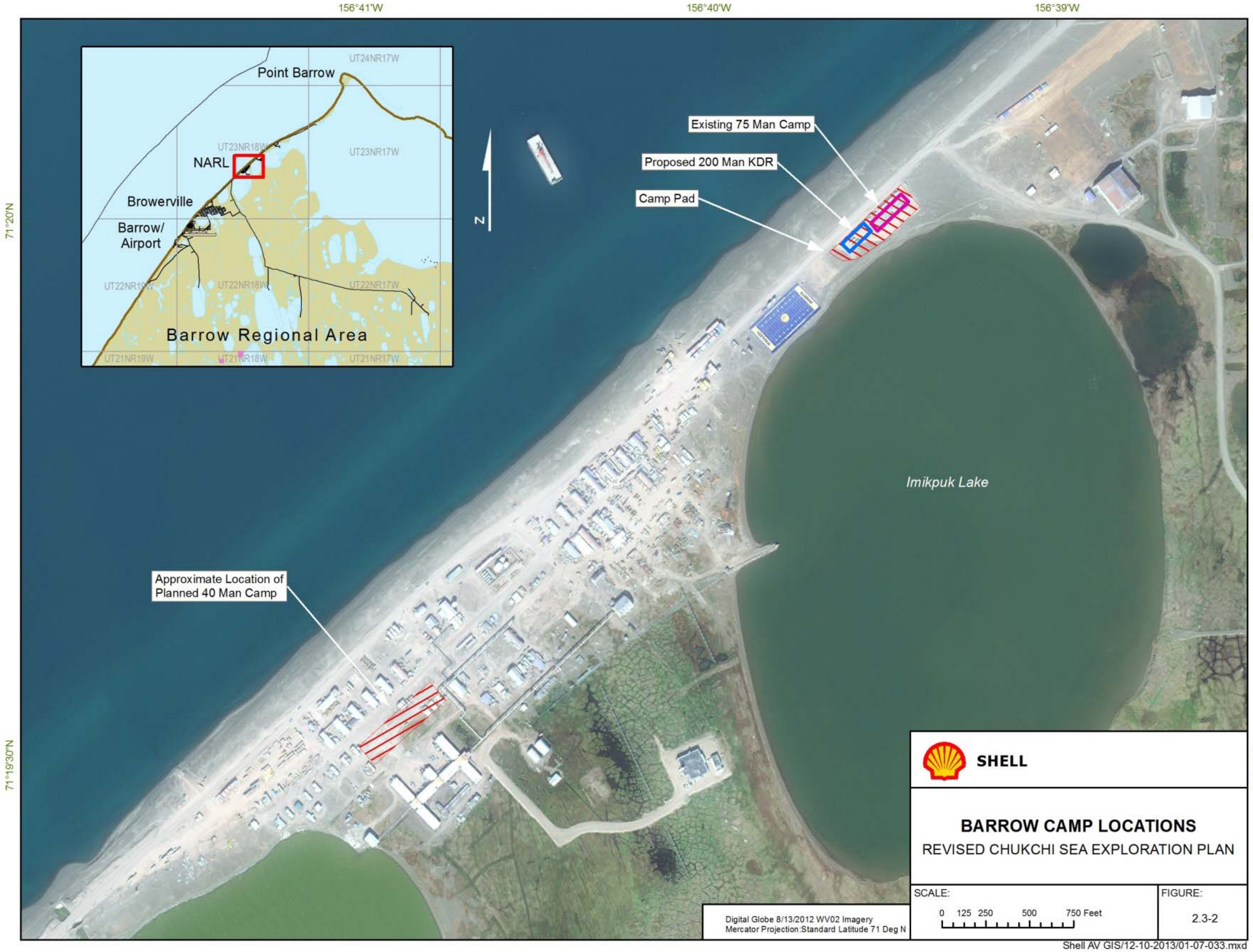
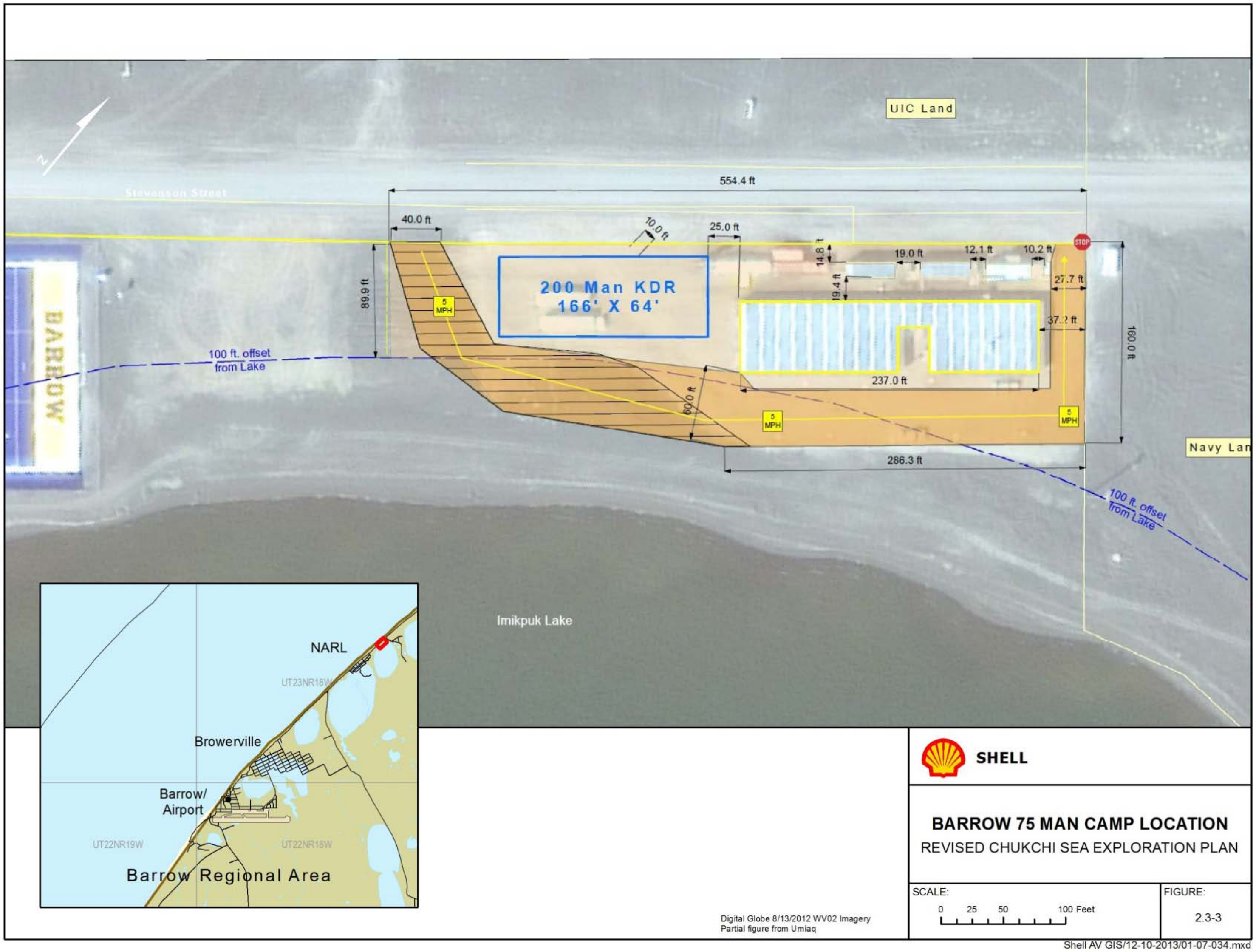


Figure 2.3-3 Layout and Planned Expansion of Shell's Existing 75-Person Man Camp



Shell Exploration & Production

Figure 2.3-4 Passenger Facility Location

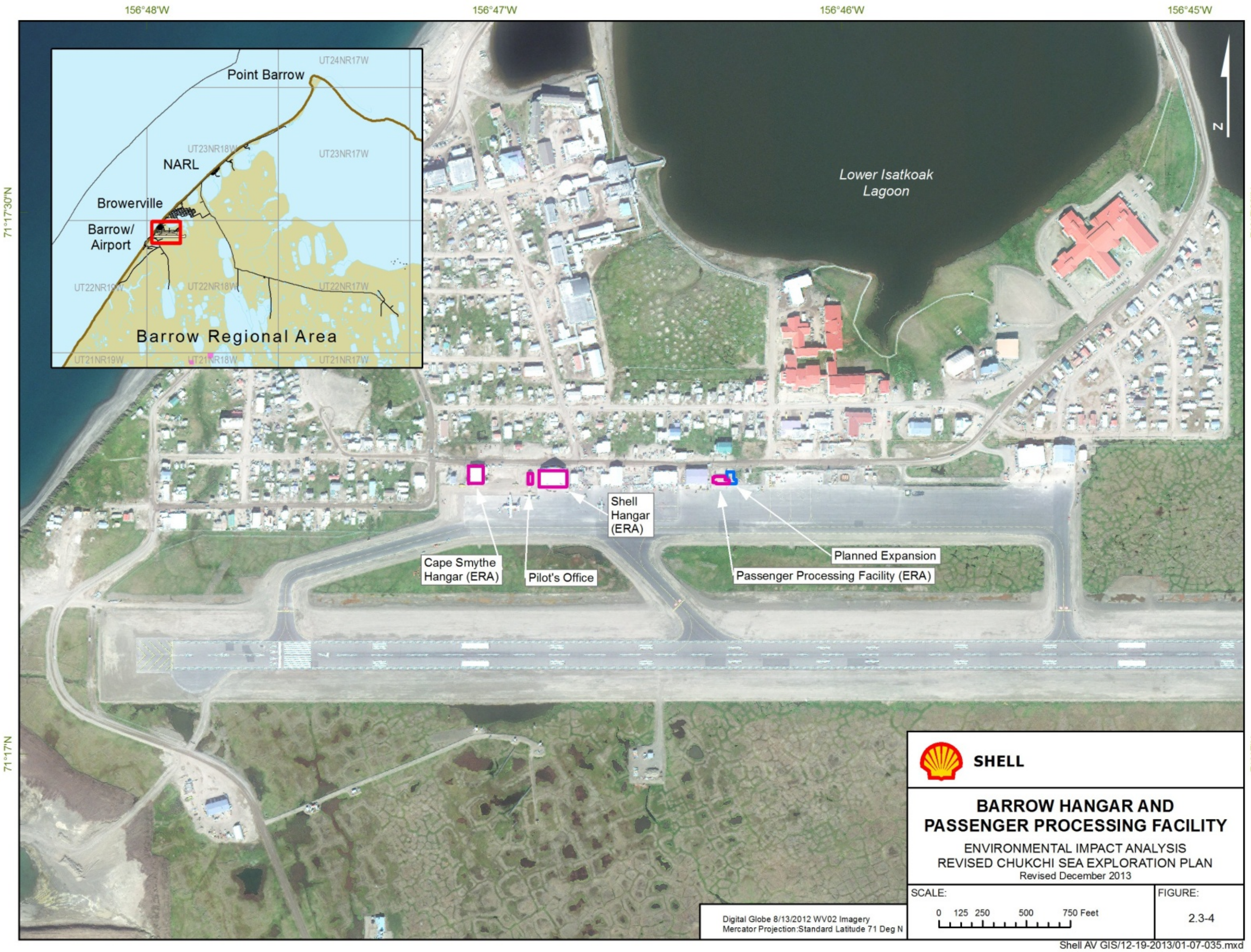


Figure 2.3-5 Passenger Facility Expansion Diagram

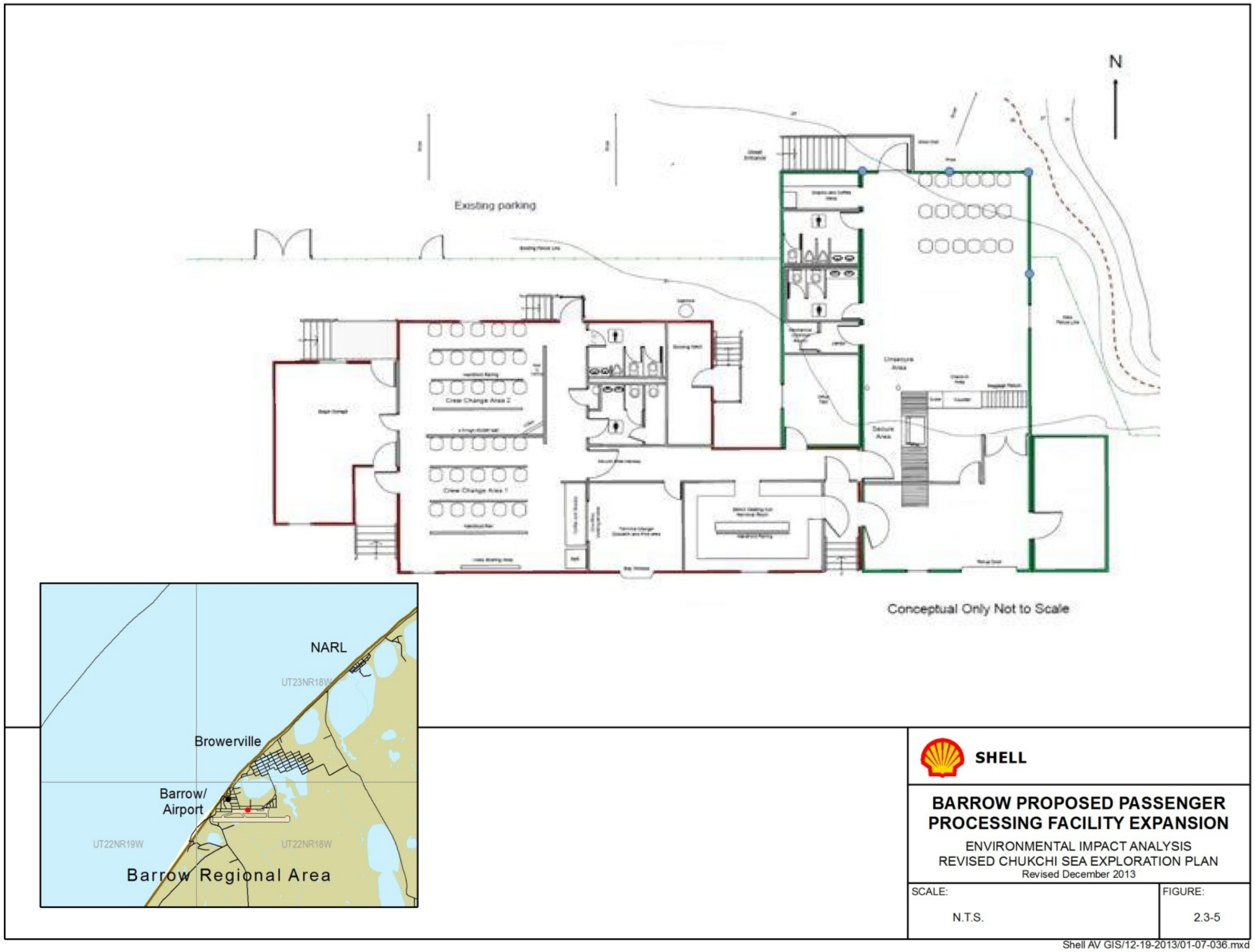
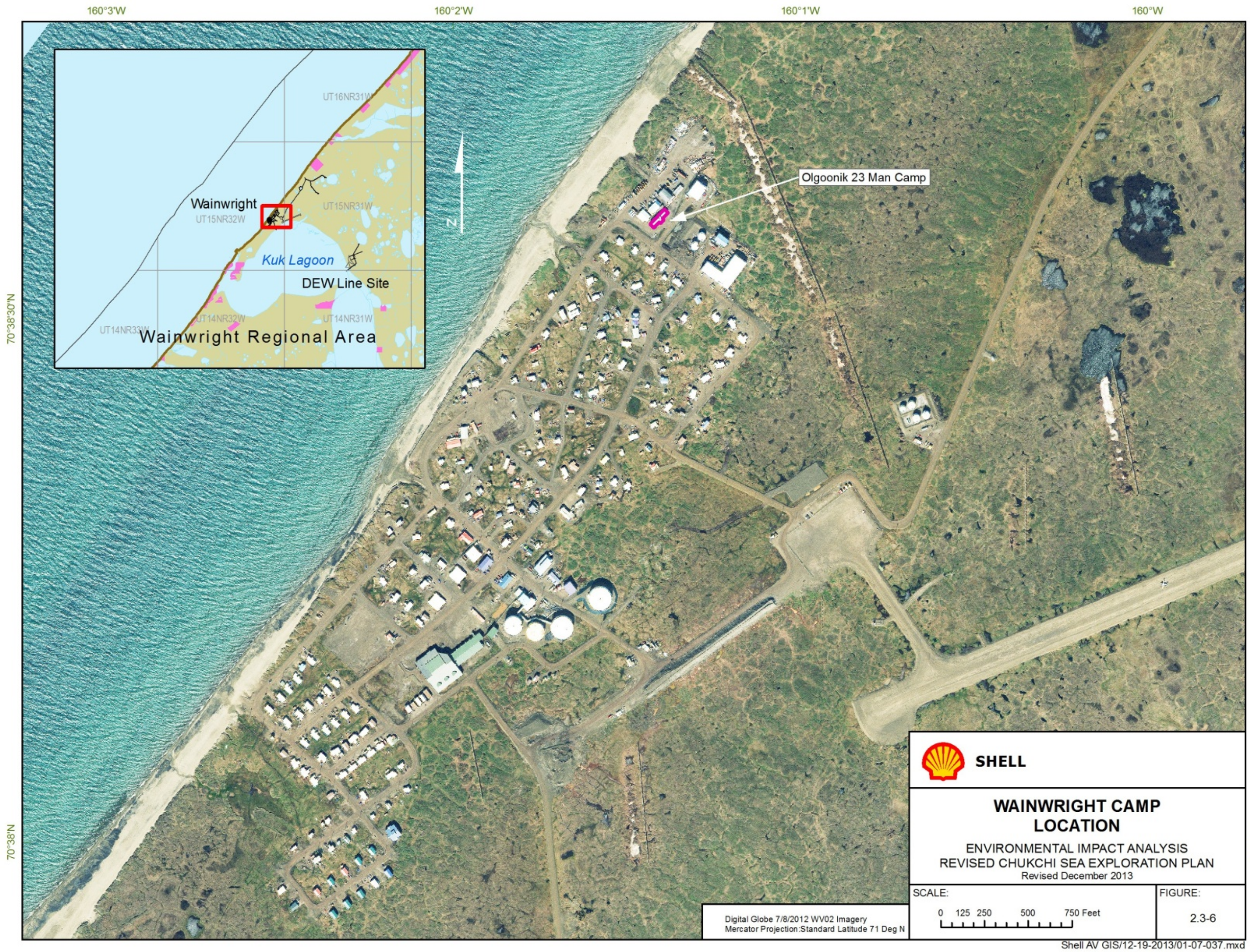


Figure 2.3-6 Wainwright Camp Location



RFAI No. 2 (Section: EP 5.0, Page 5.1)

Provide the most recent UMIAQ reports: UMIAQ 2012 and UMIAQ 2013.

See the attached RFAI Socio 2 response documents.

RFAI No. 3 (Section: EIA 4.1.12 & 4.1.13, Page 4-26)

Provide detailed information regarding numbers of transits, crew changes, and estimated treated sanitary waste quantities to be discharged from vessels.

The expected frequency of transit (trips) for each vessel directly associated with the exploration drilling program are provided in Table 2.1-3 on page 2-4 of the EIA for the submitted EP Revision 2.

Crew rotations vary depending on the specific job responsibilities the crew member has, and the vessel, aircraft, or terminal at which the crew member is stationed. Crew rotation on the drillship is expected to be 21 days for most personnel as indicated in EP Revision 1. Crew changes are planned to be carried out primarily by helicopter. The frequency of crew change helicopter flights may be up to 40/week as indicated on page 13-2 of the EP Revision 2 and page 2-5 of the EIA for EP Revision 2 as submitted. Also as indicated on page 2-1 of the EIA for EP Revision 2, Shell may as a contingency conduct crew changes using a vessel to transport crew members from the drillship or offshore vessels to the beach at Barrow. As described in the submittal, this is a contingency if the crew changes cannot be effected by helicopter. Because the crew changes by vessel are only a contingency, we cannot estimate the frequency or number of such vessel trips.

Estimates of the volumes of treated sanitary wastes that may be discharged from vessels associated with the exploration drilling program are provided Table 4.1.2-1 on page 4-11 of the EIA for EP Revision 2.

RFAI No. 4 (Section: EIA Page 4-30)

Provide SA Beluga Whale harvest reports for the communities of Wainwright and Point Lay through 2012.

Beluga harvests reported to Shell Subsistence Advisors (SAs) for the 2010-2012 from the villages of Wainwright and Point Lay are provided below in Table 4.1.13-3.

The above information was provided as requested. A table will be added to the EIA for EP Revision 2 that provides annual beluga harvests for Barrow, Wainwright, Point Lay, and Point Hope for 1990-2012; however the harvest data are from the Alaska Beluga Whale Committee.

Table 4.1.13-3: Reported Beluga Harvests for Wainwright and Point Lay in 2010-2012

Village	Number of Belugas Reported as Harvested		
	2010	2011	2012
Wainwright	0	1	33
Point Lay	0	0	14

RFAI No. 5 (Section: 2.0 Page 2-1)

***Provide a map showing the locations of the maximum pollutant concentrations occurring offshore within the subsistence areas*.**

Figure 1 has been prepared and shows locations of peak model-predicted offshore concentrations by receptor and averaging time based on the results in Table 2. For the offshore concentrations, BOEM also requested that drawings with isopleths be provided for the peak 1-hour concentrations within the offshore subsistence area. Figures 2 through Figure 6 provide those isopleths for NO_X, PM_{10}, $PM_{2.5}$, CO and SO_2, respectively.

This information also incorporates changes to the dispersion modeling results since submittal of Shell's Chukchi Sea Exploration Plan Revision 2 on November 6, 2013 (see response to Air Quality, RFAI No. 1). Table 1 (Case 1) and Table 2 (Case 2) provide the dispersion modeling results for the offshore locations based on the logic pattern described under response to Air Quality, RFAI No. 5.

Table 1. Summary of Maximum Offshore Concentration Locations (Case 1)

Offshore Peak Impacts		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m^3	in µg/m^3	in µg/m^3	in µg/m^3	No.	(km)	(km)
NOx	1-hour	18.5	53	71	3760	631	-230	94
PM10	1-hour	7.7	143	151	500	631	-230	94
PM2.5	1-hour	7.7	143	151	500	N/A	-230	94
CO	1-hour	12.6	1145	1158	55000	631	-230	94
SO2	1-hour	0.2	16	16	5200	577	-242	78

Table 2. Summary of Maximum Offshore Concentration Locations (Case 2)

Offshore Peak Conc.		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m^3	in µg/m^3	in µg/m^3	in µg/m^3	No.	(km)	(km)
NOx	1-hour	28.0	53	81	3760	631	-230	94
PM10	1-hour	11.6	143	155	500	631	-230	94
PM2.5	1-hour	11.6	143	155	500	631	-230	94
CO	1-hour	12.6	1145	1158	55000	631	-230	94
SO2	1-hour	0.2	16	16	5200	577	-242	78

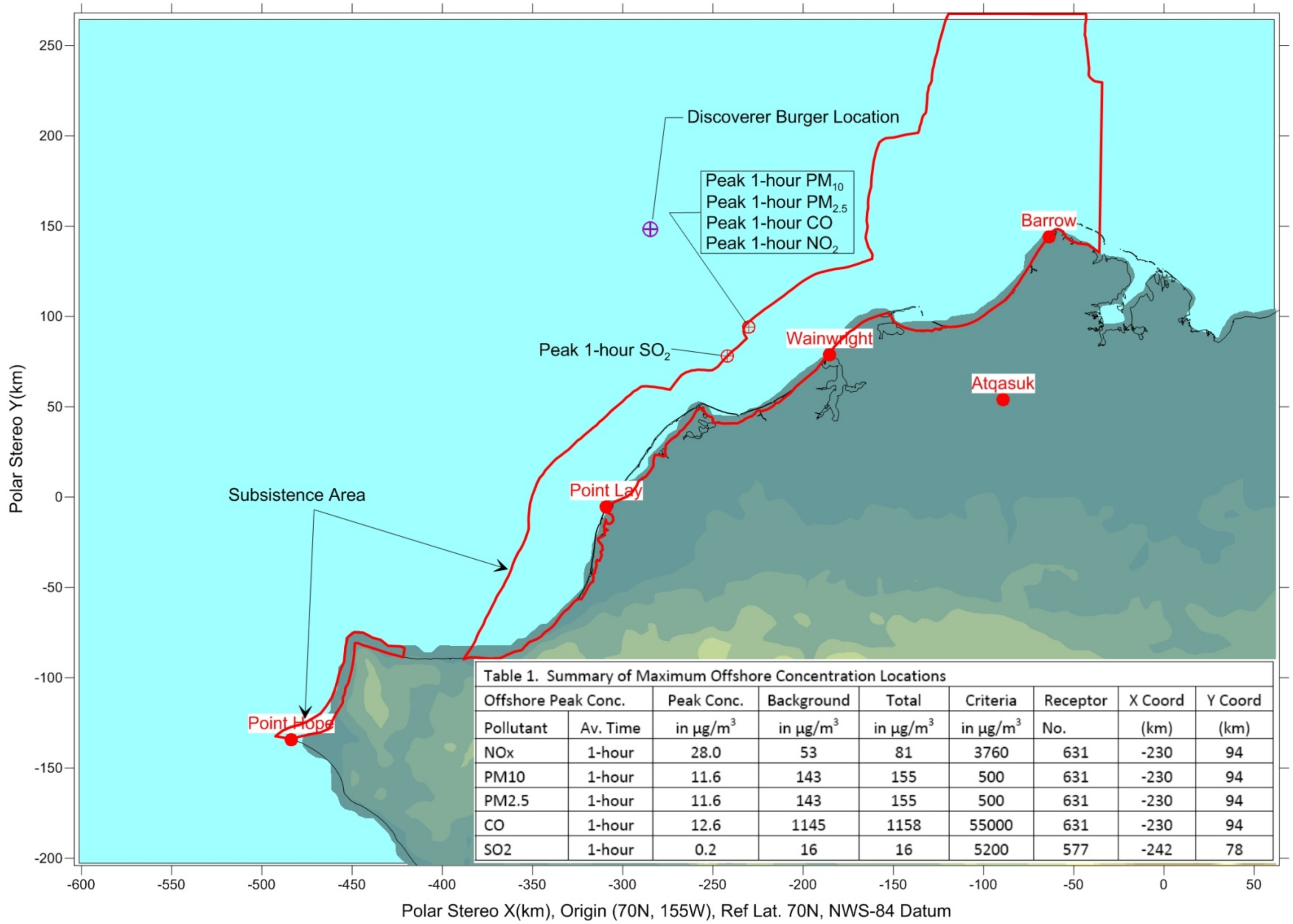


Table 1. Summary of Maximum Offshore Concentration Locations

Offshore Peak Conc.		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m³	in µg/m³	in µg/m³	in µg/m³	No.	(km)	(km)
NOx	1-hour	28.0	53	81	3760	631	-230	94
PM10	1-hour	11.6	143	155	500	631	-230	94
PM2.5	1-hour	11.6	143	155	500	631	-230	94
CO	1-hour	12.6	1145	1158	55000	631	-230	94
SO2	1-hour	0.2	16	16	5200	577	-242	78

Figure 1: Location of Maximum Offshore Concentrations (Case 2)

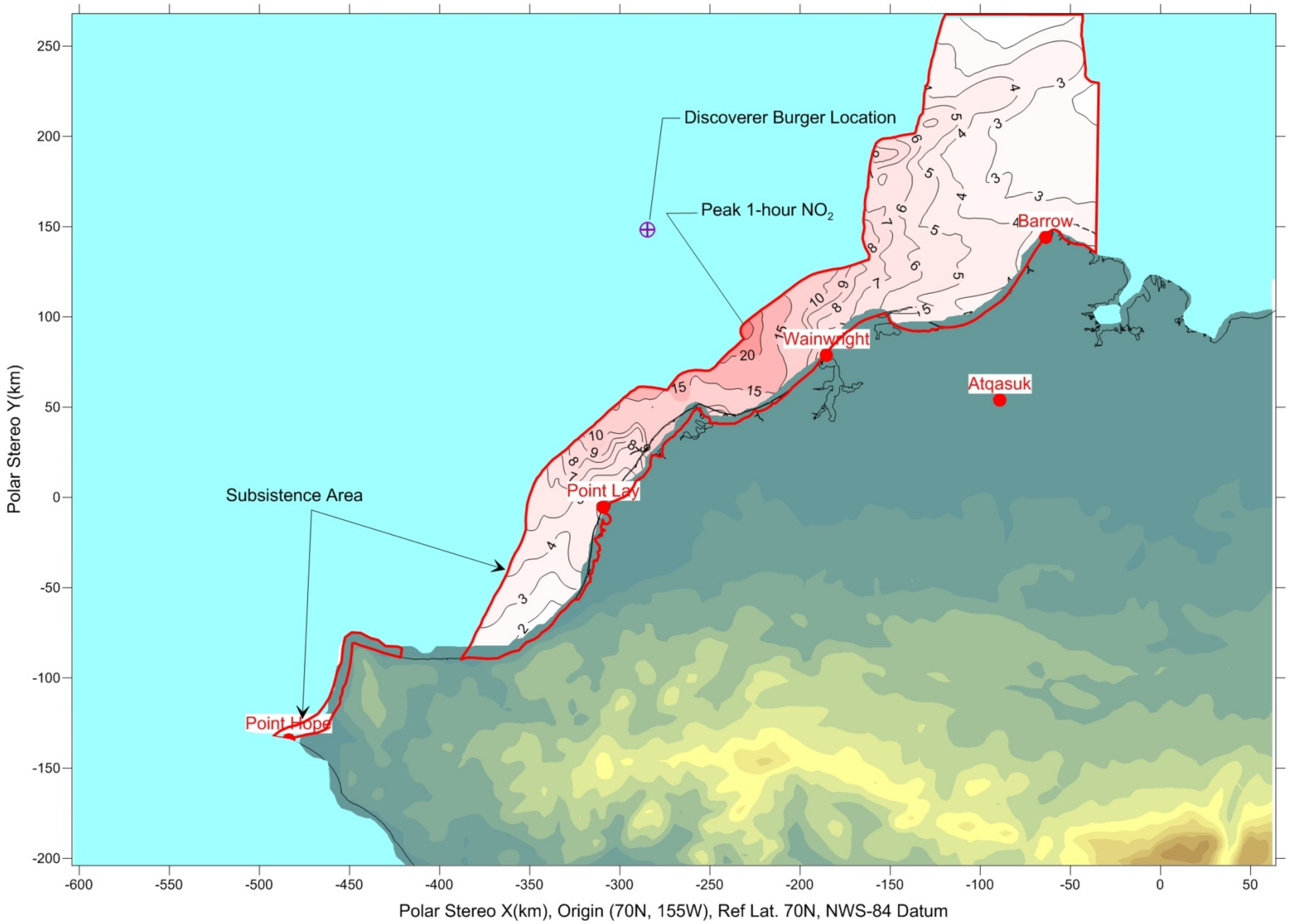


Figure 2: Isopleths of peak 1-hour NO_2 Concentration in Offshore Subsistence Use Area in micrograms per cubic meter (µg/m3)

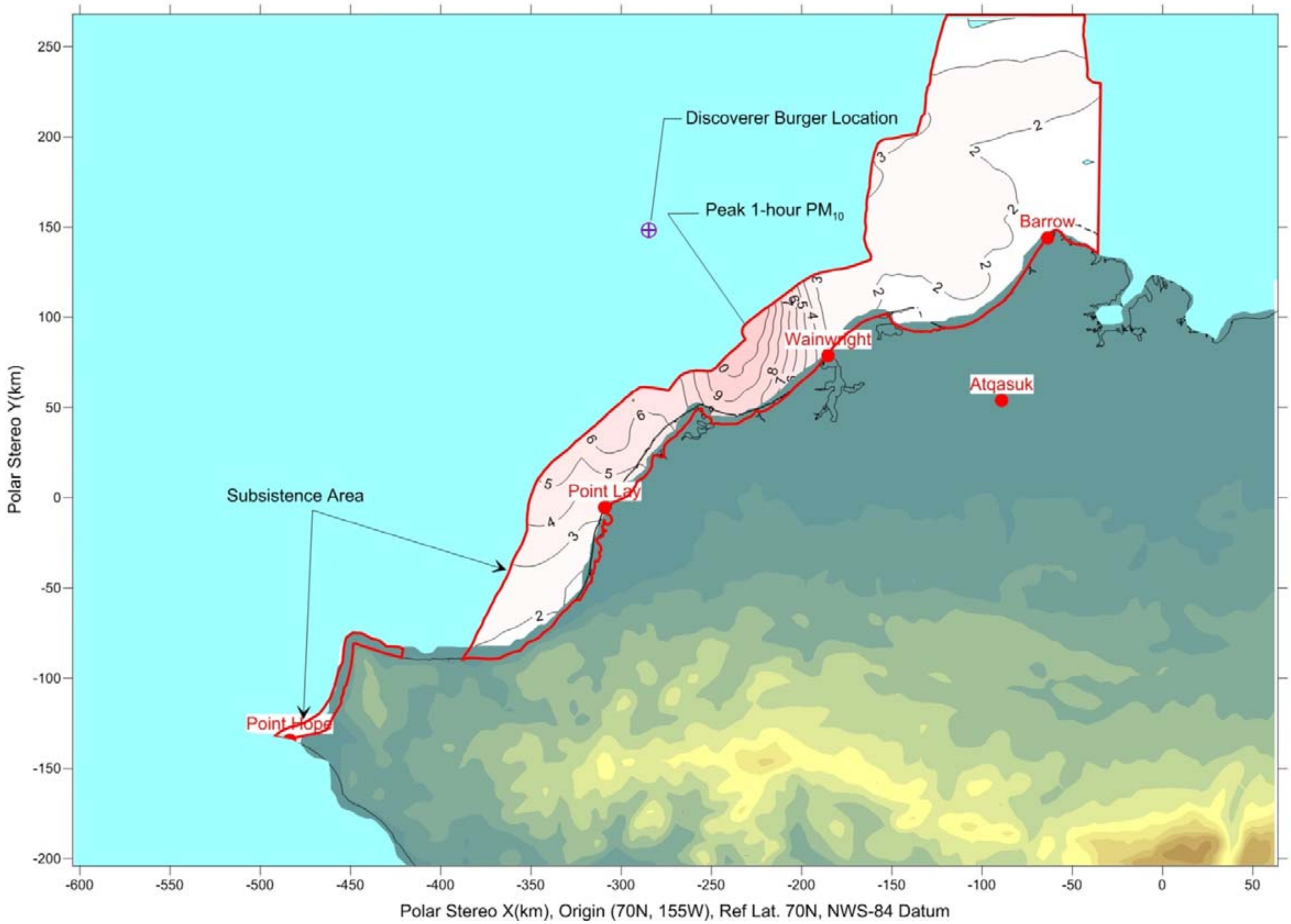


Figure 3: Isopleths of peak 1-hour PM_{10} Concentration in Offshore Subsistence Use Area in micrograms per cubic meter (µg/m3)

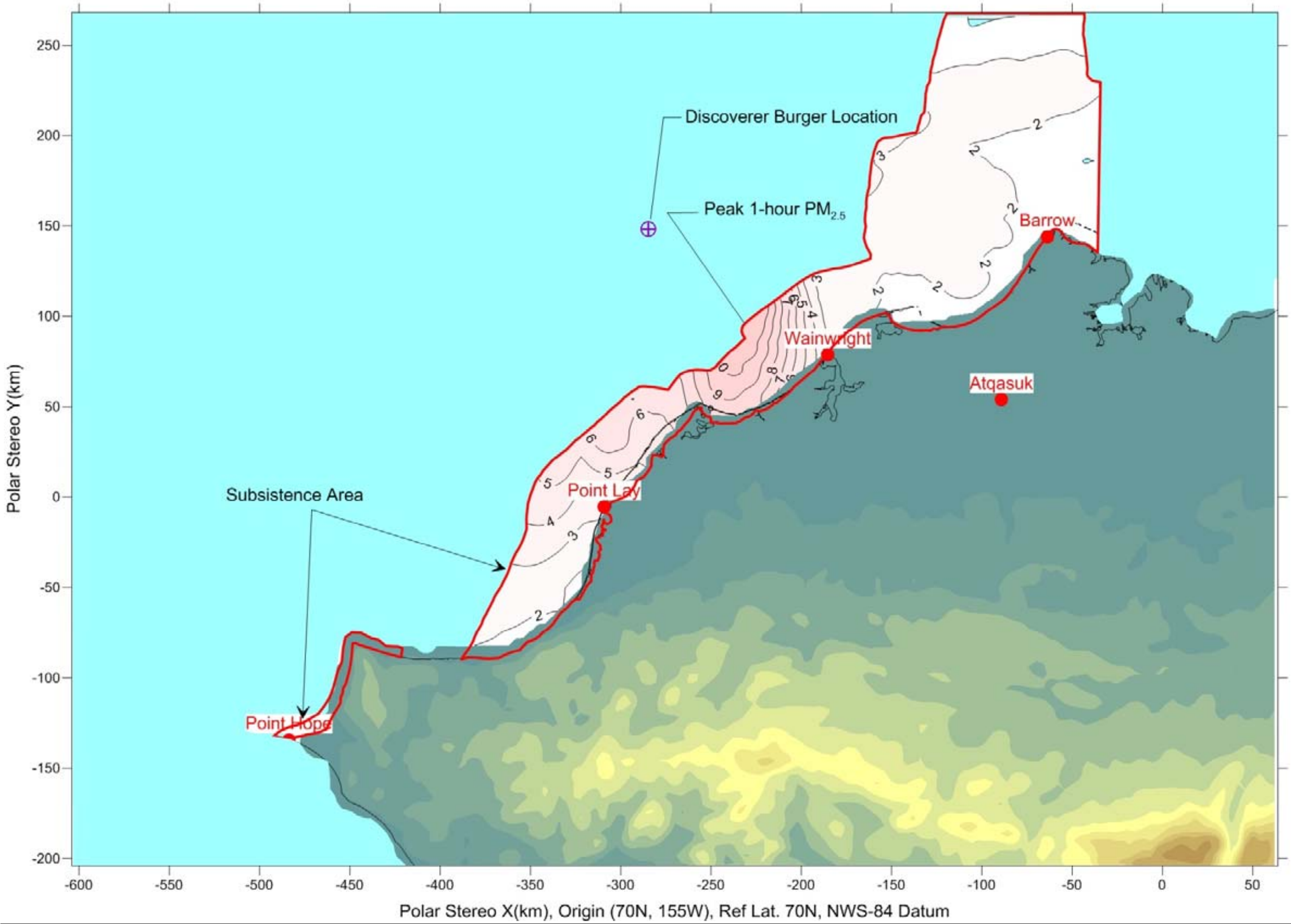


Figure 4: Isopleths of Peak 1-hour $PM_{2.5}$ Concentration in Offshore Subsistence Use Area in micrograms per cubic meter (μg/m3)

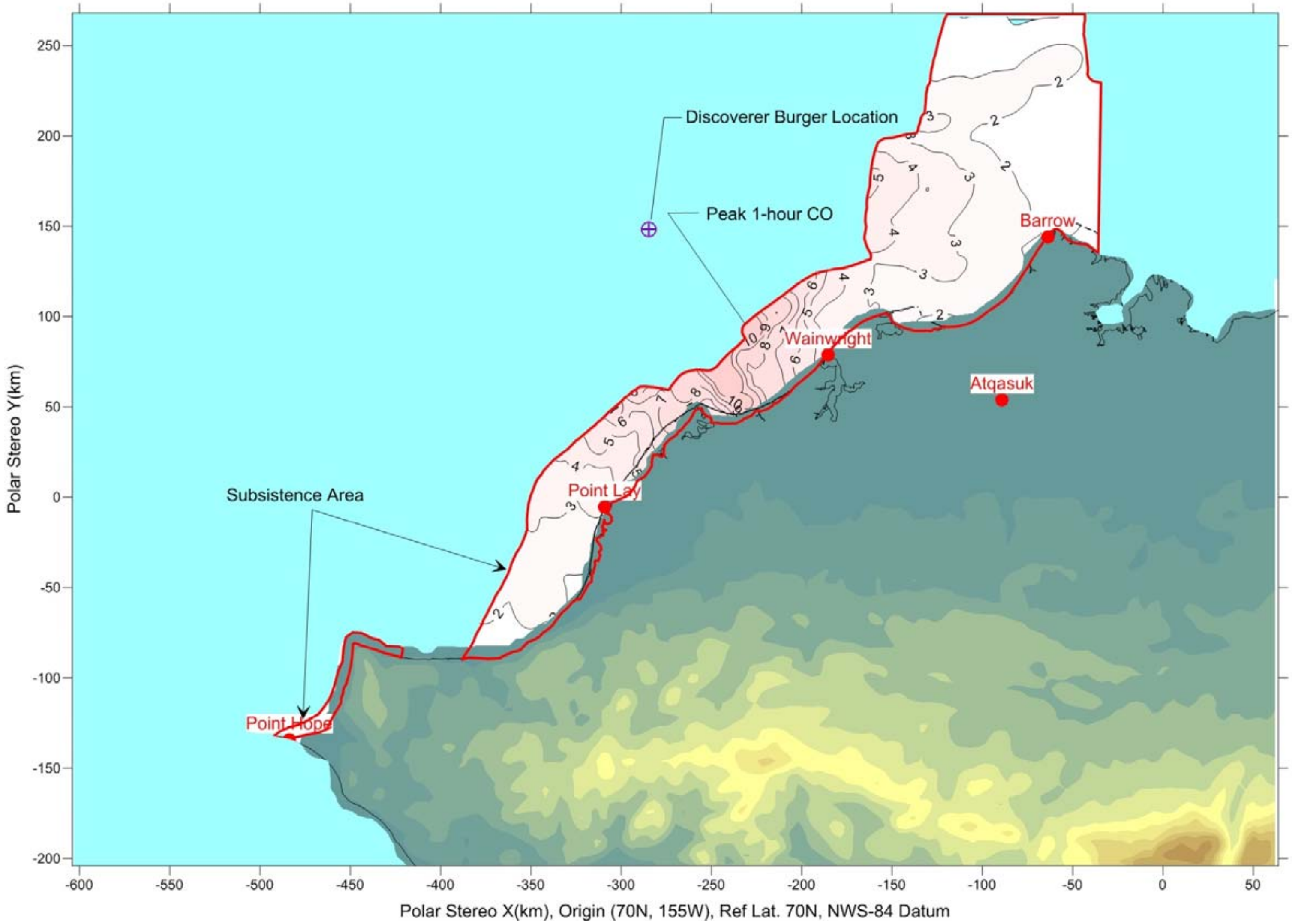


Figure 5: Isopleths of Peak 1-hour CO Concentration in Offshore Subsistence Use Area in micrograms per cubic meter (μg/m3)

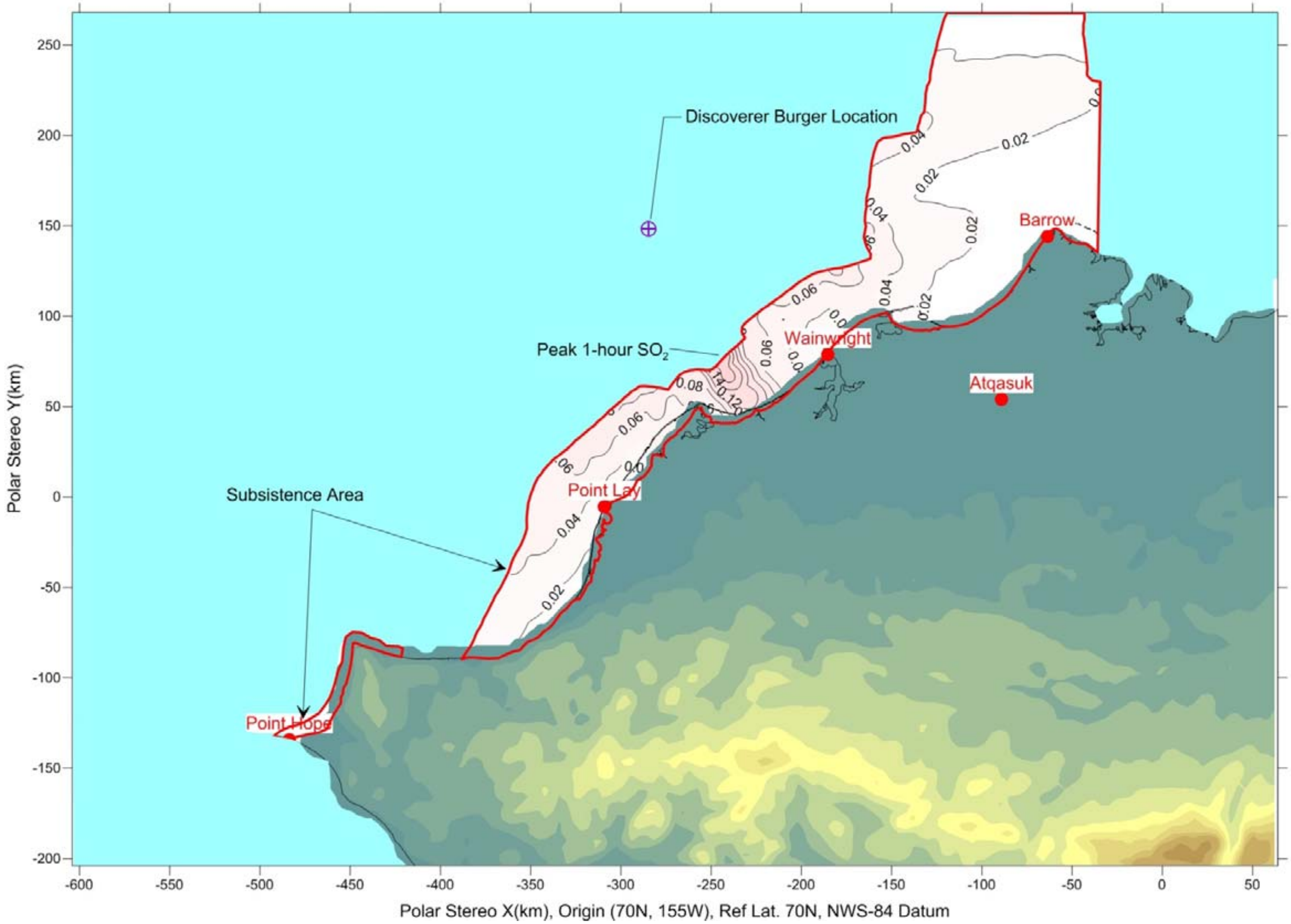


Figure 6: Isopleths of Peak 1-hour SO2 Concentration in Offshore Subsistence Use Area in micrograms per cubic meter (μg/m3)

Archaeology

RFAI No. 1 (Section: EP 13.0(a) Page 13-2)

Provide full details regarding the staging of near shore tug and barge in Goodhope Bay: precise location, moorings, depth, distance from shore, any other seabed disturbance, discharges, staffing, etc. If the seabed will be disturbed, provide an archaeological report or information sufficient for BOEM to determine that no historic properties will be affected.

The precise location of mooring is yet to be determined; however it will be in the vicinity of 66° 13’ N 163° 28’ W, which is approximately 7.0 nmi from land on the 5.0 fathom contour. Setting of three mooring buoys is anticipated with each buoy having up to three anchors.

Setting and retrieval of the anchors will result in some disturbance of the seafloor, but the extent of the disturbance will be small. Shell selected the area in large part because it has been selected and approved as a potential place of refuge (PPOR) in the Northwest Alaska Subarea Plan. The review process for selecting PPORs considers the existence of sensitive resources such as historic properties. Subsea surveys have not been conducted at the location, but it is the conclusion of an archaeological review requested by Shell (RFAI Arch 1 attachment) that there is low potential for any effects to historic resources from the planned moorings and staging in Goodhope Bay.

Vessels will remain compliant with the existing waste management plan, MARPOL regulations, and Vessel General Permit for any discharge of gray water or treated effluent. Crew changes will occur throughout the season using a landing craft vessel (yet to be contracted) transiting out from Kotzebue to the vessel locations in Kotzebue Sound. Vessels may also receive resupply of food stores via this landing craft.

Section 13 a) of the EP revision 2 will be modified to include this additional mooring information. Shell will modify the text in Section 2.1 of the EIA for EP Revision 2 to reflect the information provided above. A new section (Section 4.1.12 Impact of Vessel Traffic (Mooring) on Cultural Resources) containing some of this analysis will be added to the impact analysis in the EIA.

A technical memorandum on the archaeological resources of the area is attached - RFAI Arch 1 document.

RFAI No. 2 (Section: EIA 4.3.2 Page 4-47)

Provide an archaeological report on the proposed camp in Barrow or information sufficient for BOEM to ensure that no historic properties will be affected.

Shell's existing 75-person man camp will be expanded by adding a Kitchen / Dining / Recreation (K/D/R) unit. The primary camp is on a pad constructed by UIC in 2012; the facilities on the pad, including the planned K/D/R expansion, are Shell facilities. No State or Federal permits were required of UIC for construction. Construction was permitted with the North Slope Borough and no archaeological reports were required or prepared. A review of the AHRS database indicates there are historic properties in the area including the NARL facilities themselves – the NARL Historic District (BAR-00075), which has been determined eligible for National Register of Historic Places listing by the Alaska State Historic Preservation Officer, but not been nominated to the Register. Any effects to BAR-00075 from the installation and expansion of Shell's 75-person man camp with a K/D/R unit will be temporary and reversible. Thus these effects should not affect the historic integrity of the NARL Historic District. The existing accommodations and the planned K/D/R unit are modular, portable, facilities that will only be there as long as Shell's exploration drilling program requires them. The facilities are located on mats and skids and are self contained, not connected with municipal utilities.

Shell now plans to also use a 40-person man camp in the same area. This man camp is being relocated by UIC. Shell plans to lease / reserve the accommodations for up to 40 persons at this site.

A new section (Section 4.3.3 Impact of Shorebase Increases on Cultural resources and Historic Properties) containing the above information and analysis will be added to the EIA for EP Revision 2.

Birds

RFAI No. 1 (Section: EIA Preface, Page xviii)

Provide report in electronic format: "Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 – 2012" (Gall and Day 2013).

Shell has attached an electronic copy of the report Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 – 2012" (Gall, Day, and Morgan 2013). The report was in a draft form (Gall and Day 2013) at the time EP Revision 2 was prepared. The attached file (RFAI Birds 1) is for the final report.

RFAI No. 2 (Section: EP Appendix I, Page i)

Provide a description of the measures Shell took, or will take, to satisfy the conditions of Lease Stipulation 7 regarding bird collisions for the Polar Pioneer.

Stipulation number 7 does not apply to the Polar Pioneer when it is moored in Dutch Harbor.

RFAI No. 3 (Section: EP 13.0, Page 13-1)

Provide IHA and LOA applications.

According to 30 CFR 550.213(a) Shell is only required to list the federal, state and local application approvals or permits Shell must obtain to conduct the proposed exploration activities.

The IHA application was submitted to NMFS on December 3, 2013 and is attached. The LOA application has not yet been submitted to the USFWS. When it is submitted to the USFWS a copy will be sent to BOEM.

RFAI No. 4 (Section: EP Attachment A, Page A-3)

Correct the title to remove the parenthetical "(Stipulation Area)." Stipulation 7 applies to the Chukchi Sea, not only to the listed blocks.

Shell has removed the language (Stipulation Area) from the title.

Oil Spill

RFAI No. 1 (Section: EP 13.0, Page 13-2)

Provide information regarding whether fuel transfers will occur within Kotzebue Sound/Goodhope Bay for tugs, capping stack barge, or near shore barge. If fuel transfers will occur provide the following:

1) ***how many times might refueling occur during the season of operation;***
2) ***an estimate of fuel spill volume (if a hose ruptures, for example);***
3) ***type of fuel that would be transferred;***
4) ***minimum distance to shoreline;***
5) ***verification that the "Shell Fuel Transfer Plan" is in effect and applicable to these operations; and***
6) ***any mitigation measures in place to address fuel transfer spills, if they occur***

The only vessels requiring refuel whilst moored in Kotzebue sound are the Arctic Challenger (ACS Barge) and CORBIN FOSS (Tug for ACS). These are expected to be refueled with approx 100,000 gallons ULSD (ultra-low sulfur diesel) once each during the operating season. The mooring location is in excess of 6nm from land, in vicinity of 66 13N 163 28W. If required, Shell intends to refuel via a commercial fuel barge performing regularly scheduled fueling operations along the coastal communities of Alaska. The Fuel Transfer plan will be in effect for any fuel transfer operations.

General

RFAI No. 1 (Section: EP 5.6, Page 23)

Clarify "as-yet undefined ports" and the vessels that will be using these ports.

Vessel staging and anchor locations outside the area used for the NEPA air quality analysis include Dutch Harbor and Goodhope Bay in the western part of Kotzebue Sound.

Section 5.6 of Appendix O will be clarified as indicated in the response above.

RFAI No. 2 (Section: EP Table 6.c-2, Page 6-5)

Provide an explanation for the inclusion of the additive "biocide" in the drilling fluid components. What are its effects to wildlife and how long does it remain active? If this material is to be released into the ocean, provide detailed information about its potential effects.

Micro-organisms, primarily bacteria, buildup naturally in untreated mud systems; these bacteria break down various components of the drilling fluids degrading the drilling fluids. The biocide Busan 1060 was added as a contingency drilling fluid component that may be used to prevent this bacterial growth.

EPA (2008) has concluded that the biocide is practically non-toxic to birds, slightly to moderately toxic to laboratory mammals, and practically non-toxic to moderately toxic to marine species (fish and invertebrates). A maximum of 0.4 pounds per barrel of Busan 1060 is planned for any water based fluid formulation. Shell's current drilling fluid plan (MI-SWACO 2013) contains the results of toxicity tests on 17 different water based drilling fluid formulations, all of which contain 0.4 pounds per barrel of the biocide Busan 1060. Of the 17 tests, six of the fluids had LC50 values >500,000 ppm with the remaining 11 tests ranging between 91,800 ppm and 365,000 ppm.

EPA's NPDES General Permit AKG-28-8100 requires operators to use drilling fluids have an LC50 value greater than 30,000 ppm and this must be verified and documented by laboratory testing. EPA (2012) concluded in their Ocean Discharge Criteria Evaluation prepared for General Permit AKG-28-8100, that such drilling fluids will not result in unreasonable degradation of marine waters, and this included an assessment of persistence and bioaccumulation of the drilling fluids and their components in the Chukchi Sea. The EPA further concluded that the discharges are not likely to affect species protected under the Endangered Species Act (ESA) which includes most of the marine mammal species in the area and several bird species of seabirds.

It should be noted that the toxicity tests referenced above are conducted on the types of organisms (adult and larval crustaceans, fish) that are generally considered to be most sensitive to potentially toxic chemicals, and are conducted with very low dilutions of the drilling fluids. Additionally, as described in Section 4.5.3 of EP Revision 2, both modeling and discharge monitoring studies have shown that discharged drilling fluids are diluted by magnitudes of 1,000 or more within a very short distance from the outlet and within a couple minutes when discharged at open ocean water environments within the range of water depths found at Shell's drill sites. At these dilutions there will be no effect on fish and wildlife.

The biocide degrades due to abiotic and biotic processes in the environment. Persistence in water depends on the pH, with the chemical degrading more quickly at lower pH's (EPA 2008). Testing abiotic hydrolysis, half-lives of 3.4 hr, 16 min, and 32 sec for pH's of 10.9, 9.5, and 9.0 respectively at temperatures of 22 °C have been reported (Bakke et al. 2001 in EPA 2008), but other studies have found half-lives of 3.2 days, 5.0 days, and 302 days at a pH of 5, 7, and 9 respectively. The biocide is also readily bio-degradable (EPA 2008 citing Voerts et al. 1975) as 100 percent of the biocide was degraded by direct metabolism under both aerobic an anaerobic conditions at 28 °C. Formaldehyde is one degradate, but formaldehyde is itself short-lived in the marine environment. Bio-concentration by fish or other aquatic organism is unlikely (EPA 2008).

Section 6c) of EP Revision 2 will be modified to show that the biocide is a contingency product, to be used only as needed. Section 2.4 of the EIA for EP Revision 2 will be modified to reflect the information provided above. Tables 2.4-1 and 2.4-2 in Section 2.4 will be modified to indicate that the biocide is a contingency product, to be used only as needed.

Bakke, J.M., J. Buhaung, and J. Riha. 2001. Hydrolysis of 1,3,5-Tris(2-hydroxyethyl) hexahydro-s-triazine and its reaction with H_2S. Department of Chemistry, Norwegian University of Science and Technology. Ind. Eng. Chem. Res. 40:6051-6054.

EPA. 2008. Hexahydro-1,3,5 tris (2-hydroxyethyl)-s-triazine (HHT). P.C. Code 083301. Human health and ecological risk assessments for the reregistration eligibility decision (RED) document. Cace 3074. CAS Registry No. 4719-04-4. Memodrandum from William J. Hazel, Ph.D., Chemist, Risk Assessor; Jenny Tao, Toxicologist; Jonathan Chen, Ph.D., Incident Report; Cassi Walls, Ph.D., Occupational/Residential Assessor; Najm Shamim, Ph.D., Dietary Assessor, Product Chemist; William Erickson, Ecological Effects; James Breithaupt, Environmental Fate to Risk Assessment and Science Support Branch (RASSB) Antimicrobials Division (7510P) to Norm Cook, Branch Chief, Risk Assessment and Science Support Branch (RASSB), Antimicrobials Division (7510P). Office of Prevention, Pesticides, and Toxic Substances, United States Environmental Protection Agency, Washington, D.C.

Voets, J.P., P. Pipyn, P. Van Lancker, and W. Verstraete. 1975. Degradation of microbiocides under Different Environmental Conditions. J. appl. Bact. 40:67-72.

Table of Contents

Attachments

A: Emission Inventory Tables
B: Engine Certificates
C: Vendor Specification Sheets
D: Preliminary Source Test Data
E: January 11, 2012 Letter from Shell to EPA

AIR QUALITY

RFAI No. 1

Active spreadsheets that were used for the calculations to allow verification of data provided in Appendix O – include each emission unit by make and model. The spreadsheets must not contain any locked cells, hidden rows or columns or text (i.e. white text on a white background), and the workbooks and spreadsheets must not be password protected, unless the password is provided to the Regional Supervisor.

On December 12, 2013, Shell provided a diskette with the Excel workbook file titled "Discoverer_BOEM_EI_20131011_final_D.xlsx" to Mr. David Johnston with Alaska BOEM that includes the original spreadsheets for the November 6, 2013 Chukchi Sea EP Revision 2. In addition, the pdf file "Discoverer_BOEM_EI_20131011_final_D.pdf" was provided at that time that included a printer friendly version of the Excel workbook.

Since the November 6, 2013 submittal of Shell's Chukchi Sea EP Revision 2, necessary updates to the emission unit inventory are recognized. These updates include the following:

- Update to the rating for the Caterpillar D3512C generator engines for the *Discoverer* "Generation" category (see response to Air Quality, RFAI No. 2).
- Updates to emission factor selection (see response to Air Quality, RFAI No. 5).
- Update to vessel selection for the Anchor Handler 2. The *Tor Viking* is now replaced with the *Ross Chouest* as the candidate vessel for future drilling seasons. This update requires changes to the Ice Management & Anchor Handling "Propulsion & Generation" and "Boilers" categories.
- Update to correct the volatile organic compounds (VOC) emission factor for the *Discoverer* "Boilers" category. Actual source test data is applied for these units.
- Update to correct the VOC emission factor for the *Discoverer* "Incinerator" category. Actual source test data is applied for this unit.
- Update to correct the VOC emission factor for the Ice Management & Anchor Handling "Incinerator" category. A more appropriate emission factor for the expected type of incinerators to be used has been identified for these units.
- Update to correct the SO_2 emission factor for all combustion sources that burn ultra low sulfur diesel (ULSD). An error was recognized in the stoichiometric calculation. Upon further review, it was discovered that the combustion sources SO_2 emission factor was in pounds per million British thermal units (lb/MMBtu) instead of pounds per gallon (lb/gallon).

Based on these described changes, Shell submits an update to the spreadsheets in Appendix O and is providing the Excel workbook titled "Discoverer_BOEM_EI_20131219_final_D.xlsx". In addition, the pdf file "Discoverer_BOEM_EI_20131219_final_D.pdf" is provided in Attachment A of this response that includes a printer friendly version of the Excel workbook.

RFAI No. 2

Documentation or clarification concerning the capacity of the 3512C generator sets. Shell states that the generation units on the Noble Discoverer are Caterpillar 3512C generator sets. Shell lists the

capacity of the 6 Caterpillar 3512C generators at 6000KW (Attachment A, Appendix O). Caterpillar's specification for the 3512C generator shows a minimum rating of 1250 ekW and a maximum rating of 1500 ekW.

Attachment B of this response includes the engine certificates for the six Caterpillar D3512C generator engines to be installed on the Noble *Discoverer* by the end of 2013. These certificates document the capacity of each of the D3512C engines for the Noble *Discoverer* as 1,476 horsepower (1,101 kilowatts), each.

RFAI No. 3

Documentation concerning the estimated control efficiency of 50% per pollutant (Section 5.4, Appendix O).

The controlled emission factors for nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM), and VOC for the *Discoverer* main generator engines (Caterpillar D3512C) are derived using an estimated control efficiency of 50 percent. These engines are fitted with Selective Catalytic Reduction (SCR) and Catalytic Diesel Particulate Filter (CDPF) controls, the same emission controls used in the 2012 drill season on the previous main generator engines (Caterpillar D399). According to vendor specification sheets (see Attachment C of this response) and an April 2012 table of preliminary results of a source test completed for a Caterpillar 3512C engine equipped with the same SCR and CDPF controls installed on the *Discoverer* (see Attachment D of this response), control efficiencies are documented to range from 60 to 95 percent. In order to be conservative in our estimated projected maximum emissions, the use of an estimated control efficiency of 50 percent was applied to the emission factors.

RFAI No. 4

Information describing what constitutes "good engine operating practices" to lower emissions by reducing all diesel engine load factors by 20% in Section 2.0 of Appendix O.

As stated in the September 29, 2012 Noble *Discoverer* Application to Revise PSD Permit, during operation, maximum continuous power ratings of marine engines are typically 10 to 20 percent below "name-plate" power ratings. These types of "good engine operating practices" are performed in order to extend the equipment life because, unlike power plants and on-road diesel vehicles, engines in vessels tend to be built into the hull and cannot be economically replaced in total. For example, Noble has installed an electrical distribution system with controls that limit the engines' operating rate on several groups of engines. Documentation of this practice is further explained in the January 11, 2012 letter from Susan Childs to EPA's Natasha Greaves (see Attachment E of this response). This practice was applied during the actual source testing required under the EPA air permit and was described under the *Discoverer* Drillship Test Protocol submitted to EPA's Natasha Greaves on February 22, 2012.

RFAI No. 5

Documentation of MARPOL Annex VI compliance for each engine claiming the lower MARPOL emissions standards. Documentation of EPA marine engine tier standards for each engine claiming the lower EPA emissions standards. Using emission factors simply described as "a mixture of other generic emission factors" is not sufficient.

Within the Chukchi Sea Exploration Plan Revision 2 submitted on November 6, 2013, Shell provided an assessment of air quality impacts expected to occur for a future exploration drilling season. As described in Appendix O, this assessment includes equipment categories of emission unit types (e.g. propulsion, heaters, etc.) that are expected to be operated during the season with an associated emission rate for the group. In an effort to maintain operational flexibility, categories of units have been listed rather than individual emission units.

This approach provides flexibility to operate various engines within a group that meet the criteria listed for a particular group. For each category of emission units, an associated emission factor (e.g., source test, Tier standard, AP-42) has been selected that represents an achievable emission rate for the units in the group. Under this plan, Shell may retain the ability to switch out certain equipment within a group as necessary without deviating from a particular premise of the EP.

Emission factors used in the air quality analysis provided under the response to Air Quality, RFAI No. 1 are primarily of three types:

- Results of emission source tests on the actual unit to be used;
- Marine Category 1 – Tier 2 emission factors (40 CFR 94.8 Table A-1); or
- EPA AP-42 emission factors from Table 3.4-1.

Actual emission source test results are used in cases where the actual unit tested is likely to be the same in an upcoming drilling season. As described above, some equipment may not be identified at this time for use or there may be a need to switch equipment prior to the next drilling season. In these cases, a published emission factor was used that is appropriate for the category group.

Tier 2 published emission factors were generally used in the inventory because they are the highest Tier Level emission rates for most marine engines. However, some engines in the inventory date to a time before the Tier Levels were established, so a logic pattern was established which determined the emission factors to use. The logic pattern is as follows:

Option 1. If the engines have been source tested and it is certain that the engines will be used in the upcoming drill season, then the source test values are used.

Option 2. If the engines have been source tested but it is uncertain the engines will be used in an upcoming drill season, the decision on which emission factor to use is based on the results of the source test:

Option 2a. If the source test resulted in emission rates less than the Tier 2 level, the Tier 2 level is used, whether or not documentation can be provided that the engine is in fact a Tier 2 engine. The source test itself is assumed to be justification that this engine can meet the Tier 2 levels.

Option 2b. If the source test resulted in emission rates higher than the Tier 2 level, both the Tier 2 emission factor (Case 1) and the AP-42 emission factor (Case 2, if AP-42 is higher) are analyzed in separate model runs to "bracket" the range of possible values. (see response to Environmental, Sociocultural/Subsistence, RFAI No. 5; and response to Air Quality, RFAI No. 16).

Option 3. If the engine has not been source tested but documentation can be provided that the engine is in fact a Tier 2 engine, the Tier 2 emission factors are used.

Option 4. If the engine has not been source tested and no documentation can be provided on the Tier Level of the engine, both the Tier 2 emission factor (Case 1) and the AP-42 emission factor (Case 2, if AP-42 is higher) are analyzed in separate model runs to bracket the range of possible values.

The Case 1 dispersion modeling analysis applies the Tier standards listed in the inventory (see response to Air Quality, RFAI No. 16). The Case 2 dispersion modeling analysis applies more conservative emission rate values to demonstrate that the Tier 2 standards identified in Appendix O are more conservative for the applicable categories. Table 1 provides a summary of the emission factor selection used for the Case 2 dispersion modeling where Tier 2 standards are identified in Appendix O.

Table 1. Summary of Emission Factor Selection for Dispersion Modeling Analysis (Case 2)

	Emission Rates Listed in Appendix O with Tier 2 Ratings		
	NO_X	CO*	PM
Discoverer			
Propulsion	Option 4, AP-42	Option 2b, Tier 2	Option 4, AP-42
Small IC Engines	Not Applicable	Option 2b, Tier 2	Option 2a
Seldom –Used IC Engines	Option 4, AP-42	Option 2b, Tier 2	Option 4, AP-42
OSR Propulsion & Generation	Option 2b, AP-42	Option 2b, Tier 2	Option 2b, AP-42
Offshore Supply Propulsion & Generation	Option 2b, AP-42	Option 2b, Tier 2	Option 2b, AP-42
Science Vessel Propulsion & Generation	Option 2b, AP-42	Option 2b, Tier 2	Option 2b, AP-42
Arctic Oil Storage Tanker	Option 3	Option 2b, Tier 2	Option 3

*No Tier 1 or Tier 0 CO emission standards do not exist for marine engines and AP-42 applicable emission standards are less than the Tier 2 standards used.

Since 40 CFR 94.8 Table A-1 does not provide a VOC emission factor, an emission factor from EPA's non-road compression ignition engines (Tier 1), 40 CFR 89.112 Table 1 was selected.

Finally, as described in Appendix O, Section 5.4 "For the onshore emission units, the emission factors are a mixture of other generic emission factors." These emission factors are from 40 CFR 89.112, Nonroad and EPA AP-42, Section 1.4, Natural Gas Combustion. These emission factors are representative of the proposed man camp engines and hangar/storage building heat boiler planned for use at this time.

MARPOL Annex VI emission standards were not used in the emission inventories.

RFAI No. 6

Documentation of the "safety policy" referenced in Table 6 of Section 5.2 of Appendix O to reduce engine power level by 50%.

Dynamic Positioning (DP) vessels are equipped with computer-controlled systems that automatically maintain the vessel's position and heading. Because DP vessels must operate in close proximity to other vessels or structures, DP systems have been developed to require redundant components and systems that, in the case of a failure, must be immediately available and must have sufficient capacity that the DP operation can continue until work in progress can be finished safely. As such, vessels operating in normal

DP mode must limit the load on the power system so that the vessel will be left with adequate power and thrusters to maintain position after a failure. A more accurate term for this operational consideration is "safety factor" to describe the measures used to ensure adequate control and to prevent potential vessel collisions.

The 50 percent limit for DP operations is based on observation of several DP vessels in normal operation in the Gulf of Mexico. This was confirmed by reviewing actual power demands during heavy sea conditions of several Gulf of Mexico Platform Supply Vessels, both totally diesel electric (e.g., *Sisuaq*) and some that were mechanical (e.g. *Harvey Explorer*). In addition, Shell reviewed resupply events from the 2012 Beaufort Sea Drilling Program for the Sisuaq to better characterize resupply events in the Arctic. During the 2012 drill season, Shell recorded 5-minute electrical output data while the *Sisuaq* operated within 25 miles of the Kulluk drilling unit. Using this 5-minute data, total hourly average electrical output for the combined four main generator engines was calculated. Shell reviewed approximately 380 hours of data. Over the course of the 2012 season, the maximum hourly power capacity from all four engines was 34.4 percent and the seasonal average power capacity was 9.4 percent.

RFAI No. 7

Documentation or other supporting justification that short-term use limitation in equations (1) through (5) in Section 5.2 of Appendix O are established practices.

Under equations (1) through (5), Shell has calculated the short-term utilizations for various equipment that are based on operator knowledge and represent the best professional judgment for anticipated operation. These estimations were developed after consultation with Shell staff and contractors and represent reasonable, typical scenarios for how these types of equipment are run under normal and expected use.

Equation (1) is based on the total aggregate rating of the non-cementing IC engines (1,263 kW) within the "Small IC Engines" category (1,763 kW). The non-cementing IC engines are the maximum group of small IC engines, which can't be utilized at the same time as the cementing engines. In order to determine a final maximum power level for the small IC engines (57 percent), a maximum power level of 80 percent was utilized (see response to Air Quality, RFAI No. 4).

$$\frac{1{,}263\ kW}{1{,}763\ kW} \times 80\% = 57\%$$

Equation (2) is based on the maximum capacity of the largest engine (679 hp) within the "Seldom-Used Engines" category and the total aggregate rating for the "Seldom-Used Engines" category (645 kW). The "Seldom Used Engines" category includes the emergency generator, lifeboats, and diver engines. Due to the nominal use of engines in this category, it is assumed that the engines from the *Discoverer* "Seldom-Used" group will not operate at the same time. Therefore, in order to calculate the highest hourly emission factor for the "Seldom-Used" engines, the maximum capacity of the largest engine from this group is used. The maximum power level of 63 percent was determined for this group by incorporating the maximum power level of 80 percent (see response to Air Quality, RFAI No. 4).

$$679\ hp \div 1.34\ {}^{hp}/_{kW} \div 645\ kW \times 80\% = 63\%$$

Equation (3) is based on an average of the output for different operational activities for the offshore supply vessels (OSV). In order to calculate the average use for an hour, DP mode is estimated at 50 percent capacity (see response to Air Quality, RFAI No. 6) for one OSV and 65 percent for the other OSV that will be in transit to or from the Chukchi Sea. Based on discussions with Shell Marine staff, an OSV is estimated to most efficiently operate while cruising at a power use of approximately 65 percent. The final average power level for this group is 58 percent.

$$(50\% \ + 65\%) \div 2 = 58\%$$

Equation (4) is based on the aggregate rating for the Arctic Oil Storage Tanker (20, 611 kW), the maximum rating for the propulsion engines (15,820 kW), and the three generators (3,360 kW) that exist on this vessel. Based on discussion with Shell staff and contractors, during the drill season the propulsion engines are estimated to operate at 30 percent power in addition to 2 of the 3 generators (one generator engine is kept offline to be used as backup) will operate at 80 percent power (see response to Air Quality, RFAI No. 4). The final maximum power level for this group is estimated at 32 percent.

$$30\% \times \frac{15{,}820\ kW}{20{,}611\ kW} + 80\% \times \frac{3{,}360\ kW\ (2/3)}{20{,}611\ kW} = 32\%$$

Equation (5) includes the maximum rating for the man camp generators (1,396 kW). The man camp contains two primary generators (448 kW) and one 500 kW emergency backup generator. The emergency backup is the largest generator of the man camp group. This generator is operated for 15 minutes per week as a regular performance check. In order to determine a final maximum hourly power level for this group (59 percent), the 80 percent limit was utilized (see response to Air Quality, RFAI No. 4).

$$80\% \times \frac{448\ \times 2\ kW}{1{,}396\ kW} + 80\% \times \frac{15\ minutes}{60\ minutes} \times \frac{500\ kW}{1{,}396\ kW} = 59\%$$

For the power use utilizations, fuel use is directly related to power consumption and may be an acceptable surrogate for confirming the utilizations. Annual (i.e., seasonal) fuel consumption may be recorded as a tool for confirming these values and for continually improving these planning assumptions.

RFAI No. 8

Documentation or clarification for using the 15% power to lift the drill stem in equations (6) through (15) in Section 5.2 for Appendix O.

Under equations (6) through (15), Shell has calculated short-term utilizations for reasons similarly as described under response to Air Quality, RFAI No. 7 above. Based on engineering knowledge and normal drilling experience, an estimated utilization of power needs during drilling activities is provided in Section 5.2. In equation (6) maximum power on a seasonal average from the generator engines is anticipated to be needed for only ¾ of an hour to conduct actual drilling to turn the bit and drill deeper. For the remainder of an hour, power needs are substantially reduced to conduct other activities such as lifting drill stem pipe. As described above, these estimations were developed after consultation with Shell staff and contractors and represent typical scenarios for how these types of equipment are run under normal and expected use. Equations (7) through (15) do not incorporate the assumption for 15% power to lift the drill stem.

RFAI No. 9

Clarification of the column heading "Aggregate Nameplate Rating" and justification of the method used to aggregate the rating in Table 2-4 of Section 5.1 of Appendix O.

"Aggregate Nameplate Rating" in Table 2 through Table 3 indicates the combined rating/output for the category of emissions in the unit group type, vessel type, or support equipment type. Table 2 through Table 3 includes the sums of ratings as an aggregate per source group category. Table 4 does not include a similar column heading.

RFAI No. 10

Clarification of the column heading "policy limits on emissions units/group" in Table 5 of Section 5.1 of Appendix O.

The heading "Policy Limits on Emission Units/Groups" is an inaccurate description of the column of data represented. This column of data listed under Table 5 describes the category of emission units, vessel types, or fuel types for which there is an associated short-term limitation applied in the emissions inventory. There is no specific written policy per se associated with these data.

RFAI No. 11

Documentation that propulsion engine emissions were used in the projected emissions inventory for purposes of 30 CFR 550.303(d).

Propulsion engine emissions for the Noble *Discoverer* are included under Page 2 of Attachment A of Appendix O and under Attachment A of this response (see response to Air Quality, RFAI No. 1). The propulsion engine for the Noble *Discoverer* is estimated to operate for two days per drilling season.

RFAI No. 12

Clarification of the row heading "Project Duration Total" in Table 7 of Section 5.5 of Appendix O, and an explanation of the values under this heading.

The information provided under "Project Duration Total" in Table 7 of Section 5.5 of Appendix O fulfills the regulatory requirements. Under 30 CFR 550.218(a)(1)(iii), the "emissions over the duration of the proposed exploration activities" are required to be included under the EP. As described under the Chukchi Sea EP Revision 2, three years are estimated to complete the six wells described and the annual/seasonal emissions provided in Table 7 are scaled appropriately (three times increase) to reflect the project duration total emissions.

RFAI No. 13

Data or other information to clarify the characterizations of emissions from equipment and surface vehicles for construction as "minor" and "small" in Section 4.10.3 of Appendix O.

Under the responses to these RFAIs (Operational, RFAI No. 23; and Environmental, Sociocultural/Subsistence, RFAI No. 1), Shell has provided an update to modify the plan for the Barrow man camp and facilities at the airport. For the Barrow man camp, Shell now plans to: 1) maintain the existing 75-person man camp near NARL; 2) add a kitchen/dining/recreation (K/D/R) area to this existing 75-person man camp – the KDR unit would adjoin the existing facilities and be located on the same pad; and 3) lease/utilize additional accommodations at the existing 40-person Ukpeaġvik Iñupiat Corporation (UIC) modular construction camp which is at the UIC storage location in Barrow and will be relocated to its new location on the existing UIC pad. Passenger processing facility expansion and hangar repairs are planned for the Barrow airport area at this time.

The planned K/D/R unit will consist of 14 skid-mounted modular buildings delivered by rolligon within Barrow over the 2013/14 winter season and will be installed on the existing pad at NARL. The K/D/R unit will be placed on mats and dunnage on the existing pad material (sand/gravel). After the K/D/R unit is set, gravel will be hauled in by approximately 15 to 20 truck loads and mixed with the beach sand in the driveway area of the pad along the back and end of the K/D/R over the existing pad to stabilize the new driving area. As similar to the emission unit inventory for the camp described in Appendix O of the Chukchi Sea EP Revision 2, power from the two existing generators at NARL and a third backup engine will be used to support the K/D/R unit and the 75-person camp near NARL.

The UIC 40-person camp is planned to be relocated from its existing location in Barrow to a similar pad near the existing NARL camp. These facilities are not Shell's and Shell will only lease the facilities at the new location. This camp will be relocated regardless of Shell's activities associated with this project.

Passenger processing facility expansion near the airport will involve the construction of buildings but no major site preparation is required. The expansion will consist of four buildings. It will adjoin the existing passenger processing facility and would occur on previously developed lands adjacent to the airport and controlled by the FAA. Hangar repairs will include repair and replacement of a new hangar door for aircraft.

The majority of emissions associated with the construction activities are expected to be associated with transport of the skid-mounted modular buildings and placement of the limited amount of new gravel. Vehicle activity will include delivery of the manufactured buildings to their locations and cranes to load and/or unload the buildings for each delivery. Because the modular buildings are expected to be transported over frozen ground, road dust emissions are minimal. Fugitive dust emissions may occur from importing gravel and minor grading at the NARL camp. This type of activity is considered normal pad maintenance and the associated dust emissions are also small and minimal. Any fugitive dust will be mitigated through watering of dusty surfaces and roadways and covering gravel trucks.

RFAI No. 14

Diagrams, figures, and text missing from Appendix C of the EIA.

The text missing at the end of Section 5.1.1 of Attachment C (page 14) is a reference to Table 4. The sentence is revised as "Emission rates for project emissions units are summarized in **Table 4**."

In addition, Figure 3 was missing on page 24 of Attachment C. Please see Figure 3 below.

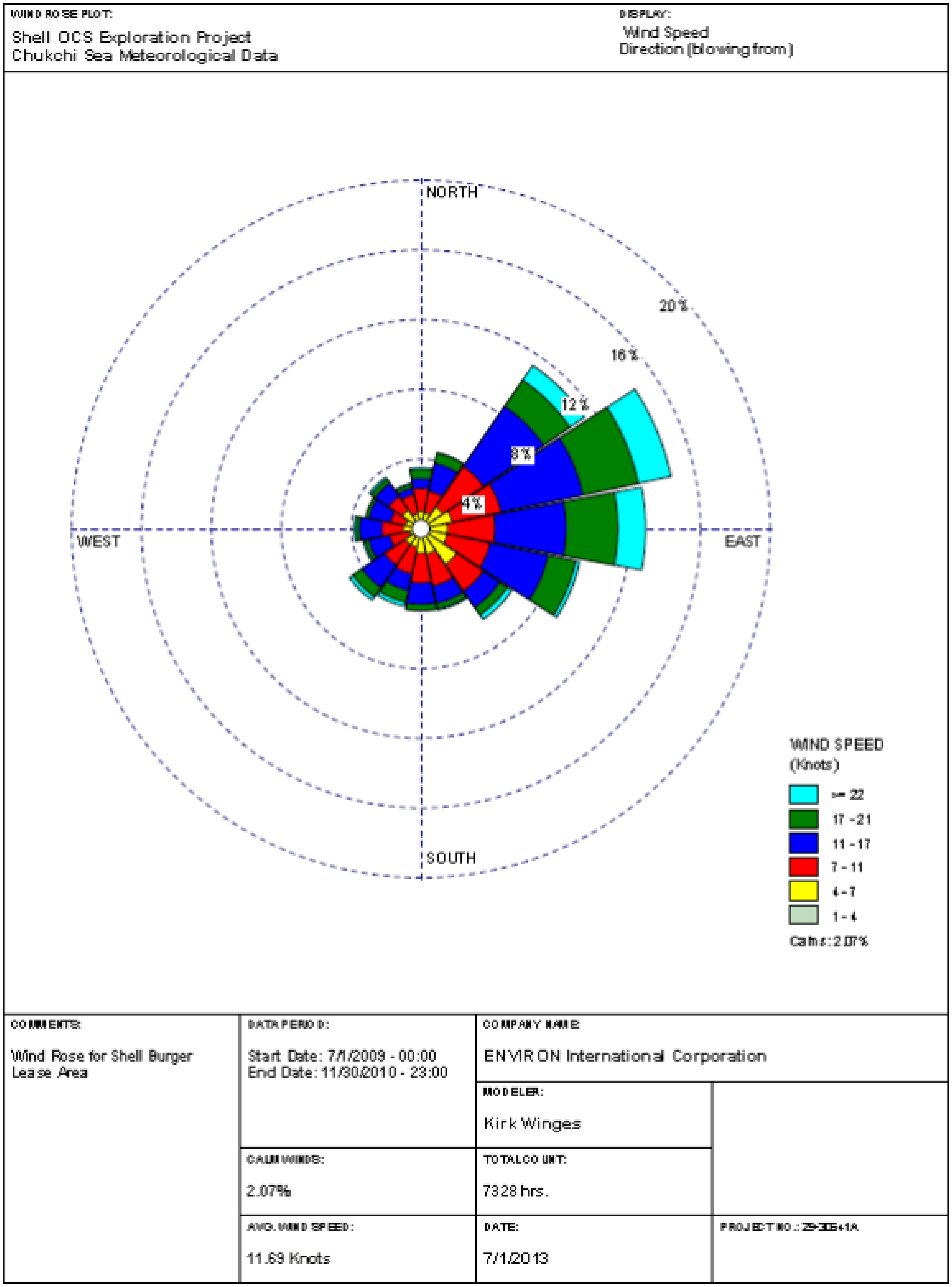


Figure 3. Wind Rose for Shell Burger Lease Area

RFAI No. 15

Provide documentation that aggregate or averaged methods are not applied to nonlinear functions.

In all cases, emissions are based on engine or boiler firing operating rates (or incinerator throughput) and a fixed emission factor. In every case, we assumed a linear relationship between the activity level and emissions. For example, a small compression ignition engine with a NO_X emission factor of 5.5 grams per kilowatt hour would emit 550 grams (1.2 pounds) per hour operating at 100 kW and three times that (1,650 grams or 3.6 pounds per hour) operating at 300 kW.

RFAI No. 16

Provide a map showing the locations of the maximum pollutant concentrations occurring onshore.

Figure 7 has been prepared and shows the locations of peak model-predicted onshore concentrations by receptor and averaging time based on the results in Table 3.

This information also incorporates changes to the dispersion modeling since submittal of Shell's Chukchi Sea Exploration Plan Revision 2 on November 6, 2013 (see response to Air Quality, RFAI No. 1). Table 2 (Case 1) and Table 3 (Case 2) provide the dispersion modeling results for the onshore locations based on the logic pattern described under response to Air Quality, RFAI No. 5.

Table 2. Summary of Maximum Onshore Concentration Locations (Case 1)

Onshore Peak Impacts		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m^3	in µg/m^3	in µg/m^3	in µg/m^3	No.	(km)	(km)
NOx	1-hour	9	53	62	188	6237	-278	18
NOx	Annual	0.009	2	2	100	6920	-258	50
PM10	24-hour	1.9	57	59	150	6498	-282	30
PM2.5	24-hour	1.9	18	20	35	6498	-282	30
PM2.5	Annual	0.006	2	2	12	6920	-258	50
CO	1-hour	9	1145	1154	40000	6846	-230	46
CO	8-hour	5	1145	1150	10000	7064	-206	58
SO2	1-hour	0.1	16	16	196	6846	-230	46
SO2	3-hour	0.1	13	13	1300	6922	-222	50
SO2	24-hour	0.03	5	5	365	6923	-218	50
SO2	Annual	0.0001	2	2	80	6920	-258	50

Table 3. Summary of Maximum Onshore Concentration Locations (Case 2)								
Onshore Peak Impacts		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m^3	in µg/m^3	in µg/m^3	in µg/m^3	No.	(km)	(km)
NOx	1-hour	14	53	67	188	6237	-278	18
NOx	Annual	0.014	2	2	100	6920	-258	50
PM10	24-hour	2.8	57	60	150	6498	-282	30
PM2.5	24-hour	2.8	18	21	35	6498	-282	30
PM2.5	Annual	0.008	2	2	12	6920	-258	50
CO	1-hour	9	1145	1154	40000	6846	-230	46
CO	8-hour	5	1145	1150	10000	7064	-206	58
SO2	1-hour	0.1	16	16	196	6846	-230	46
SO2	3-hour	0.1	13	13	1300	6922	-222	50
SO2	24-hour	0.03	5	5	365	6923	-218	50
SO2	Annual	0.0001	2	2	80	6920	-258	50

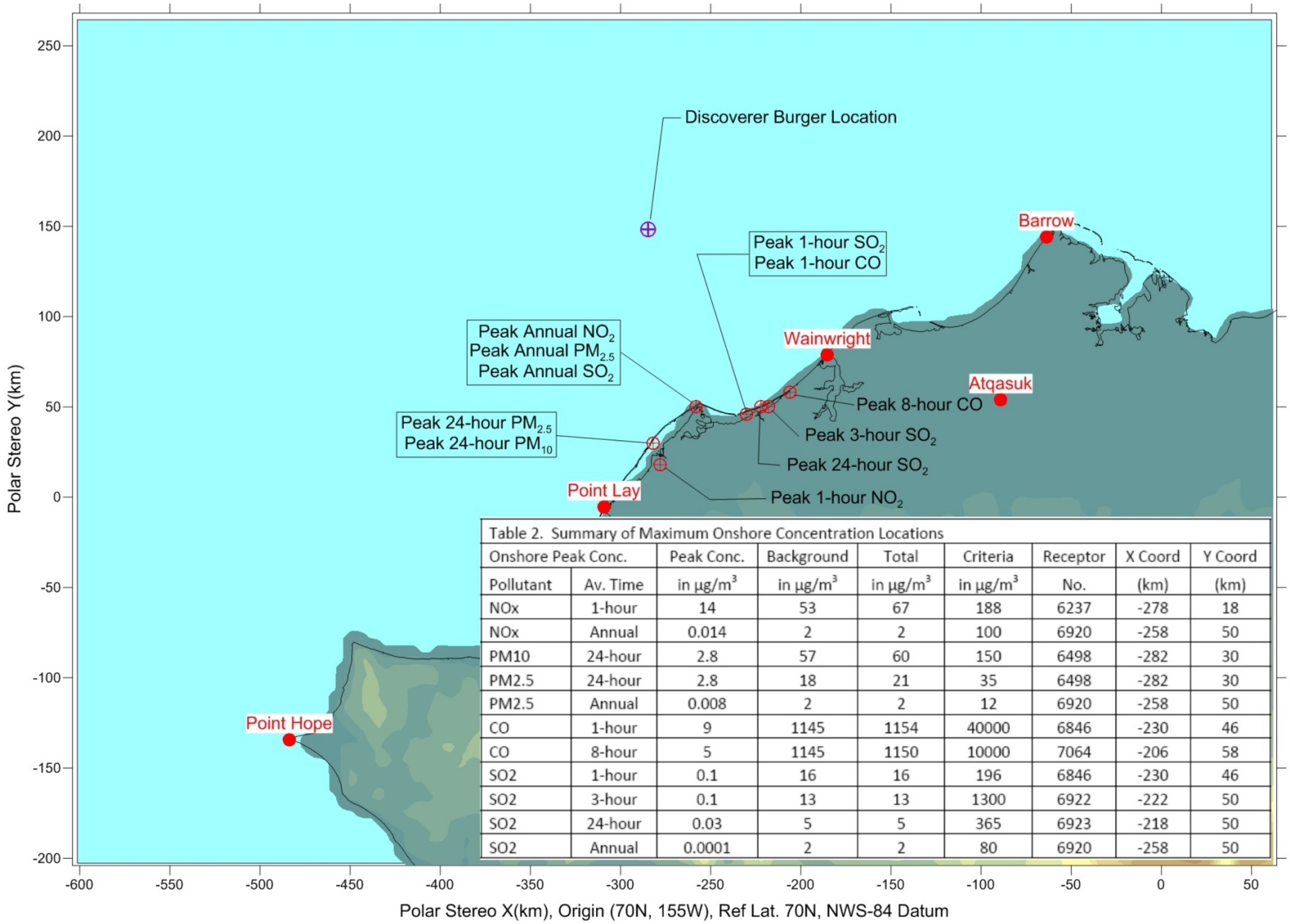


Table 2. Summary of Maximum Onshore Concentration Locations

Onshore Peak Conc.		Peak Conc.	Background	Total	Criteria	Receptor	X Coord	Y Coord
Pollutant	Av. Time	in µg/m³	in µg/m³	in µg/m³	in µg/m³	No.	(km)	(km)
NOx	1-hour	14	53	67	188	6237	-278	18
NOx	Annual	0.014	2	2	100	6920	-258	50
PM10	24-hour	2.8	57	60	150	6498	-282	30
PM2.5	24-hour	2.8	18	21	35	6498	-282	30
PM2.5	Annual	0.008	2	2	12	6920	-258	50
CO	1-hour	9	1145	1154	40000	6846	-230	46
CO	8-hour	5	1145	1150	10000	7064	-206	58
SO2	1-hour	0.1	16	16	196	6846	-230	46
SO2	3-hour	0.1	13	13	1300	6922	-222	50
SO2	24-hour	0.03	5	5	365	6923	-218	50
SO2	Annual	0.0001	2	2	80	6920	-258	50

Figure 2. Locations of Maximum Onshore Concentrations (Case 2 Results)

Attachment A: Emission Inventory Tables

Discoverer OCS Source - Hourly Maximum NEPA Emissions for each source group

		NOx_pph	PM_pph	CO_pph	VOC_pph	Pb_pph	SO2_pph
		NO_X lb/hr	PM lb/hr	CO lb/hr	VOC lb/hr	Pb lb/hr	SO_2 lb/hr
	Discoverer						
D_GEN	Generation	39.63	1.17	9.32	3.50	1.4E-3	0.53
D_P	Propulsion	82.29	2.29	57.14	14.86	1.4E-3	0.52
D_SE	Small IC engines	12.25	0.45	11.13	2.90	2.7E-4	0.10
D_SU	Seldom-Used IC engines	6.43	0.18	4.47	1.16	1.1E-4	0.04
D_B	Boilers	2.53	0.03	0.29	0.01	1.4E-4	0.17
D_I	Incinerator	0.44	0.95	1.49	0.06	2.9E-2	0.48
	SUBTOTAL	*143.57*	*5.06*	*83.85*	*22.48*	*3.3E-2*	*1.84*
	Ice Management & Anchor Handling (4 vessels)						
IB_P&G	Propulsion & Generation	384.19	22.19	83.22	180.31	1.7E-2	6.29
IB_H&B	Boilers	3.19	0.08	0.04	0.06	2.1E-4	0.25
IB_I	Incinerator	1.26	3.62	4.35	0.88	6.2E-2	1.01
	SUBTOTAL	*388.64*	*25.89*	*87.61*	*181.24*	*8.0E-2*	*7.55*
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
OSR_P&G	All IC Engines (non-emergency)	233.26	6.48	161.99	42.12	4.0E-3	1.47
	SUBTOTAL	*233.26*	*6.48*	*161.99*	*42.12*	*4.0E-3*	*1.47*
	Offshore Supply (2 vessels)						
OSV_P&G	All IC Engines (non-emergency)	146.42	4.07	101.68	26.44	2.5E-3	0.92
	SUBTOTAL	*146.42*	*4.07*	*101.68*	*26.44*	*2.5E-3*	*0.92*
	Science Vessel						
RV_P&G	All IC Engines (non-emergency)	66.32	1.84	46.06	11.98	1.1E-3	0.42
	SUBTOTAL	*66.32*	*1.84*	*46.06*	*11.98*	*1.1E-3*	*0.42*
	Arctic Oil Storage Tanker						
T_P&G	All IC Engines (non-emergency)	103.78	2.88	72.07	18.74	1.8E-3	0.65
	SUBTOTAL	*103.78*	*2.88*	*72.07*	*18.74*	*1.8E-3*	*0.65*
	On-shore Support						
Heli	Helicopter	0.20	0.04	1.25	1.50	-	0.06
ManCamp_G	Man Camp Generators	7.73	0.36	6.30	2.34	-	0.08
Bldg	Hangar/Storage Building Boiler	0.49	0.04	0.41	0.02	2.5E-6	0.05
Veh	Vehicles	7.9E-3	7.9E-4	0.29	7.7E-3	-	1.6E-3
	SUBTOTAL	*8.43*	*0.43*	*8.25*	*3.86*	*2.5E-6*	*0.19*
	TOTAL	**1,090**	**47**	**562**	**307**	**1.2E-1**	**13**

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: S. Pryor		
AIR SCIENCES INC. DENVER • PORTLAND	PROJECT NO: 180-23-1	PAGE: 2	OF: 2	SHEET: 1
ENGINEERING CALCULATIONS	SUBJECT: NEPA Mass Emission Summary	DATE: December 20, 2013		

Discoverer OCS Source - Seasonal Maximum NEPA Emissions for each source group

	NOx_tps	PM_tps	CO_tps	VOC_tps	Pb_tps	SO2_tps
	NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	Pb ton/season	SO_2 ton/season
Discoverer						
Generation	45.66	1.34	10.74	4.03	1.7E-3	0.61
Propulsion	1.97	0.05	1.37	0.36	3.4E-5	0.01
Small IC engines	17.64	0.64	16.03	4.17	4.0E-4	0.15
Seldom-Used IC engines	0.06	1.5E-3	0.04	0.01	9.5E-7	3.5E-4
Boilers	1.82	0.02	0.21	0.01	1.0E-4	0.12
Incinerator	0.64	1.37	2.15	0.08	4.2E-2	0.69
SUBTOTAL	*67.78*	*3.44*	*30.54*	*8.65*	*4.5E-2*	*1.58*
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	154.88	8.95	33.55	72.69	6.9E-3	2.54
Boilers	1.27	0.03	0.02	0.02	8.2E-5	0.10
Incinerator	1.26	3.62	4.35	0.88	6.2E-2	1.01
SUBTOTAL	*157.40*	*12.60*	*37.91*	*73.59*	*6.9E-2*	*3.65*
Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
All IC Engines (non-emergency)	107.12	2.98	74.39	19.34	1.8E-3	0.68
SUBTOTAL	*107.12*	*2.98*	*74.39*	*19.34*	*1.8E-3*	*0.68*
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	131.39	3.65	91.25	23.72	2.3E-3	0.83
SUBTOTAL	*131.39*	*3.65*	*91.25*	*23.72*	*2.3E-3*	*0.83*
Science Vessel						
All IC Engines (non-emergency)	66.86	1.86	46.43	12.07	1.1E-3	0.42
SUBTOTAL	*66.86*	*1.86*	*46.43*	*12.07*	*1.1E-3*	*0.42*
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	46.38	1.29	32.21	8.38	7.9E-4	0.29
SUBTOTAL	*46.38*	*1.29*	*32.21*	*8.38*	*7.9E-4*	*0.29*
On-shore Support						
Helicopter	0.28	0.05	1.80	2.16	-	0.08
Man Camp Generators	12.76	0.64	11.16	4.15	-	0.14
Hangar/Storage Building Boiler	0.35	0.03	4.88	0.01	1.8E-6	0.04
Vehicles	1.2E-2	1.2E-3	0.42	1.1E-2	-	0.00
SUBTOTAL	*13.41*	*0.72*	*18.27*	*6.33*	*1.8E-6*	*0.27*
TOTAL	**590**	**27**	**331**	**152**	**1.2E-1**	**8**

Seasonal Pollutant Total

NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	Pb ton/season	SO_2 ton/season	CO_2e ton/season
590	27	331	152	1.2E-1	8	92,961

Revised/New

OPERATING ASSUMPTIONS

ACTIVITY LEVELS

1 2 3 4 5 6 7 8 9 10

	Emission Units	capacity		hourly max load % of capacity	per season max load % of capacity	days/season	Load Comments
	Discoverer						
D_GE	Generation	6,609	kW	80%	64%	120	Season: 15% use for 1/4 and 80% for 3/4 = 64%
D_P	Propulsion	6,480	kW	80%	80%	2	Season: max use of Propulsion is estimated for 2 days
D_SE	Small IC engines	1,763	kW	57%	57%	120	Season: emissions represented by generation (no Cementing)
D_SU	Seldom-Used IC engines	645	kW	63%	63%	0.7	Hour: eGen only operating at 80% capacity, Season: 1 hr/wk
D_B	Boilers	16	MMBtu/hr	100%	50%	120	Season: expected max use of Boilers is 50%
D_I	Incinerator	276	lb/hr	100%	100%	120	no operational restrictions preventing 100% use
	Auxiliary Support - within 25 nm						
	Ice Management & Anchor Handling (4 vessels)						
IB_P&	Propulsion & Generation	78,640	kW	80%	22%	120	Season: calculations and assumptions available on Support Vessels Sheet
IB_H&	Boilers	23	MMBtu/hr	100%	28%	120	Season: calculations and assumptions available on Support Vessels Sheet
IB_I	Incinerator	584	lb/hr	100%	69%	120	Season: calculations and assumptions available on Support Vessels Sheet
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
OSR_I	All IC Engines (non-emergency)	18,369	kW	80%	26%	120	Season: calculations and assumptions available on Support Vessels Sheet
	Offshore Supply (2 vessels)						
OSV_	All IC Engines (non-emergency)	16,042	kW	58%	36%	120	Season: calculations and assumptions available on Support Vessels Sheet
	Science Vessel						
RV_P&	All IC Engines (non-emergency)	8,357	kW	50%	35%	120	Season: calculations and assumptions available on Support Vessels Shee
	Arctic Oil Storage Tanker						
FT_P&	All IC Engines (non-emergency)	20,611	kW	32%	10%	120	Season: calculations and assumptions available on Support Vessels Shee
	On-shore Support						
Heli	Helicopter	40	roundtrips per week			120	See Helicopter Sheet
ManCa	Man Camp Generators	1,396	kW	59%	51%	168	See Onshore Sheet, 2 Diesel fired Gens at 80%, 1 as back up operated 15 min/wk
Bldg	Hangar/Storage Building Boiler	5	MMBtu/hr	100%	50%	120	Natural Gas fired Boiler - heat input
Veh	Vehicles	200	gal/wk			123	Based on 3/4 ton diesel on-road truck, see Vehicle Sheet

ASSUMED AUXILIARY SUPPORT CANDIDATE VESSELS FOR EI	
Ice Management 1	Fennica
Ice Management 2	Nordica
Anchor Handler 1	Aiviq
Anchor Handler 2	Ross Chouest
Oil Spill Response Vessel	Nanuq
Oil Spill Response - Tug/Barge	Ocean Wave/Arctic Endeavour
Offshore Supply Vessel 1	Sisuaq
Offshore Supply Vessel 2	Supporter
Science vessel	Sisuaq or similar
Arctic Oil Storage Tanker	Affinity

ASSUMPTIONS			Reference
Diesel engine thermal efficiency	7,000	Btu/hp-hr	AP42 Table 3.3-1, 10/96
Diesel heating value	0.1312	MMBtu/gallon	Tesoro Nikiski, Email Royal Harris 4/20/11
Diesel density	7.00	lb/gal	Tesoro Nikiski, Email Royal Harris 4/20/11
Municipal solid waste HHV	9.95	MMBtu/short ton	Table C-1 to Subpart C of 40 CFR Part 98
Emission factors represent over 90% of the capacity power			

CONVERSIONS

1.34	hp/kW	2,000	lb/ton	32.07	wt S
0.7457	kW / hp	24	hr/day	64.06	wt. SO2
1,000,000	Btu/MMBtu	168	hr/wk	2.00	wt. conversion of S to SO2
453.592	g/lb	2.2	lb/kg	0.608	lb/hp-hr to kg/kW-hr
17.1	wk/season	1000	g/kg		

blue values are input, black values are calculated or linked

1 2 3 NOx_pph NOx_tps PM_pph PM_tps CO_pph CO_tps VOC_pph VOC_tps Pb_pph Pb_tps

EMISSIONS

		NOx		PM		CO		VOC		Pb	
	Emission Units	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**
	Discoverer										
D_Gl	Generation	40	46	1	1	9	11	3	4	1E-3	2E-3
D_P	Propulsion	82	2	2	5E-2	57	1	15	4E-1	1E-3	3E-5
D_SI	Small IC engines	12	18	4E-1	6E-1	11	16	3	4	3E-4	4E-4
D_St	Seldom-Used IC engines	6	6E-2	2E-1	2E-3	4	4E-2	1	1E-2	1E-4	9E-7
D_B	Boilers	3	2	3E-2	2E-2	3E-1	2E-1	1E-2	7E-3	1E-4	1E-4
D_I	Incinerator	4E-1	6E-1	1E+0	1	1	2	6E-2	8E-2	3E-2	4E-2
	SUBTOTAL	144	68	5	3	84	31	22	9	3E-2	4E-2
	Auxiliary Support - within 25 nm										
	Ice Management & Anchor Handling (4 vessels)										
IB_P	Propulsion & Generation	384	155	22	9	83	34	180	73	2E-2	7E-3
IB_H	Boilers	3	1	8E-2	3E-2	4E-2	2E-2	6E-2	2E-2	2E-4	8E-5
IB_I	Incinerator	1	1	4	4	4	4	9E-1	9E-1	6E-2	6E-2
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)										
OSR	All IC Engines (non-emergency)	233	107	6	3	162	74	42	19	4E-3	2E-3
	Offshore Supply (2 vessels)										
OSV	All IC Engines (non-emergency)	146	131	4	4	102	91	26	24	3E-3	2E-3
	Science Vessel										
RV_I	All IC Engines (non-emergency)	66	67	2	2	46	46	12	12	1E-3	1E-3
	Arctic Oil Storage Tanker										
FT_F	All IC Engines (non-emergency)	104	46	3	1	72	32	19	8	2E-3	8E-4
	SUBTOTAL	938	509	41	22	469	282	281	137	9E-2	8E-2
	On-shore Support										
Heli	Helicopter	2E-1	3E-1	4E-2	5E-2	1	2	1	2	-	-
ManC	Man Camp Generators	8	13	4E-1	6E-1	6	11	2	4	-	-
Bldg	Hangar/Storage Building Boiler	5E-1	4E-1	4E-2	3E-2	4E-1	5	2E-2	1E-2	2E-6	2E-6
Veh	Vehicles	8E-3	1E-2	8E-4	1E-3	3E-1	4E-1	8E-3	1E-2	-	-
	SUBTOTAL	8	13	4E-1	7E-1	8	18	4	6	2E-6	2E-6
	TOTAL	1,090	590	47	27	562	331	307	152	1E-1	1E-1

1 2 3 SO2_pph SO2_tps GHG_pph GHG_tps

EMISSIONS continued

	Emission Units	SO_2 lb/hr	SO_2 ton/season	GHG lb/hr	GHG ton/season
	Discoverer				
D_GEN	Generation	5E-1	6E-1	8,097	9,327
D_P	Propulsion	5E-1	1E-2	7,939	191
D_SE	Small IC engines	1E-1	1E-1	1,547	2,228
D_SU	Seldom-Used IC engines	4E-2	3E-4	621	5
D_B	Boilers	2E-1	1E-1	2,602	1,874
D_I	Incinerator	5E-1	7E-1	280	403
	SUBTOTAL	2	2	21,085	14,028
	Auxiliary Support - within 25 nm				
	Ice Management & Anchor Handling (4 vessels)				
IB_P&G	Propulsion & Generation	6	3	96,341	38,838
IB_H&B	Boilers	2E-1	1E-1	3,756	1,493
IB_I	Incinerator	1	1	592	592
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)				
OSR_P&	All IC Engines (non-emergency)	1	7E-1	22,504	10,334
	Offshore Supply (2 vessels)				
OSV_P&	All IC Engines (non-emergency)	9E-1	8E-1	14,126	12,676
	Science Vessel				
RV_P&(	All IC Engines (non-emergency)	4E-1	4E-1	6,399	6,450
	Arctic Oil Storage Tanker				
FT_P&G	All IC Engines (non-emergency)	7E-1	3E-1	10,012	4,475
	SUBTOTAL	11	6	153,730	74,858
	On-shore Support*				
Heli	Helicopter	6E-2	8E-2	858	1,236
ManCam	Man Camp Generators	8E-2	1E-1	1,251	2,214
Bldg	Hangar/Storage Building Boiler	5E-2	4E-2	816	588
Veh	Vehicles	2E-3	2E-3	25	37
	SUBTOTAL	2E-1	3E-1	2,950	4,075
	TOTAL	13	8	177,765	92,961

SO_2 EMISSIONS

		ton/season
Combustion Sources	SO_2	6
Incineration	SO_2	2
TOTAL		8

GHG EMISSIONS

		ton/season
Combustion Sources	CO_2	91,657
Combustion Sources	CH_4	4
Combustion Sources	N_2O	7E-1
Incineration	CO_2	974
Incineration	CH_4	3E-1
Incineration	N_2O	5E-2
All Sources	CO_2e	92,961

1 Fuel_gph Fuel_gpd Fuel_gps Waste_pph Waste_ppd Waste_pps

FUEL & WASTE CONSUMPTION

	Emission Units	**Capacity Values**		**MMBtu/hr**	**FUEL** gal/hr	gal/day	gal/season	**WASTE** lb/hr	lb/day	lb/season
	Discoverer									
D_GE	Generation	6,609	kW	62	378	9,073	871,045			
D_P	Propulsion	6,480	kW	61	371	8,896	17,793			
D_SE	Small IC engines	1,763	kW	17	72	1,734	208,024			
D_SU	Seldom-Used IC engines	645	kW	6	29	696	497			
D_B	Boilers	16	MMBtu/hr	16	122	2,916	174,978			
D_I	Incinerator	276	lb/hr					276	6,624	794,880
	SUBTOTAL				971	23,315	1,272,336	276	6,624	794,880
	Auxiliary Support - within 25 nm									
	Ice Management & Anchor Handling (4 vessels)									
IB_P&	Propulsion & Generation	78,640	kW	738	4,498	107,964	3,626,903			
IB_H&	Boilers	23	MMBtu/hr	23	175	4,209	139,432			
IB_I	Incinerator	584	lb/hr					584	14,016	1,168,000
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)									
OSR_I	All IC Engines (non-emergency)	18,369	kW	172	1,051	25,219	965,090			
	Offshore Supply (2 vessels)									
OSV_	All IC Engines (non-emergency)	16,042	kW	150	660	15,830	1,183,778			
	Science Vessel									
RV_P&	All IC Engines (non-emergency)	8,357	kW	78	299	7,171	602,329			
	Arctic Oil Storage Tanker									
FT_P&	All IC Engines (non-emergency)	20,611	kW	193	467	11,220	417,902			
	SUBTOTAL				7,150	171,612	6,935,433	584	14,016	1,168,000
	On-shore Support*									
Heli	Helicopter			5	40	962	115,404			
ManC	Man Camp Generators	1,396	kW	7	58	1,231	206,799			
Bldg	Hangar/Storage Building Boiler			5	38	915	54,886			
Veh	Vehicles			0.2	1	28	3,429			
	SUBTOTAL				138	3,135	380,518			
	TOTAL				8,260	198,062	8,588,288	860	20,640	1,962,880

*gallon measurements are in diesel equivalen

EMISSION FACTORS

NO_X EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D	Discoverer Generation	NO_X	3.4	g/kW-hr	0.10	lb/gal	5 engines SCR controlled, 1 engine uncontrolled due to start-up/variable loads[a]
D	Discoverer Propulsion	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Small IC engines	NO_X	5.5	g/kW-hr	0.17	lb/gal	Average value from source testing, performed 3/28/2012-5/14/2012
D	Discoverer Seldom-Used IC engines	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Boilers	NO_X	20.80	lbs/k-gal	2.1E-2	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D	Discoverer Incinerator	NO_X	3.20	lb/ton	1.6E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	NO_X	2.77	g/kW-hr	8.5E-2	lb/gal	Weighted based on vessel capacities, source test data and AP-42[b]
IB	IM/AH Boiler	NO_X	18.2	lbs/k-gal	1.8E-2	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	NO_X	4.3	lb/ton	2.2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
O	OSR Propulsion & Generation	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
O	Offshore Supply P & G	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
R	Science Vessel Propulsion & Generation	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
F	Arctic Oil Storage Tanker	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
	[a] Discoverer Generation	NO_X					
			1 engine uncontrolled at		5.9	g/kW-hr	Caterpillar 3512 Vendor Data
			5 engines controlled at		3.0	g/kW-hr	SCR Controlled with 50% reduction efficiency
	SCR NOx reduction efficiency	50%					Estimate
	[b] IM/AH Propulsion & Generation				P&G Capacity		
	Fennica	NO_X	0.57	g/kW-hr	21,530	kW	SCR controlled source test value, performed 4/13-4/27/2012
	Nordica	NO_X	0.45	g/kW-hr	21,530	kW	SCR controlled source test value, performed 4/23-4/26/2012
	Aiviq	NO_X	0.57	g/kW-hr	23,051	kW	SCR controlled source test value, performed 4/25-5/9/2012
	Ross Chouest	NO_X	14.59	g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, NOx Uncontrolled, diesel fuel 10/96
					78,640	kW	

PM EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D	Discoverer Generation	PM	0.10	g/kW-hr	3.1E-3	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
D	Discoverer Propulsion	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Small IC engines	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Seldom-Used IC engines	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Boilers	PM	0.28	lbs/k-gal	2.8E-4	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D	Discoverer Incinerator	PM	6.90	lb/ton	3.5E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	PM	0.16	g/kW-hr	4.9E-3	lb/gal	Weighted based on vessel capacities, source test data and AP-42[b]
IB	IM/AH Boiler	PM	0.46	lbs/k-gal	4.6E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	PM	12.4	lb/ton	6.2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
O	OSR Propulsion & Generation	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
O	Offshore Supply P & G	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
R	Science Vessel Propulsion & Generation	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
F	Arctic Oil Storage Tanker	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
	[a] Discoverer Generation	PM					
			1 engine uncontrolled at		0.16	g/kW-hr	Caterpillar 3512 Vendor Data
			5 engines controlled at		0.08	g/kW-hr	CDPF Controlled with 50% reduction efficiency
	CDPF PM reduction efficiency	50%					Estimate
	[b] IM/AH Propulsion & Generation				P&G Capacity		
	Fennica	PM	0.09	g/kW-hr	21,530	kW	OxyCat controlled source test value, performed 4/13-4/27/2012
	Nordica	PM	0.07	g/kW-hr	21,530	kW	OxyCat controlled source test value, performed 4/23-4/26/2012
	Aiviq	PM	0.16	g/kW-hr	23,051	kW	OxyCat controlled source test value, performed 4/25-5/9/2012
	Ross Chouest	PM	0.43	g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, PM, diesel fuel, 10/96
					78,640	kW	

EMISSION FACTORS, cont'd

CO EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D	Discoverer Generation	CO	0.80	g/kW-hr	2.5E-2	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
D	Discoverer Propulsion	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Small IC engines	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Seldom-Used IC engines	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D	Discoverer Boilers	CO	2.4	lbs/k-gal	2.4E-3	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D	Discoverer Incinerator	CO	10.80	lb/ton	5.4E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	CO	0.60	g/kW-hr	1.8E-2	lb/gal	Weighted based on vessel capacities, source test data and AP-42[b]
IB	IM/AH Boiler	CO	0.23	lbs/k-gal	2.3E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	CO	14.9	lb/ton	7.5E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OS	OSR Propulsion & Generation	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
OS	Offshore Supply P & G	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
RV	Science Vessel Propulsion & Generation	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
FT	Arctic Oil Storage Tanker	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2

[a] Discoverer Generation	CO				
		1 engine uncontrolled at	1.30	g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at	0.65	g/kW-hr	CDPF Controlled with 50% reduction efficiency
CDPF CO reduction efficiency	50%				Estimate
[b] IM/AH Propulsion & Generation			P&G Capacity		
Fennica	CO	0.08 g/kW-hr	21,530	kW	OxyCat controlled source test value, performed 4/13-4/27/2012
Nordica	CO	0.05 g/kW-hr	21,530	kW	OxyCat controlled source test value, performed 4/23-4/26/2012
Aiviq	CO	0.12 g/kW-hr	23,051	kW	OxyCat controlled source test value, performed 4/25-5/9/2012
Ross Chouest	CO	3.34 g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, CO, diesel fuel, 10/96
			78,640	kW	

VOC EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D	Discoverer Generation	VOC	0.30	g/kW-hr	9.2E-3	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
D	Discoverer Propulsion	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D	Discoverer Small IC engines	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D	Discoverer Seldom-Used IC engines	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D	Discoverer Boilers	VOC	8.5E-2	lbs/k-gal	8.5E-5	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D	Discoverer Incinerator	VOC	0.4	lb/ton	2.0E-4	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
IB	IM/AH Boiler	VOC	0.34	lbs/k-gal	3.4E-4	lb/gal	EPA AP-42, Table 1.3-3 ver. 5-10, Commercial Boilers - Distillate Oil.
IB	IM/AH Incineration	VOC	3	lb/ton	1.5E-3	lb/lb	EPA AP-42, Table 2.1-12, Refuse Combustor, Industrial/commercial, multiple chamber
OS	OSR Propulsion & Generation	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
OS	Offshore Supply P & G	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
RV	Science Vessel Propulsion & Generation	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
FT	Arctic Oil Storage Tanker	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)

[a] Discoverer Generation	VOC				
		1 engine uncontrolled at	0.45	g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at	0.23	g/kW-hr	CDPF Controlled with 50% reduction efficiency
CDPF VOC reduction efficiency	50%				Estimate
~~[b] IM/AH CDPF VOC reduction efficiency~~		~~70%~~	~~OxyCat control eff for VOCs based on Kulluk Statement of Basis for use of CDPFs (Sec. 2.3)~~		

GHG EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference	Multiplier
Combustion Sources	CO_2	73.96	kg/MMBtu	21.3	lb/gal	40 CFR Part 98, Subpart C, Table C-1 (Distillate Fuel Oil No. 2)	1
Combustion Sources	CH_4	3.0E-3	kg/MMBtu	8.7E-4	lb/gal	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum)	21
Combustion Sources	N_2O	6.0E-4	kg/MMBtu	1.7E-4	lb/gal	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum)	310
Incineration	CO_2	90.7	kg/MMBtu	1.0	lb/lb	40 CFR Part 98, Subpart C, Table C-1 (Municipal Solid Waste)	1
Incineration	CH_4	3.2E-2	kg/MMBtu	3.5E-4	lb/lb	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Wa	21
Incineration	N_2O	4.2E-3	kg/MMBtu	4.6E-5	lb/lb	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Wa	310

SO_2 EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Combustion Sources	SO_2	100	ppm S	1.4E-3	lb/gal	Stoichiometric Calculation
Incineration	SO_2	3.46	lb/ton	1.7E-3	lb/lb	EPA, AP42, Table 2.1-2, EF for Modular Excess Air Combustors, uncontrolled, 10/96

Pb EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit
Internal Combustion Engines	Pb	2.9E-5	lb/MMBtu	3.8E-6	lb/gal
Heaters & Boilers	Pb	9	lb/10^{12} Btu	1.2E-6	lb/gal
Incineration	Pb	0.213	lb/ton	1.1E-4	lb/lb

Source	Reference
Internal Combustion Engines	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5.2.2, Distillate oil-fired gas turbines.
Heaters & Boilers	AP42, Table 1.3-10. Emission Factors For Trace Elements From Distillate Fuel Oil Combustion Sources.
Incineration	EPA, AP42, Table 2.1-2, EF for Modular Excess Air Combustors, uncontrolled

Air Sciences Inc. ENGINEERING CALCULATIONS	PROJECT TITLE: Shell OCS Alaska	BY: S. Pryor		
	PROJECT NO: 180-23-1	PAGE: 1	OF: 1	SHEET: 1
	SUBJECT: AQRP Mass Emission Summary	DATE: December 20, 2013		

Discoverer OCS Source - Seasonal AQRP Emissions for each source group

		NOx_tps	PM_tps	CO_tps	VOC_tps	SO2_tps
		NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season
	Discoverer					
D_GEN	Generation	123.79	3.36	27.28	9.44	0.95
D_P	Propulsion	2.47	0.07	1.71	0.45	0.02
D_SE	Small IC engines	30.78	1.12	27.98	7.27	0.25
D_SU	Seldom-Used IC engines	14.74	0.41	10.24	2.66	0.09
D_B	Boilers	3.64	0.05	0.42	0.01	0.24
D_I	Incinerator	0.64	1.37	2.15	0.08	0.69
	SUBTOTAL	*176.05*	*6.37*	*69.77*	*19.92*	*2.25*
	Ice Management & Anchor Handling (4 vessels)					
IB_P&G	Propulsion & Generation	880.03	22.47	156.53	97.36	3.40
IB_H&B	Boilers	4.60	0.12	0.06	0.09	0.35
IB_I	Incinerator	1.81	5.21	6.27	1.26	1.45
	SUBTOTAL	*886.43*	*27.80*	*162.86*	*98.71*	*5.21*
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)					
OSR_P&G	All IC Engines (non-emergency)	251.92	7.00	174.94	45.49	1.59
	SUBTOTAL	*251.92*	*7.00*	*174.94*	*45.49*	*1.59*
	Offshore Supply (2 vessels)					
OSV_P&G	All IC Engines (non-emergency)	366.68	10.19	254.64	66.21	2.31
	SUBTOTAL	*366.68*	*10.19*	*254.64*	*66.21*	*2.31*
	Science Vessel					
RV_P&G	All IC Engines (non-emergency)	191.02	5.31	132.65	34.49	1.20
	SUBTOTAL	*191.02*	*5.31*	*132.65*	*34.49*	*1.20*
	Arctic Oil Storage Tanker					
FT_P&G	All IC Engines (non-emergency)	117.78	3.27	81.79	21.27	0.74
	SUBTOTAL	*117.78*	*3.27*	*81.79*	*21.27*	*0.74*
	TOTAL	**1,990**	**60**	**877**	**286**	**13**
	PROJECT DURATION TOTAL	**5,970**	**180**	**2,630**	**858**	**40**

Seasonal Pollutant Total

NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season
1,990	60	877	286	13

BOEM EXEMPTION FORMULA	30 CFR 550.303
	NOx ton/year
Discoverer Only	176
Discoverer & Auxiliary Support	1,990

Formula:

E=33.3D NOx, TSP, SO_2, VOC

MINIMUM DISTANCE BASED ON EMISSIONS	**Based on: NOx**
Drill Rig Only	5.3 statute miles
Drill Rig & Auxiliary Support	59.8 statute miles

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: S. Pryor		
AIR SCIENCES INC. DENVER • PORTLAND	PROJECT NO: 180-23-1	PAGE: 1	OF: 5	SHEET: 2
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Chukchi Project-AQRP Inventory	DATE: December 20, 2013		

FOR AQRP ANALYSIS ONLY

Revised/New

OPERATING ASSUMPTIONS

ACTIVITY LEVELS

1 2 3 4 5 6 7 1

	Emission Units to permit	capacity		hourly max load % of capacity	per season max load % of capacity	days/season	Load Comments
	Discoverer						
D_GE	Generation	6,609	kW	80%	100%	120	
D_P	Propulsion	6,480	kW	80%	100%	2	Season: max use of Propulsion is estimated for 2 days
D_SE	Small IC engines	1,763	kW	80%	100%	120	
D_SU	Seldom-Used IC engines	645	kW	80%	100%	120	
D_B	Boilers	16	MMBtu/hr	100%	100%	120	
D_I	Incinerator	276	lb/hr	100%	100%	120	
	Auxiliary Support - within 25 nm						
	Ice Management & Anchor Handling (4 vessels)						
IB_P&	Propulsion & Generation	78,640	kW	80%	30%	120	
IB_H&	Boilers	23	MMBtu/hr	100%	100%	120	
IB_I	Incinerator	584	lb/hr	100%	100%	120	
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
OSR_I	All IC Engines (non-emergency)	18,369	kW	80%	60%	120	
	Offshore Supply (2 vessels)						
OSV_	All IC Engines (non-emergency)	16,042	kW	80%	100%	120	
	Science Vessel						
RV_P	All IC Engines (non-emergency)	8,357	kW	80%	100%	120	
	Arctic Oil Storage Tanker						
FT_P&	All IC Engines (non-emergency)	20,611	kW	80%	25%	120	

ASSUMED AUXILIARY SUPPORT CANDIDATE VESSELS FOR EI

Ice Management 1	Fennica
Ice Management 2	Nordica
Anchor Handler 1	Aiviq
Anchor Handler 2	Ross Chouest
Oil Spill Response Vesse	Nanuq
Oil Spill Response - Tug/Barge	Ocean Wave/Arctic Endeavour
Offshore Supply Vessel 1	Sisuaq
Offshore Supply Vessel 2	Supporter
Science vessel	Sisuaq or similar
Arctic Oil Storage Tanker	Affinity

ASSUMPTIONS			Reference
Diesel engine thermal efficiency	7,000	Btu/hp-hr	AP42 Table 3.3-1, 10/96
Diesel heating value	0.1312	MMBtu/gallon	Tesoro Nikiski, Email Royal Harris 4/20/11
Diesel density	7.00	lb/gal	Tesoro Nikiski, Email Royal Harris 4/20/11
Municipal solid waste HHV	9.95	MMBtu/short ton	Table C-1 to Subpart C of 40 CFR Part 98
Emission factors represent over 90% of the capacity power			

CONVERSIONS

1.34	hp/kW	2,000	lb/ton	32.07	wt S
0.7457	kW / hp	24	hr/day	64.06	wt. SO2
1,000,000	Btu/MMBtu	168	hr/wk	2.00	wt. conversion of S to SO2
453.592	g/lb	2.2	lb/kg	0.608	lb/hp-hr to kg/kW-hr
17.1	wk/season	1000	g/kg		

blue values are input, black values are calculated or linked

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: S. Pryor		
AIR SCIENCES INC.	PROJECT NO: 180-23-1	PAGE: 2	OF: 5	SHEET: 2
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Chukchi Project-AQRP Inventory	DATE: December 20, 2013		

EMISSIONS

1	2	3 NOx_pph	NOx_tps	PM_pph	PM_tps	CO_pph	CO_tps	VOC_pph	VOC_tps	SO2_pph	SO2_tps
		NOx		PM		CO		VOC		SO_2	
	Emission Units	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**
	Discoverer										
D_G	Generation	69	124	2	3	15	27	5	9	5E-1	1E+0
D_P	Propulsion	82	2	2	7E-2	57	2	15	4E-1	5E-1	2E-2
D_SI	Small IC engines	17	31	6E-1	1	16	28	4	7	1E-1	3E-1
D_SI	Seldom-Used IC engines	8	15	2E-1	4E-1	6	10	1	3	5E-2	9E-2
D_B	Boilers	3	4	3E-2	5E-2	3E-1	4E-1	1E-2	1E-2	2E-1	2E-1
D_I	Incinerator	4E-1	6E-1	1E+0	1	1	2	6E-2	8E-2	5E-1	7E-1
	SUBTOTAL	179	176	6	6	95	70	26	20	2	2
	Auxiliary Support - within 25 nm										
	Ice Management & Anchor Handling (4 vessels)										
IB_P	Propulsion & Generation	1,630	880	42	22	290	157	180	97	6	3
IB_H	Boilers	3	5	8E-2	1E-1	4E-2	6E-2	6E-2	9E-2	2E-1	4E-1
IB_I	Incinerator	1	2	4	5	4	6	9E-1	1	1	1
	Oil Spill Response (Vessel, Tug & Barge, 3 WB)										
OSR	All IC Engines (non-emergency)	233	252	6	7	162	175	42	45	1	2
	Offshore Supply (2 vessels)										
OSV	All IC Engines (non-emergency)	204	367	6	10	141	255	37	66	1	2
	Science Vessel										
RV_I	All IC Engines (non-emergency)	106	191	3	5	74	133	19	34	7E-1	1
	Arctic Oil Storage Tanker										
FT_P	All IC Engines (non-emergency)	262	118	7	3	182	82	47	21	2	7E-1
	SUBTOTAL	2,439	1,814	68	54	853	807	327	266	13	11
	TOTAL	2,618	1,990	74	60	948	877	352	286	15	13
	PROJECT DURATION TOTAL	7,855	5,970	221	180	2,845	2,630	1,057	858	44	40

BOEM EXEMPTION FORMULA

MINIMUM DISTANCE BASED ON EMISSIONS 30 CFR 550.303

	Based on: NOx	
Drill Rig Only	5.3	statute miles
Drill Rig & Auxiliary Suppor	59.8	statute miles

1

FUEL & WASTE CONSUMPTION

					FUEL			WASTE	
Emission Units	**Capacity Values**		**MMBtu/hr**	**gal/hr**	**gal/day**	**gal/season**	**lb/hr**	**lb/day**	**lb/season**
Discoverer									
D_GE Generation	6,609	kW	62	378	9,073	1,361,007			
D_P Propulsion	6,480	kW	61	371	8,896	22,241			
D_SE Small IC engines	1,763	kW	17	101	2,420	362,997			
D_SU Seldom-Used IC engines	645	kW	6	37	886	132,834			
D_B Boilers	16	MMBtu/hr	16	122	2,916	349,956			
D_I Incinerator	276	lb/hr					276	6,624	794,880
SUBTOTAL				1,008	24,192	2,229,035	276	6,624	794,880
Auxiliary Support - within 25 nm									
Ice Management & Anchor Handling (4 vessels)									
IB_P& Propulsion & Generation	78,640	kW	738	4,498	107,964	4,858,363			
IB_H& Boilers	23	MMBtu/hr	23	175	4,209	505,113			
IB_I Incinerator	584	lb/hr					584	14,016	1,681,920
Oil Spill Response (Vessel, Tug & Barge, 3 WB)									
OSR_I All IC Engines (non-emergency)	18,369	kW	172	1,051	25,219	2,269,667			
Offshore Supply (2 vessels)									
OSV_ All IC Engines (non-emergency)	16,042	kW	150	918	22,024	3,303,566			
Science Vessel									
RV_P& All IC Engines (non-emergency)	8,357	kW	78	478	11,473	1,720,940			
Arctic Oil Storage Tanker									
FT_P& All IC Engines (non-emergency)	20,611	kW	193	1,179	28,297	1,061,126			
SUBTOTAL				8,299	199,185	13,718,774	584	14,016	1,681,920
TOTAL				9,307	223,376	15,947,809	860	20,640	2,476,800

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		PROJECT NO: 180-23-1	PAGE: 4	OF: 5	SHEET: 2
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NO_X EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D_	Discoverer Generation	NO_X	5.9	g/kW-hr	0.18	lb/gal	Caterpillar 3512 Vendor Data
D_	Discoverer Propulsion	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Small IC engines	NO_X	5.5	g/kW-hr	0.17	lb/gal	Average value from source testing, performed 3/28/2012-5/14/2012
D_	Discoverer Seldom-Used IC engines	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Boilers	NO_X	20.8	lbs/k-gal	2.1E-2	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D_	Discoverer Incinerator	NO_X	3.2	lb/ton	1.6E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	NO_X	11.75	g/kW-hr	0.36	lb/gal	Weighted based on vessel capacities, IMO Tier 2, EPA Marine Tier 2 and AP-42[a]
IB	IM/AH Boiler	NO_X	18.2	lbs/k-gal	1.8E-2	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	NO_X	4.3	lb/ton	2.2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OS	OSR Propulsion & Generation	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
OS	Offshore Supply P & G	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
RV	Science Vessel Propulsion & Generation	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
FT	Arctic Oil Storage Tanker	NO_X	7.2	g/kW-hr	0.22	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2

[a] IM/AH Propulsion & Generation				P&G Capacity		
Fennica	NO_X	12.0	g/kW-hr	21,530	kW	IMO Tier I at 750 rpm
Nordica	NO_X	12.0	g/kW-hr	21,530	kW	IMO Tier I at 750 rpm
Aiviq	NO_X	9.8	g/kW-hr	23,051	kW	EPA 40 CFR 94.8 Marine Category 2, Tier 2, 15 ≤ displacement < 20
Ross Chouest	NO_X	14.59	g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, NOx Uncontrolled, diesel fuel 10/96
				78,640	kW	

PM EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D_	Discoverer Generation	PM	0.16	g/kW-hr	0.00	lb/gal	Caterpillar 3512 Vendor Data
D_	Discoverer Propulsion	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Small IC engines	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Seldom-Used IC engines	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Boilers	PM	0.28	lbs/k-gal	2.8E-4	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D_	Discoverer Incinerator	PM	6.90	lb/ton	3.5E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	PM	0.30	g/kW-hr	0.01	lb/gal	Weighted based on vessel capacities, source test data, EPA Marine Tier 2 and AP-42[a]
IB	IM/AH Boiler	PM	0.46	lbs/k-gal	4.6E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	PM	12.40	lb/ton	6.2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OS	OSR Propulsion & Generation	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
OS	Offshore Supply P & G	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
RV	Science Vessel Propulsion & Generation	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
FT	Arctic Oil Storage Tanker	PM	0.20	g/kW-hr	6.2E-3	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2

[a] IM/AH Propulsion & Generation				P&G Capacity		
Fennica	PM	0.18	g/kW-hr	21,530	kW	Uncontrolled - assumed 50% control form OxyCat controlled EF
Nordica	PM	0.15	g/kW-hr	21,530	kW	Uncontrolled - assumed 50% control form OxyCat controlled EF
Aiviq	PM	0.50	g/kW-hr	23,051	kW	EPA 40 CFR 94.8 Marine Category 2, Tier 2, 15 ≤ displacement < 20
Ross Chouest	PM	0.43	g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, PM, diesel fuel, 10/96
				78,640	kW	
CDPF PM reduction efficiency	50%					Estimate

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CO EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D_	Discoverer Generation	CO	1.3	g/kW-hr	0.04	lb/gal	Caterpillar 3512 Vendor Data
D_	Discoverer Propulsion	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Small IC engines	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Seldom-Used IC engines	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
D_	Discoverer Boilers	CO	2.4	lbs/k-gal	2.4E-3	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D_	Discoverer Incinerator	CO	10.8	lb/ton	5.4E-3	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	CO	2.09	g/kW-hr	0.06	lb/gal	Weighted based on vessel capacities, source test data, EPA Marine Tier 2 and AP-42[a]
IB	IM/AH Boiler	CO	0.23	lbs/k-gal	2.3E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/21/2012 (2 vessels)
IB	IM/AH Incineration	CO	14.9	lb/ton	7.5E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OS	OSR Propulsion & Generation	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
OS	Offshore Supply P & G	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
RV	Science Vessel Propulsion & Generation	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
FT	Arctic Oil Storage Tanker	CO	5.0	g/kW-hr	0.15	lb/gal	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2

[a] IM/AH Propulsion & Generation				P&G Capacity		
Fennica	CO	0.16	g/kW-hr	21,530	kW	Uncontrolled - assumed 50% control form OxyCat controlled EF
Nordica	CO	0.16	g/kW-hr	21,530	kW	Uncontrolled - assumed 50% control form OxyCat controlled EF
Aiviq	CO	5.0	g/kW-hr	23,051	kW	EPA 40 CFR 94.8 Marine Category 2, Tier II, 15 ≤ displacement < 20
Ross Chouest	CO	3.34	g/kW-hr	12,529	kW	EPA, AP-42, Table 3.4-1, CO, diesel fuel, 10/96
				78,640	kW	
CDPF CO reduction efficiency	50%					Estimate

VOC EMISSION FACTORS

id	Source	Pollutant	EF	unit	EF	unit	Reference
D_	Discoverer Generation	VOC	0.45	g/kW-hr	0.01	lb/gal	Caterpillar 3512 Vendor Data
D_	Discoverer Propulsion	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D_	Discoverer Small IC engines	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D_	Discoverer Seldom-Used IC engines	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
D_	Discoverer Boilers	VOC	0.085	lbs/k-gal	8.5E-5	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
D_	Discoverer Incinerator	VOC	0.4	lb/ton	2.0E-4	lb/lb	Average value from source testing, performed 6/11/2012
IB	IM/AH Propulsion & Generation	VOC	1.3	g/kW-hr	0.04	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
IB	IM/AH Boiler	VOC	0.34	lbs/k-gal	3.4E-4	lb/gal	EPA AP-42, Table 1.3-3 ver. 5-10, Commercial Boilers - Distillate Oil
IB	IM/AH Incineration	VOC	3	lb/ton	1.5E-3	lb/lb	EPA AP-42, Table 2.1-12, Refuse Combustor, Industrial/commercial, multiple chambe
OS	OSR Propulsion & Generation	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
OS	Offshore Supply P & G	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
RV	Science Vessel Propulsion & Generation	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
FT	Arctic Oil Storage Tanker	VOC	1.3	g/kW-hr	4.0E-2	lb/gal	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)

SO_2 EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Combustion Sources	SO_2	100	ppm S	1.4E-3	lb/gal	Stoichiometric Calculation
Incineration	SO_2	3.46	lb/ton	1.7E-3	lb/lb	EPA, AP42, Table 2.1-2, EF for Modular Excess Air Combustors, uncontrolled, 10/96

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ENGINEERING CALCULATIONS	SUBJECT: Discoverer Rig Engine Specs	DATE: December 13, 2013		

Discoverer Sources

Unit ID	Description	Make/Model	Rating	Capacity	Maximum hrs/day	Maximum hrs/wk	Maximum Fuel Use MMBtu/hr	Maximum Fuel Use gal/hr	Maximum Fuel Use gal/day	Notes
D-1	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-2	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-3	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-4	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-5	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-6	Generator Engine	Caterpillar 3512C	1,476 hp	80%	24	168	8.27	63.0	1,512.2	
D-7	Propulsion Engine	STX-MAN/6S42MC7	6,480 kW	80%	24	48	48.63	370.7	8,896.3	1
D-8	Emergency Generator	Caterpillar 3412	679 hp	80%	2	2	3.80	29.0	58.0	2
D-12	HPU Engine	John Deere/JD6068HF485	243 hp	80%	24	168	1.36	10.4	249.0	3
D-13	HPU Engine	John Deere/JD6068HF485	243 hp	80%	24	168	1.36	10.4	249.0	
D-14	Port Deck Crane	Liebherr/D9508 A7	450 kW	80%	24	168	3.38	25.7	617.8	
D-15	Starbd Deck Crane	Liebherr/D9508 A7	450 kW	80%	24	168	3.38	25.7	617.8	
D-16	Cementing Unit	Detroit / 8V-71N	335 hp	80%	24	168	1.88	14.3	343.2	
D-17	Cementing Unit	Detroit / 8V-71N	335 hp	80%	24	168	1.88	14.3	343.2	
D-21	Heat Boiler	Clayton 200 Boiler	7.97 MMBtu/hr	100%	24	168	7.97	60.8	1,458.1	
D-22	Heat Boiler	Clayton 200 Boiler	7.97 MMBtu/hr	100%	24	168	7.97	60.8	1,458.1	
D-23	Incinerator	TeamTec/GS500C	276 lb/hr	100%	24	168	-	-	-	
Seldom Used										
D-LB-1	Lifeboat No. 1 Engine	Sabb	29 hp	100%	4	28	0.20	1.5	6.2	4
D-LB-2	Lifeboat No. 2 Engine	Sabb	29 hp	100%	4	28	0.20	1.5	6.2	4
D-LB-3	Lifeboat No. 3 Engine	Sabb	29 hp	100%	4	28	0.20	1.5	6.2	4
D-LB-4	Lifeboat No. 4 Engine	Sabb	29 hp	100%	4	28	0.20	1.5	6.2	4
1	Diver Engine		35 hp	100%	4	28	0.25	1.9	7.5	4
2	Diver Engine		35 hp	100%	4	28	0.25	1.9	7.5	4
							132.49	1,010.0	23,403.7	

Source Group	Current Group	Rounded Group	Capacity	hr/day	Maximum hrs/wk	Current gal/hr	Current gal/day	Notes
Generation	6,609 kW	6,700 kW	80%	24	168	378.1	9,073.4	
Propulsion	6,480 kW	6,500 kW	80%	24	48	370.7	8,896.3	1
Small IC Engines	1,763 kW	1,800 kW	57%	24	168	129.8	2,478.0	
non-Cementing IC	1,263 kW	1,300 kW						
Cementing IC	500 kW	500 kW						
Seldom-used IC Engines	645 kW	700 kW	100%	4	28	9.9	39.7	2, 3
Boilers	15.94 MMBtu/hr	16 MMBtu/hr	100%	24	168	121.5	2,916.3	
Incinerator	276 lb/hr	276 lb/hr	100%	24	168	-	-	
						1,010.0	23,403.7	

Notes

1 Propulsion engine used 2 days per season
2 Emergency Generator is tested for 2 hrs every 30 days.
3 D-9-11 MLC Air Compressors are excluded from EI as the current system does not require air compressors to function.
4 Seldom-used units are expected to run < 4 hour per week.

Assumptions	
7,000	Btu/hp-hr
0.13118	MMBtu/gallon

Conversions			
0.7457	kW / hp	453.592	g/lb
1.34	hp/kW		
1,000,000	btu/MMBtu		

blue values are input, black values are calculated or linked

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Discoverer Sources

Unit ID	Description	Make/Model	Rating		Engine Certification/ Vendor Guarantee	Spec Sheet Available
Generation						
D-1	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-2	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-3	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-4	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-5	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-6	Generator Engine	Caterpillar 3512C	1,476	hp	EPA TIER-2 2006	YES
D-7	Propulsion Engine	STX-MAN/6S42MC7	6,480	kW	IMO NOx Tier II	YES
Small IC Engine						
D-12	HPU Engine	John Deere/JD6068HF485	243	hp	EPA Tier 3	YES
D-13	HPU Engine	John Deere/JD6068HF485	243	hp	EPA Tier 3	YES
D-14	Port Deck Crane	Liebherr/D9508 A7	450	kW	US-EPA/CARB 40 CFR, Tier 3	YES
D-15	Starbd Deck Crane	Liebherr/D9508 A7	450	kW	US-EPA/CARB 40 CFR, Tier 3	YES
D-16	Cementing Unit	Detroit / 8V-71N	335	hp	Not Tier Regulated	YES
D-17	Cementing Unit	Detroit / 8V-71N	335	hp	Not Tier Regulated	YES
Heat Boilers						
D-21	Heat Boiler	Clayton 200 Boiler	7.97	MMBtu/hr	Low NOx - Low CO Fiber Metal Bu	YES
D-22	Heat Boiler	Clayton 200 Boiler	7.97	MMBtu/hr	Low NOx - Low CO Fiber Metal Bu	YES
D-23	Incinerator	TeamTec/GS500C	276	lb/hr	IMO MEPC 76(40)	YES
Seldom Used						
D-8	Emergency Generator	Caterpillar 3412	679	hp	Not on spec sheet	YES
D-LB-1	Lifeboat No. 1 Engine	Sabb	29	hp	No spec sheet	NO
D-LB-2	Lifeboat No. 2 Engine	Sabb	29	hp	No spec sheet	NO
D-LB-3	Lifeboat No. 3 Engine	Sabb	29	hp	No spec sheet	NO
D-LB-4	Lifeboat No. 4 Engine	Sabb	29	hp	No spec sheet	NO
1	Diver Engine		35	hp	No spec sheet	NO
2	Diver Engine		35	hp	No spec sheet	NO

CURRENT EMISSION FACTORS

Discoverer Generation	NO_X	3.4	g/kW-hr	5 engines SCR controlled, 1 engine uncontrolled due to start-up/variable loads [a]
Discoverer Propulsion	NO_X	7.2	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Small IC engines	NO_X	5.5	g/kW-hr	Average value from source testing, performed 3/28/2012-5/14/2012
Discoverer Seldom-Used IC engines	NO_X	7.2	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Boilers	NO_X	20.80	lbs/k-gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	NO_X	3.20	lb/ton	Average value from source testing, performed 6/11/2012
Discoverer Generation	PM	0.10	g/kW-hr	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads [a]
Discoverer Propulsion	PM	0.20	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Small IC engines	PM	0.20	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	PM	0.20	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Boilers	PM	0.28	lbs/k-gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	PM	6.90	lb/ton	Average value from source testing, performed 6/11/2012
Discoverer Generation	CO	0.80	g/kW-hr	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads [a]
Discoverer Propulsion	CO	5.0	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Small IC engines	CO	5.0	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	CO	5.0	g/kW-hr	40 CFR 94.8 Table A-1. Marine Category 1 - Tier 2
Discoverer Boilers	CO	2.4	lbs/k-gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	CO	10.80	lb/ton	Average value from source testing, performed 6/11/2012
Discoverer Generation	VOC	0.30	g/kW-hr	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads [a]
Discoverer Propulsion	VOC	1.3	g/kW-hr	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
Discoverer Small IC engines	VOC	1.3	g/kW-hr	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
Discoverer Seldom-Used IC engines	VOC	1.3	g/kW-hr	40 CFR 89.112 Table 1. EPA Nonroad CI engines (Tier 1)
Discoverer Boilers	VOC	8.5E-2	lbs/k-gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	VOC	0.4	lb/ton	Average value from source testing, performed 6/11/2012

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: S. Pryor		
AIR SCIENCES INC. DENVER • PORTLAND	PROJECT NO: 180-23-1	PAGE: 1	OF: 14	SHEET: 2
ENGINEERING CALCULATIONS	SUBJECT: Auxiliary Support Engine Specs	DATE: December 19, 2013		

Revised/New

Auxiliary Support Fleet Engine Usage Summary Table

Task	Vessel	Group	EU Category	EI Usage hourly	seasonal	days	Notes[1]
Ice Management 1	Fennica	IM/AH	Propulsion & Generation	80%	33%	120	2
	Fennica	IM/AH	Boilers	100%	50%	120	3
	Fennica	IM/AH	Incinerator	100%	100%	120	
Ice Management 2	Nordica	IM/AH	Propulsion & Generation	80%	7%	10	4
	Nordica	IM/AH	Boilers	100%	4%	10	5
	Nordica	IM/AH	Incinerator	100%	8%	10	6
Anchor Handler 1	Aiviq	IM/AH	Propulsion & Generation	80%	40%	120	7
	Aiviq	IM/AH	Boilers	100%	50%	120	
	Aiviq	IM/AH	Incinerator	100%	100%	120	
Anchor Handler 2	Ross Chouest	IM/AH	Propulsion & Generation	80%	10%	15	8
	Ross Chouest	IM/AH	Boilers	100%	6%	15	9
	Ross Chouest	IM/AH	Incinerator	N/A	N/A	N/A	10
Oil Spill Response Vessel	Nanuq	OSR	All IC Engines (non-emergency)	80%	26%	120	11
OSR Vessel Work boats	3 34-ft Kvickaks	OSR	All IC Engines (non-emergency)	80%	25%	120	12
Oil Spill Response - Tug/Barge	Ocean Wave/AEB	OSR	All IC Engines (non-emergency)	80%	25%	120	13
Nearshore OSR - Tug/Barge	Pt. Oliktok/AEB	OSR	All IC Engines (non-emergency)	0%	0%	0	
Nearshore OSR T/B Work boats	3 34-ft Kvickaks, 1 47-f	OSR	All IC Engines (non-emergency)	0%	0%	0	
Offshore Supply Vessel 1	Sisuaq	OSV	All IC Engines (non-emergency)	50%	50%	120	14
Offshore Supply Vessel 2	Harvey Supporter	OSV	All IC Engines (non-emergency)	65%	22%	40	15
Science Vessel	Sisuaq	OSV	All IC Engines (non-emergency)	50%	35%	120	18
Support Tug	Ocean Wave	OSV	All IC Engines (non-emergency)	0%	0%	0	16
Re-supply Tug/Barge	Lauren Foss/Tuuq	OSV	All IC Engines (non-emergency)	0%	0%	0	17
Arctic Oil Storage Tanker	Affinity	OST	All IC Engines (non-emergency)	32%	10%	120	19
Shallow Water Landing Craft	Arctic Seal		All IC Engines (non-emergency)	0%	0%	0	20
Arctic Containment System							
Tug	Crowley Invader Tug	ACS	All IC Engines (non-emergency)	0%	0%	0	21
Barge	Arctic Challenger	ACS	All IC Engines (non-emergency)	0%	0%	0	21
Anchor Handler 3	Vidar Viking	ACS	All IC Engines (non-emergency)	0%	0%	0	21

Notes	Reference
1 Percentages further explained in the "Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska AQRP and NEPA EI Report" October 2013	
2 Ice Management 1 P&G: Hrly: 80% (max 1-hr), Seasonal: 80% for 7 days (while ice fragmenting) & 30% for remaining 113 days (moving around to track ice).	Item 6[a]
3 Ice Management 1 Boiler: 50% power for entire season	
4 Ice Management 2 P&G: Hourly: 80% (max 1-hr), Seasonal: 80% power for 10 days (while ice fragmenting)	Item 10[a]
5 Ice Management 2 Boiler: 50% power for 10 of the 120 days	
6 Ice Management 2 Incinerator: 100% power for 10 of the 120 days	
7 Anchor Handler 1: average of 40% power for entire season.[b]	Item 16[a]
8 Anchor Handler 2 P&G: Hourly: 80% (max 1-hr), Seasonal: 80% power for 15 of the 120 days	
9 Anchor Handler 2 Boiler: 50% power for 15 of the 120 days	
10 Tor Viking does not have an incinerator, therefore the use capacities are not accounted for in the fleet seasonal use percentages	
11 OSRV: Assume 20% while anchored, an additional 5% representing a minimal need to shift locations = 25% + 30% power while booming 30 of the 120 days	
12 OSRV WB: Assume 50% power during training exercises and booming, 12 hours per day for 120 days	
13 OSR T/B: Assume 20% while anchored, an additional 5% representing a minimal need to shift locations = 25%	
14 OSV 1: Hourly: 50% power in DP mode. Seasonal: 50% entire season	
15 OSV2: Hourly: 65% power in Shuttle (highest engine efficiency), Seasonal: vessel in air region 33% of the time ->65%*33%=22%	
16 Support Tug: outside most of the time, not included in emission inventory	
17 Resupply T/B: Season: 1-2 trips at most and most likely while setting/removing anchors	Item 7[d]
18 Science Vessel: Anchored half time, travel around drill site half time (20% + 50%)/2 = 35%	
19 OST: Hourly: 30% propulsion + 2 gens at 80% capacity. Seasonal: 30% propulsion (while re-positioning, 6 of 120 days) + 2 gens at 80% capacity[c].	
20 Shallow Water Landing Craft: Occasional trips as needed between offshore vessels & shore bases, not included in emission inventory	
21 ACS: Remains in a location in the arctic, outside the Lease Sale Area from where it can respond if needed, not included in the EI.	

references to notes

a 2014 Chukchi EP Logistics Inquiry (Lev) 060213.docx

b 2014ChukchiEPQuestionaire_Logistics053013.docx

c Arctic Oil Storage Tanker Seasonal: to run propulsion engine 5% of the time or 6 out of 120 days. Not to run propulsion > 30% nameplate capacity

d email response from Lev Yompolski 6/26/2013 '[ACTION REQUIRED] 2014 Chukchi Sea Exploration Plan Revisions: Request for Emission Inventory Information'

Conversions

7	days/week	1,340.483	hp/MW
24	hrs/day	1.340	hp/kW
1.00E+06	btu/MMBtu	2.205	lb/kg

Assumptions

7,000	Btu/hp-hr
0.1312	MMBtu/gallon

EI CURRENTLY BASED ON THIS TABLE

EI Close Support Group Engine Capacity Summary

Vessel Group	Propulsion & Generation (kW)	Seldom Used (kW)	Emergency (kW)	Boilers (MMBtu/hr)	Incinerator (lb/hr)	All IC Engines (non-emergency) (kW)	Usage hourly	Usage seasonal
[1] Ice Management & Anchor Handling	78,640	1,830	3,210	23	584			
Propulsion & Generation							80%	22%
Boilers							100%	28%
Incinerator							100%	69%
[2] Oil Spill Response	17,321	1,048	291	0	125			
All IC Engines (non-emergency)						18,369	80%	26%
[3] Offshore Supply Vessels	14,600	1,442	250	0	176			
All IC Engines (non-emergency)						16,042	58%	36%
[4] Science Vessel	7,300	1,057	125	0	88			
All IC Engines (non-emergency)						8,357	50%	35%
[5] Arctic Oil Storage Tanker	19,180	1,431	295	85	188			
All IC Engines (non-emergency)						20,611	32%	10%
TOTAL	137,041	6,808	4,171	108	1,161			

assumed to have minimal use within close proximity to the Rig

[1] Fennica, Nordica, Aiviq & Tor Viking
[2] Nanuq, 3 34-ft Kvichaks, Ocean Wave/AEB
[3] Sisuaq & Supporter
[4] Sisuaq
[5] Affinity

BASED ON REVISED EP VESSEL LIST

Auxiliary Support Vessel Engine Capacity Summary

Vessel Assignment	Vessel	Propulsion & Generation (kW)	Seldom Used (kW)	Emergency (kW)	Boilers (MMBtu/hr)	Incinerator (lb/hr)
Ice Management & Anchor Handling						
Ice Management 1	Fennica	21,530	0	300	9	154
Ice Management 2	Nordica	21,530	0	300	9	154
Anchor Handler 1	Aiviq	23,051	397	2,290	5	276
Anchor Handler 2	Ross Chouest	12,529	1,433	320	0	0
	Total	78,640	1,830	3,210	23	584
Oil Spill Response						
Oil Spill Response Vessel	Nanuq	7,338	197	166	0	125
OSR Vessel Work boats	3 34-ft Kvickaks	1,370	0	0	0	0
Oil Spill Response - Tug	Sea Robin	4,058	0	0	0	0
Oil Spill Response - Barge	Klamath					
Nearshore OSR - Tug	Pt. Oliktok	1,791	11	0	0	0
Nearshore OSR - Barge	Arctic Endeavor	160	851	0	0	0
Nearshore OSR T/B Work boats	3 34-ft Kvickaks, 1 47-ft Rozema	2,275	0	0	0	0
	Total	16,992	1,059	166	0	125
Offshore Supply						
Offshore Supply Vessel 1	Sisuaq	7,300	1,057	125	0	88
Offshore Supply Vessel 2	Harvey Supporter	7,300	385	125	0	88
Science Vessel	Sisuaq or similar	7,300	1,057	125	0	88
Support Tug	Ocean Wave	8,453	0	125	0	0
Re-supply Tug	Lauren Foss	6,459	406	0	0	0
Re-supply Barge	Tuuq					
	Total	36,812	2,904	500	0	264
Arctic Oil Storage Tanker	Affinity	19,180	1,431	295	85	188
Shallow Water Landing Craft	Arctic Seal	1,449	37	0	0	0
Arctic Containment System						
Tug	Crowley Invader Tug	5,563	0	0	0	0
Barge	Arctic Challenger					
Anchor Handler	Vidar Viking	14,240	0	130	0	0
	Total	19,803	130	0	0	0

Ice Management & Anchor Handling

Ice Management Vessel 1

Fennica

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	F-1	Main Prop Engine	Wärtsilä / 12V32	4,500	kW	4,500	80%	24	33.77	257.42	6,178.01
prop	F-2	Main Prop Engine	Wärtsilä / 12V32	4,500	kW	4,500	80%	24	33.77	257.42	6,178.01
prop	F-3	Main Prop Engine	Wärtsilä / 16V32	6,000	kW	6,000	80%	24	45.02	343.22	8,237.35
prop	F-4	Main Prop Engine	Wärtsilä / 16V32	6,000	kW	6,000	80%	24	45.02	343.22	8,237.35
boiler	F-5	Heat Boiler	Unex BH-2000	4.44	MMBtu/hr		100%	24	4.44	33.85	812.32
boiler	F-6	Heat Boiler	Unex BH-2000	4.44	MMBtu/hr		100%	24	4.44	33.85	812.32
incin	F-7	Incinerator	Unex F-1	154	lb/hr		100%	24			
gen	F-8	Harbour Set Generator	Wärtsilä/VASA 4R22	710	hp	530	100%	24	4.97	37.89	909.28
nergen	F-9	Emergency Generator	Caterpillar/3412	300	kW	300	100%	24	2.81	21.45	514.83
electric		Generator	ABB Strömberg Drives/HSG 112(	8.314	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 112(	8.314	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 900	6.235	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 900	6.235	kVA	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		ROV		500	hp	-	100%	24			

Fennica Summary by Source Category		Rating		Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	21,000	kW	158	1,201	28,831
Generation	gen	530	kW	5	38	909
Emergency	emergency	300	kW	3	21	515
Seldom Used	seldom	0	kW			
Boilers	boiler	9	MMBtu/hr	9	68	1,625
Incinerators	incin	154	lb/hr			
Propulsion & Generation		21,530	kW			

Ice Management Vessel 2

Nordica

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	Nd-1	Main Prop Engine	Wärtsilä / 12V32	4,500	kW	4,500	80%	24	33.77	257.42	6,178.01
prop	Nd-2	Main Prop Engine	Wärtsilä / 12V32	4,500	kW	4,500	80%	24	33.77	257.42	6,178.01
prop	Nd-3	Main Prop Engine	Wärtsilä / 16V32	6,000	kW	6,000	80%	24	45.02	343.22	8,237.35
prop	Nd-4	Main Prop Engine	Wärtsilä / 16V32	6,000	kW	6,000	80%	24	45.02	343.22	8,237.35
boiler	Nd-5	Heat Boiler	Unex BH-2000	4.44	MMBtu/hr		100%	24	4.44	33.85	812.32
boiler	Nd-6	Heat Boiler	Unex BH-2000	4.44	MMBtu/hr		100%	24	4.44	33.85	812.32
incin	Nd-7	Incinerator	Unex F-1	154	lb/hr		100%	24			
gen	Nd-8	Harbour Set Generator	Wärtsilä/VASA 4R22	710	hp	530	100%	24	4.97	37.89	909.28
nergen	Nd-9	Emergency Generator	Caterpillar/3412	300	kW	300	100%	24	2.81	21.45	514.83
electric		Generator	ABB Strömberg Drives/HSG 112(	8.314	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 112(	8.314	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 900	6.235	kVA	-	100%	24			
electric		Generator	ABB Strömberg Drives/HSG 900	6.235	kVA	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		Bow Thrusters	Brunvoll FV-80 LTC-2250	1,150	kW	-	100%	24			
electric		ROV		500	hp	-	100%	24			

Nordica Summary by Source Category		Rating		Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	21,000	kW	158	1,201	28,831
Generation	gen	530	kW	5	38	909
Emergency	emergency	300	kW	3	21	515
Seldom Used	seldom	0	kW			
Boilers	boiler	9	MMBtu/hr	9	68	1,625
Incinerators	incin	154	lb/hr			
Propulsion & Generation		21,530	kW			

Electric

Ice Management & Anchor Handling Continued

Anchor Handler Vessel 1

Aiviq

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	Av-1	Propulsion	Caterpillar C280-12 diesel	5,444	hp	4,063	80%	24	30.49	232.40	5,577.63
prop	Av-2	Propulsion	Caterpillar C280-12 diesel	5,444	hp	4,063	80%	24	30.49	232.40	5,577.63
prop	Av-3	Propulsion	Caterpillar C280-12 diesel	5,444	hp	4,063	80%	24	30.49	232.40	5,577.63
prop	Av-4	Propulsion	Caterpillar C280-12 diesel	5,444	hp	4,063	80%	24	30.49	232.40	5,577.63
gen	Av-5	Hybrid Generator	Caterpillar 3512	1,700	kW	1,700	100%	24	15.95	121.56	2,917.40
gen	Av-6	Hybrid Generator	Caterpillar 3512	1,700	kW	1,700	100%	24	15.95	121.56	2,917.40
gen	Av-7	Hybrid Generator	Caterpillar 3512	1,700	kW	1,700	100%	24	15.95	121.56	2,917.40
gen	Av-8	Hybrid Generator	Caterpillar 3512	1,700	kW	1,700	100%	24	15.95	121.56	2,917.40
boiler	Av-9	Heat Boiler	Aalborg/Mission TFO	40	gal/hr		100%	24	5.25	40.00	960.00
incin	Av-10	Incinerator	TeamTec/GS500C	276	lb/hr		100%	24			
seldom	Av-11	ıst Rescue Craft FP 800 Thrus	Volvo D3-200	200	hp	149	100%	24	1.40	10.67	256.14
Av-12		*Daughter Craft Delta Phantom Thruster*									
nergen	Av-12A	Main Propulsion	Yanmar 6LP-STZP	315	hp	235	100%	24	2.21	16.81	403.42
nergen	Av-12B	Main Propulsion	Yanmar 6LP-STZP	315	hp	235	100%	24	2.21	16.81	403.42
nergen	Av-13	Emergency Generator #1	Caterpillar 3508	910	kW	910	100%	24	8.54	65.07	1,561.66
nergen	Av-14	Emergency Generator #2	Caterpillar 3508	910	kW	910	100%	24	8.54	65.07	1,561.66
seldom	Av-15	·emer 64 Mn Enclosed Lifeboa	Saab/L4S.186LB	39	hp	29	100%	24	0.27	2.08	49.95
seldom	Av-16	·emer 64 Mn Enclosed Lifeboa	Saab/L4S.186LB	39	hp	29	100%	24	0.27	2.08	49.95
seldom	Av-17	TranRec150 Power Pack	Cummins 6CTA 8.3 M	190	kW	190	100%	24	1.78	13.59	326.06
electric		Shaft Hybrid Generator		2,000	kW	-	100%	24			
electric		Shaft Hybrid Generator		2,000	kW	-	100%	24			
electric		Bow Thruster	Brunvoll FU100 LTA 2450mr	1,500	kW	-	100%	24			
electric		Bow Thruster	Brunvoll FU100 LTA 2450mr	1,500	kW	-	100%	24			
electric		Bow Thruster (Fold Down)		2,500	hp	-	100%	24			
electric		Stern Thruster	Brunvoll FU80 LTA 2000mr	1,050	kW	-	100%	24			
electric		Stern Thruster	Brunvoll FU80 LTA 2000mr	1,050	kW	-	100%	24			
electric		Crane	15 ton			-	100%	24			
electric		Crane	1 ton			-	100%	24			

Aiviq Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	16,251	kW	122	930	22,311
Generation	gen	6,800	kW	64	486	11,670
Emergency	emergency	2,290	kW	21	164	3,930
Seldom Used	seldom	397	kW	4	28	682
Boilers	boiler	5	MMBtu/hr	5	40	960
Incinerators	incin	276	lb/hr			

3 Vessels *

Combined Ice Management & Anchor Handling Summary by Source Category

Propulsion	prop	58,251	kW
Generation	gen	7,860	kW
Emergency	emergency	2,890	kW
Seldom Used	seldom	397	kW
Boilers	boiler	23	MMBtu/hr
Incinerators	incin	584	lb/hr
Propulsion & Generation		66,110	kW

** Fennica, Nordica, & Aiviq*

Ice Management & Anchor Handling Continued

Anchor Handler Vessel 2 (old option)

Tor Viking

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	TV-1	Main Propulsion-SB Outer	MaK 6M32	2,880	kW	2,880	80%	24	21.61	164.75	3,953.93
prop	TV-2	Main Propulsion-SB Inner	MaK 8M32	3,840	kW	3,840	80%	24	28.82	219.66	5,271.91
prop	TV-3	Main Propulsion-PS Inner	MaK 8M32	3,840	kW	3,840	80%	24	28.82	219.66	5,271.91
prop	TV-4	Main Propulsion-PS Outer	MaK 6M32	2,880	kW	2,880	80%	24	21.61	164.75	3,953.93
gen	TV-5	Harbor Generator-SB	Caterpillar 3412	500	kW	500	100%	24	4.69	35.75	858.06
gen	TV-6	Harbor Generator-PS	Caterpillar 3412	500	kW	500	100%	24	4.69	35.75	858.06
electric		Bow Thruster		1,200	hp	-	100%	24			
electric		Bow Thruster		1,200	hp	-	100%	24			
electric		Stern Thruster		1,200	hp	-	100%	24			
boiler	TV-7	Heat Boiler	Pyro/E1130	1.37	MMBtu/hr		100%	24	1.37	10.44	250.65
emergen	TV-8	Emergency Generator	Caterpillar/3306	170	kW	170	100%	24	1.59	12.16	291.74
seldom	TV-9	Rescue Craft (MOB-boat)					100%	24			

Tor Viking Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	13,440	kW	101	769	18,452
Generation	gen	1,000	kW	9	72	1,716
Emergency	emergency	170	kW	2	12	292
Seldom Used	seldom	0	kW			
Boilers	boiler	1	MMBtu/hr	1	10	251
Incinerators	incin	0	lb/hr			
Propulsion & Generation		14,440	kW			

*4 Vessels **

Combined Ice Management & Anchor Handling Summary by Source Category				*Option 2*		*Difference*	
Propulsion	prop	71,691	kW	69,009	kW	-2,682	kW
Generation	gen	8,860	kW	9,631	kW	771	kW
Emergency	emergency	3,060	kW	3,210	kW	150	kW
Seldom Used	seldom	397	kW	1,830	kW	1,433	kW
Boilers	boiler	24	MMBtu/hr	23	MMBtu/hr	-1	MMBtu/hr
Incinerators	incin	584	lb/hr	584	lb/hr	0	lb/hr
Propulsion & Generation		80,550	kW	78,640	kW	-1,911	kW

** Fennica, Nordica, Aiviq & Tor Viking*

Option 2:Fennica, Nordica, Aiviq & Ross Chouest

Anchor Handler Vessel 2 (new option)

Ross Chouest

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	PME	Port Main Engine	Caterpillar 3612	5,502	hp	4,106	80%	24	30.81	234.88	5,637.05
prop	SME	Starboard Main Engine	Caterpillar 3612	5,502	hp	4,106	80%	24	30.81	234.88	5,637.05
prop	FDDT	FDDT	Caterpillar 3512	1,281	hp	956	80%	24	7.17	54.69	1,312.44
prop	ADDT	AFDT	Caterpillar 3512	1,281	hp	956	80%	24	7.17	54.69	1,312.44
seldom	P Winch	Port Winch	Caterpillar 3508	960	hp	716	100%	24	6.72	51.23	1,229.46
seldom	S Winch	Starboard Winch	Caterpillar 3508	960	hp	716	100%	24	6.72	51.23	1,229.46
gen	P Gen	Port Generator	Caterpillar 3412C	791	hp	590	100%	24	5.54	42.21	1,013.02
gen	C Gen	Center Generator	Caterpillar 3412C	791	hp	590	100%	24	5.54	42.21	1,013.02
gen	S Gen	Starboard Generator	Caterpillar 3412C	791	hp	590	100%	24	5.54	42.21	1,013.02
emergen	E Gen	Emergency Generator	Caterpillar 3406C	429	hp	320	100%	24	3.00	22.89	549.41
prop	TT	Tunnel Thruster	Caterpillar 3508	850	hp	634	80%	24	4.76	36.29	870.86

FDDT=Forward Diesel Directional Thruster

AFDT=Aft Diesel Directional Thruster

Ross Chouest Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	10,758	kW	81	615	14,770
Generation	gen	1,771	kW	17	127	3,039
Emergency	emergency	320	kW	3	23	549
Seldom Used	seldom	1,433	kW	13	102	2,459
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		12,529	kW			

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Oil Spill Response Fleet

OSR Vessel

Nanuq

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	N-1	Propulsion Engine	Cat/3608	2,710	kW	2,710	80%	24	20.34	155.02	3,720.54
prop	N-2	Propulsion Engine	Cat/3608	2,710	kW	2,710	80%	24	20.34	155.02	3,720.54
gen	N-3	Electrical Generator	Cat/3508	1,285	hp	959	100%	24	9.00	68.57	1,645.68
gen	N-4	Electrical Generator	Cat/3508	1,285	hp	959	100%	24	9.00	68.57	1,645.68
incin	N-6	Incinerator	ASC / CP100	125	lb/hr		100%	24			
emergen	N-5	Emergency Gen	John Deere	166	kW	166	100%	24	1.56	11.87	284.88
seldom	N-7	Lifeboat Propulsion Engine		29	hp	22	100%	24	0.20	1.55	37.14
seldom	N-8	Backpack Blower		1	hp	1	100%	24	0.01	0.05	1.28
seldom	N-9	RubberMax Boom Power Pacl	Elastec/Yanmar/3TNV70	16	kW	16	100%	24	0.15	1.14	27.46
seldom	N-10	RubberMax Boom Power Pacl	Elastec/Yanmar/3TNV70	16	kW	16	100%	24	0.15	1.14	27.46
seldom	N-11	Power Pack	Lamor	80	kW	80	100%	24	0.75	5.72	137.29
seldom	N-12	Power Pack	Vikoma/GP10-2E	7	hp	5	100%	24	0.05	0.37	8.96
seldom	N-13	Fire Boom Power Pack	Elastec	7	hp	5	100%	24	0.05	0.37	8.96
seldom	N-14	Dispersant Pump		5	hp	4	100%	24	0.04	0.27	6.40
seldom	N-15	Water Pump	Elastec/Kubota/D722E	14	kW	14	100%	24	0.13	1.00	24.03
seldom	N-16	Water Pump	Elastec/Kubota/D722E	14	kW	14	100%	24	0.13	1.00	24.03
seldom	N-17	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	N-18	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	N-19	Portable Generator	Diesel America West	6	kW	6	100%	24	0.06	0.43	10.30
seldom	N-20	Pressure Washer	Diesel America West/Model 1(	10	hp	7	100%	24	0.07	0.53	12.81
seldom	N-21	Hot Water Heater	PVI/4000 PHE 250 A-TPO	3	MMBtu/hr		100%	24	3.20	24.39	585.46
electric		Bow Thruster		1,700	hp	-	100%	24			
electric		Bow Thruster		1,700	hp	-	100%	24			
electric		Stern Thruster		1,700	hp	-	100%	24			
electric		Crane	KB-600			-	100%	24			
electric		Crane	KB-90			-	100%	24			

Nanuq Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	5,420	kW	41	310	7,441
Generation	gen	1,918	kW	18	137	3,291
Emergency	emergency	166	kW	2	12	285
Seldom Used	seldom	197	kW	5	38	923
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	125	lb/hr			
Propulsion & Generation		7,338	kW			

Work Boats with the OSR Vessel

3 Kvichak Work Boats

Propulsion Capacity	100%
	30 hr/week

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
	Kvichak No. 1 34-foot Oil Spill Response Work Boat										
prop	OSRK1-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK1-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK1-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74
	Kvichak No. 2 34-foot Oil Spill Response Work Boat										
prop	OSRK2-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK2-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK2-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74
	Kvichak No. 3 34-foot Oil Spill Response Work Boat										
prop	OSRK3-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK3-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK3-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74

3 Kvichak Work Boats Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	1,343	kW	13	96	412
Generation	gen	27	kW	0	2	8
Emergency	emergency	0	kW			
Seldom Used	seldom	0	kW			
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			

Nanuq with 3 Work Boats (IC engines) 9,071 kW

Oil Spill Response Fleet Continued

OSR Tug

Sea Robin

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	SR-1	Port Main Propulsion	Caterpillar 3606	2,481	hp	1,851	80%	24	13.89	105.91	2,541.90
prop	SR-2	Starboard Main Propulsion	Caterpillar 3606	2,481	hp	1,851	80%	24	13.89	105.91	2,541.90
gen	SR-3	Generator	Detroit 6-71	238	hp	178	100%	24	1.67	12.70	304.80
gen	SR-4	Generator	Detroit 6-71	238	hp	178	100%	24	1.67	12.70	304.80

Sea Robin Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	3,703	kW	28	212	5,084
Generation	gen	355	kW	3	25	610
Emergency	emergency	0	kW			
Seldom Used	seldom	0	kW			
Boilers	boiler		MMBtu/hr			
Incinerators	incin		lb/hr			
Propulsion & Generation		4,058	kW			

OSR Barge

Klamath *No emission units for this vessel, equipment added prior to season start*

Alternate OSR Tug/Barge combo used for emission inventory

Ocean Wave/Arctic Endeavour Barge Summary by Source Category			
Propulsion	prop	8,113	kW
Generation	gen	500	kW
Emergency	emergency	125	kW
Seldom Used	seldom	851	kW
Boilers	boiler	0	MMBtu/hr
Incinerators	incin	0	lb/hr
Propulsion & Generation		8,613	kW

2 Vessels, 3 Work boats *

Total OSR Summary by Source Category			
Propulsion	prop	14,876	kW
Generation	gen	2,445	kW
Emergency	emergency	291	kW
Seldom Used	seldom	1,048	kW
Boilers	boiler	0	MMBtu/hr
Incinerators	incin	125	lb/hr

* Nanuq, 3 34-ft Kvichaks, Ocean Wave/AEB

Propulsion & Generation	17,321	kW
All IC Engines (non-emergency)	18,369	kW

2 Vessels, 3 Work boats *

Total OSR Summary by Source Category			
Propulsion	prop	10,466	kW
Generation	gen	2,300	kW
Emergency	emergency	166	kW
Seldom Used	seldom	197	kW
Boilers	boiler	0	MMBtu/hr
Incinerators	incin	125	lb/hr

* Nanuq, 3 34-ft Kvichaks, Sea Robin

Propulsion & Generation	12,766	kW
All IC Engines (non-emergency)	12,963	kW

Oil Spill Response Fleet Continued

Nearshore OSR Tug

Pt. Oliktok

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	POT-1	Port Main Propulsion	Caterpillar 3512	1,050	hp	784	80%	24	5.88	44.82	1,075.77
prop	POT-2	Starboard Main Propulsion	Caterpillar 3512	1,050	hp	784	80%	24	5.88	44.82	1,075.77
gen	POT-3	Port Generator	Caterpillar 3304	150	hp	112	100%	24	1.05	8.00	192.10
gen	POT-4	Starboard Generator	Caterpillar 3304	150	hp	112	100%	24	1.05	8.00	192.10
seldom	POT-5	Outboard 2 cycle Engine	Johnson	9.9	hp	7	100%	24	0.07	0.53	12.68
seldom	POT-6	Portable Trash Pump	Honda Yanmar	5	hp	4	100%	24	0.04	0.27	6.40

Pt. Oliktok Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	1,567	kW	12	90	2,152
Generation	gen	224	kW	2	16	384
Emergency	emergency	0	kW			
Seldom Used	seldom	11	kW	0	1	19
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		1,791	kW			

Nearshore OSR Barge

Arctic Endeavour Barge ***Equipment list based on 2012 season***

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
gen	AEB-1	Generator	Caterpillar C4.4	80	kW	80	100%	24	0.75	5.72	137.29
gen	AEB-2	Generator	Caterpillar C4.4	80	kW	80	100%	24	0.75	5.72	137.29
seldom	AEB-3	Power Pack (HPU Engine)	Lamor/Caterpillar/C6.6	158	kW	158	100%	24	1.48	11.30	271.15
seldom	AEB-4	Power Pack (HPU Engine)	Lamor/Caterpillar/C6.6	158	kW	158	100%	24	1.48	11.30	271.15
seldom	AEB-5	Power Pack (HPU Engine)	Lamor/Deutz/F6L914	84	kW	84	100%	24	0.79	6.01	144.15
seldom	AEB-6	Crane	Manitowok NTA855-C360	350	hp	261	100%	24	2.45	18.68	448.24
seldom	AEB-7	Light Plant		30	hp	22	100%	24	0.21	1.60	38.42
seldom	AEB-8	Anchor Engine	John Deere	50	hp	37	100%	24	0.35	2.67	64.03
seldom	AEB-9	RubberMax Boom Power Pacl	Elastec/Yanmar/3TNV70	16	kW	16	100%	24	0.15	1.14	27.46
seldom	AEB-10	RubberMax Boom Power Pacl	Elastec/Yanmar/3TNV70	16	kW	16	100%	24	0.15	1.14	27.46
seldom	AEB-11	Power Pack	Vikoma/Yanmar/L100AE	7	kW	7	100%	24	0.07	0.53	12.70
seldom	AEB-12	Fire Boom Power Pack	Elastec/Yanmar/L100V6	7	kW	7	100%	24	0.06	0.49	11.67
seldom	AEB-13	2" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-14	2" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-15	2" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-16	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-17	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-18	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-19	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-20	3" Pump	Diesel America West/Yanmar/L4	3	kW	3	100%	24	0.03	0.24	5.66
seldom	AEB-21	Water Pump	Elastec	25	hp	19	100%	24	0.18	1.33	32.02
seldom	AEB-22	Water Pump	Elastec	25	hp	19	100%	24	0.18	1.33	32.02
seldom	AEB-23	Portable Generator	Diesel America West/Yanmar/L1	7	kW	7	100%	24	0.06	0.49	11.67
seldom	AEB-24	Portable Generator	Diesel America West/Yanmar/L1	7	kW	7	100%	24	0.06	0.49	11.67
seldom	AEB-25	Pressure Washer	Diesel America West/Yanmar/L1	7	kW	7	100%	24	0.06	0.49	11.67

Arctic Endeavour Barge Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	0	kW			
Generation	gen	160	kW	2	11	275
Emergency	emergency	0	kW			
Seldom Used	seldom	851	kW	8	61	1,461
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			

Pt. Oliktok/Arctic Endeavour Barge Summary by Source Category

Propulsion	prop	1,567	kW
Generation	gen	384	kW
Emergency	emergency	0	kW
Seldom Used	seldom	862	kW
Boilers	boiler	0	MMBtu/hr
Incinerators	incin	0	lb/hr

Oil Spill Response Fleet Continued

Work Boats with the Nearshore OSR Tug/Barge

3 Kvichak & 1 Rozema Work Boats

Propulsion Capacity 100%

30 hr/week

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	Fuel Consumption gal/hr	Fuel Consumption gal/day
Kvichak No. 1 34-foot Oil Spill Response Work Boat											
prop	OSRK1-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK1-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK1-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74
Kvichak No. 2 34-foot Oil Spill Response Work Boat											
prop	OSRK2-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK2-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK2-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74
Kvichak No. 3 34-foot Oil Spill Response Work Boat											
prop	OSRK3-1	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
prop	OSRK3-2	Propulsion	Cummins QSB 5.9	300	hp	224	100%	4	2.10	16.01	68.61
gen	OSRK3-3	Generator	Northern Lights/M773LW3	12	hp	9	100%	4	0.08	0.64	2.74
Rozema No. 1 47-foot Oil Spill Response Skimmer											
prop	OSRK4-1	Propulsion	Lugger 6140	600	hp	448	100%	4	4.20	32.02	137.22
prop	OSRK4-2	Propulsion	Lugger 6140	600	hp	448	100%	4	4.20	32.02	137.22
gen	OSRK4-3	Generator	Northern Lights/M773LW2	12	hp	9	100%	4	0.08	0.64	2.74

3 Kvichak & 1 Rozema Work Boats Summary by Source Category

				Fuel Consumption MMBtu/hr	Fuel Consumption gal/hr	Fuel Consumption gal/day
Propulsion	prop	2,239	kW	21	160	686
Generation	gen	36	kW	0	3	11
Emergency	emergency	0	kW			
Seldom Used	seldom	0	kW			
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		2,275	kW			

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Offshore Supply Continued

Offshore Supply Vessel 1 & Science Vessel

Sisuaq

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	S-1	Port Outboard Main Engine	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	S-2	Port Inboard Main Engine	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	S-3	Starboard Inboard Main Engin	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	S-4	tarboard Outboard Main Engi	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
nergen	S-5	Emergency Generator	Cummins/6CTA8.3-DM	125	kW	125	100%	24	1.17	8.94	214.51
seldom	S-6	TranRec150 Power Pack	Cummins 6CTA 8.3 M	190	kW	190	100%	24	1.78	13.59	326.06
seldom	S-7	AFT-DOP 250 Power Pack	Cummins 6AT3.4-P93	98	hp	73	100%	24	0.69	5.23	125.51
seldom	S-8	FWD-DOP 250 Power Pack	Cummins 6AT3.4-P93	98	hp	73	100%	24	0.69	5.23	125.51
seldom	S-9	Ocean Buster Power Pack	Lombardini Series 25LD 425/	19	kW	19	100%	24	0.18	1.36	32.61
seldom	S-10	3D. Air Comp M&I Cutting S	Cummins/94N14	450	hp	336	100%	24	3.15	24.01	576.31
seldom	S-11	RT Air Comp M&I Cutting S	Cummins/94N14	450	hp	336	100%	24	3.15	24.01	576.31
incin		Incinerator	Atlas/200 SWS	40	kg/hr		100%	24			
seldom		FRC Outboard Engine	Evinrude E-Tec 40/F40DBLU	40	hp	30	100%	24	0.28	2.13	51.23
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Main Drive Motor		3,350	hp	-	100%	24			
electric		Main Drive Motor		3,350	hp	-	100%	24			
electric		Thruster	Schottel SRP-2020FP	3,350	hp	-	100%	24			
electric		Thruster	Schottel SRP-2020FP	3,350	hp	-	100%	24			
electric		Bow Thruster	Schottel SST 4 FP	1,581	hp	-	100%	24			
electric		Bow Thruster	Schottel SST 4 FP	1,581	hp	-	100%	24			

Sisuaq Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	7,300	kW	55	418	10,022
Generation	gen	0	kW			
Emergency	emergency	125	kW	1	9	215
Seldom Used	seldom	1,057	kW	10	76	1,814
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	88	lb/hr			
Propulsion & Generation		7,300	kW			

Offshore Supply Continued

Offshore Supply Vessel 2

Harvey Supporter *Sister Ship to Sisuaq, equipment list based on Sisuaq*

Propulsion Engines 80%

Remaining Sources 100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	Sp-1	Port Outboard Main Engine	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	Sp-2	Port Inboard Main Engine	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	Sp-3	;tarboard Inboard Main Engin	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
prop	Sp-4	tarboard Outboard Main Engi	Cummins QSK60DM 16	1,825	kW	1,825	80%	24	13.69	104.40	2,505.53
emergen	Sp-5	Emergency Generator	Cummins/6CTA8.3-DM	125	kW	125	100%	24	1.17	8.94	214.51
seldom	Sp-6	TranRec150 Power Pack	Cummins 6CTA 8.3 M	190	kW	190	100%	24	1.78	13.59	326.06
seldom	Sp-7	AFT-DOP 250 Power Pack	Cummins 6AT3.4-P93	98	hp	73	100%	24	0.69	5.23	125.51
seldom	Sp-8	FWD-DOP 250 Power Pack	Cummins 6AT3.4-P93	98	hp	73	100%	24	0.69	5.23	125.51
seldom	Sp-9	Ocean Buster Power Pack	Lombardini Series 25LD 425/	19	kW	19	100%	24	0.18	1.36	32.61
incin		Incinerator	Atlas/200 SWS	40	kg/hr		100%	24			
seldom		FRC Outboard Engine	Evinrude E-Tec 40/F40DBLU	40	hp	30	100%	24	0.28	2.13	51.23
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Generator	Hyundai Heavy Industries	1,825	kW	-	100%	24			
electric		Main Drive Motor		3,350	hp	-	100%	24			
electric		Main Drive Motor		3,350	hp	-	100%	24			
electric		Thruster	Schottel SRP-2020FP	3,350	hp	-	100%	24			
electric		Thruster	Schottel SRP-2020FP	3,350	hp	-	100%	24			
electric		Bow Thruster	Schottel SST 4 FP	1,581	hp	-	100%	24			
electric		Bow Thruster	Schottel SST 4 FP	1,581	hp	-	100%	24			

Harvey Supporter Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	7,300	kW	55	418	10,022
Generation	gen	0	kW			
Emergency	emergency	125	kW	1	9	215
Seldom Used	seldom	385	kW	4	28	661
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	88	lb/hr			

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Offshore Supply Continued

Resupply Tug

Lauren Foss

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	LF-1	Port Main Propulsion	ALCO 16-251F	4,100	hp	3,060	80%	24	22.96	175.03	4,200.64
prop	LF-2	Starboard Main Propulsion	ALCO 16-251F	4,100	hp	3,060	80%	24	22.96	175.03	4,200.64
gen	LF-3	Generator	Cummins	170	kW	170	100%	24	1.59	12.16	291.74
gen	LF-4	Generator	Cummins	170	kW	170	100%	24	1.59	12.16	291.74
seldom	LF-5	Emergency Generator	John Deere	70	kW	70	100%	24	0.66	5.01	120.13
seldom	LF-6	Hydraulic Bow Thruster		450	hp	336	100%	24	3.15	24.01	576.31

Lauren Foss Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	6,119	kW	46	350	8,401
Generation	gen	340	kW	3	24	583
Emergency	emergency	0	kW			
Seldom Used	seldom	406	kW	4	29	696
Boilers	boiler		MMBtu/hr			
Incinerators	incin		lb/hr			
Propulsion & Generation		6,459	kW			

Resupply Barge

Tuuq *No emission units for this vessel, equipment added prior to season start*

Support Tug

Ocean Wave

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	OW-1	Port Main Propulsion	Caterpillar C-280-12	4,057	kW	4,057	80%	24	30.44	232.05	5,569.14
prop	OW-2	Starboard Main Propulsion	Caterpillar C-280-12	4,057	kW	4,057	80%	24	30.44	232.05	5,569.14
gen	OW-3	Harbor Generator	Caterpillar C-18	340	kW	340	100%	24	3.19	24.31	583.48
nergen	OW-4	Emergency Generator	Caterpillar C-6.6	125	kW	125	100%	24	1.17	8.94	214.51
electric	OW-5	Port Shaft Generator	1475 kVA	1,475	kVA	-	100%	24			
electric	OW-6	Starboard Shaft Generator	1476 kVA	1,475	kVA	-	100%	24			
electric	OW-7	Bow Thruster	Berg (Electric) VFD	850	hp	-	100%	24			

Ocean Wave Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	8,113	kW	61	464	11,138
Generation	gen	340	kW	3	24	583
Emergency	emergency	125	kW	1	9	215
Seldom Used	seldom	0	kW			
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		8,453	kW			

4 Vessels *

Total Offshore Supply Summary by Source Category			
Propulsion	prop	28,832	kW
Generation	gen	680	kW
Emergency	emergency	375	kW
Seldom Used	seldom	1,848	kW
Boilers	boiler	0	MMBtu/hr
Incinerators	incin	176	lb/hr

* Sisuaq, Harvey Supporter, Ocean Wave, Lauren Foss

Propulsion & Generation	29,512	kW
All IC Engines (non-emergency)	31,360	kW

Arctic Oil Storage Tanker

Affinity

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	A-1	Propulsion	STX MAN B&W 7S60MC-C	15,820	kW	15,820	80%	24	118.71	904.96	21,719.15
gen	A-2	Generator P	STX MAN B&W 7L23	1,120	kW	1,120	100%	24	10.51	80.09	1,922.05
gen	A-3	Electrical C	STX MAN B&W 7L23	1,120	kW	1,120	100%	24	10.51	80.09	1,922.05
gen	A-4	Generator S	STX MAN B&W 7L23	1,120	kW	1,120	100%	24	10.51	80.09	1,922.05
nergen	A-5	Em Generator	Cummins NT 855 D(M)	295	kW	295	100%	24	2.77	21.09	506.25
seldom	A-6	Power Pack	Cummins KTA 19-M3	477	kW	477	100%	24	4.47	34.11	818.59
seldom	A-7	Power Pack	Cummins KTA 19-M3	477	kW	477	100%	24	4.47	34.11	818.59
seldom	A-8	Power Pack	Cummins KTA 19-M3	477	kW	477	100%	24	4.47	34.11	818.59
boiler	A-9	Auxiliary Boiler	KANGRIM MB07S01	85	MMBtu/hr		100%	24	85.00	647.96	15,551.15
incin	A-10	Incinerator	TeamTec OG 400	188	lb/hr		100%	24			

Affinity Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	15,820	kW	119	905	21,719
Generation	gen	3,360	kW	32	240	5,766
Emergency	emergency	295	kW	3	21	506
Seldom Used	seldom	1,431	kW	13	102	2,456
Boilers	boiler	85	MMBtu/hr	85	648	15,551
Incinerators	incin	188	lb/hr			
Propulsion & Generation		19,180	kW			
All IC Engines (non-emergency)		20,611	kW			

Hourly Usage

4,746 kW (propulsion @ 30%)
1,792 kW (2 of 3 generators @ 80%)
32% hourly percent use

Seasonal Usage

237 kW (propulsion @ 30%), for 6 days
1,792 kW (2 of 3 generators @ 80%), for 120 days
10% seasonal percent use

Shallow Water Landing Craft

Arctic Seal — *Stack height* 28.25 ft

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop		Main Engine	Caterpillar/3408	850	hp	634	80%	24	4.76	36.29	870.86
prop		Main Engine	Caterpillar/3408	850	hp	634	80%	24	4.76	36.29	870.86
gen		Generator	Caterpillar/3306	90	kW	90	100%	24	0.84	6.44	154.45
gen		Generator	Caterpillar/3306	90	kW	90	100%	24	0.84	6.44	154.45
seldom		Hydraulic Pump		25	hp	19	100%	24	0.18	1.33	32.02
seldom		Hydraulic Pump		25	hp	19	100%	24	0.18	1.33	32.02

Arctic Seal Summary by Source Category

				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	1,269	kW	10	73	1,742
Generation	gen	180	kW	2	13	309
Emergency	emergency	0	kW			
Seldom Used	seldom	37	kW	0	3	64
Boilers	boiler		MMBtu/hr			
Incinerators	incin		lb/hr			
Propulsion & Generation		1,449	kW			

Arctic Containment System

ACS Tug

Crowley Invader

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	CI-1	Port Main Propulsion	EMD 20-645-E5	3,600	hp	2,687	80%	24	20.16	153.68	3,688.37
prop	CI-2	Starboard Main Propulsion	EMD 20-645-E5	3,600	hp	2,687	80%	24	20.16	153.68	3,688.37
gen	CI-3	Auxiliary Engine	Caterpillar D3304	127	hp	95	100%	24	0.89	6.78	162.65
gen	CI-4	Auxiliary Engine	Caterpillar D3304	127	hp	95	100%	24	0.89	6.78	162.65

Crowley Invader Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	5,373	kW	40	307	7,377
Generation	gen	190	kW	2	14	325
Emergency	emergency	0	kW			
Seldom Used	seldom	0	kW			
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		5,563	kW			
All IC Engines (non-emergency)		5,563	kW			

ACS Barge

Arctic Challenger *No emission units for this vessel, equipment added prior to season start*

ACS Anchor Handler

Vidar Viking

Propulsion Engines	80%
Remaining Sources	100%

	Unit ID	Description	Make/Model	Rating		kW	Capacity	hrs/day	Fuel Consumption MMBtu/hr	gal/hr	gal/day
prop	VV-1	Main Engine	MAK 8M32	3,840	kW	3,840	80%	24	28.82	219.66	5,271.91
prop	VV-2	Main Engine	MAK 8M32	3,840	kW	3,840	80%	24	28.82	219.66	5,271.91
prop	VV-3	Main Engine	MAK 6M32	2,880	kW	2,880	80%	24	21.61	164.75	3,953.93
prop	VV-4	Main Engine	MAK 6M32	2,880	kW	2,880	80%	24	21.61	164.75	3,953.93
gen	VV-5	Generator		400	kW	400	100%	24	3.75	28.60	686.45
gen	VV-6	Generator		400	kW	400	100%	24	3.75	28.60	686.45
emergen	VV-7	Emergency Generator		130	kW	130	100%	24	1.22	9.30	223.09
electric	VV-8	Bow Thruster	Brunvoll	1,200	hp	-	100%	24			
electric	VV-9	Bow Thruster	Brunvoll	1,200	hp	-	100%	24			
electric	VV-10	Stern Thruster	Brunvoll	1,200	hp	-	100%	24			

Vidar Viking Summary by Source Category				Fuel Consumption MMBtu/hr	gal/hr	gal/day
Propulsion	prop	13,440	kW	101	769	18,452
Generation	gen	800	kW	8	57	1,373
Emergency	emergency	130	kW	1	9	223
Seldom Used	seldom	0	kW			
Boilers	boiler	0	MMBtu/hr			
Incinerators	incin	0	lb/hr			
Propulsion & Generation		14,240	kW			
All IC Engines (non-emergency)		14,240	kW			

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: D. Steen		
ENGINEERING CALCULATIONS	PROJECT NO: 180-23-1	PAGE: 1	OF: 1	SHEET: 3
	SUBJECT: EDMS Helicopter Emissions	DATE: October 11, 2013		

RUN FOR 1 LTO SERIES

EDMS 5.1.4 Emissions Inventory Report
Aircraft Emissions by Mode
Study: Helicopter_20130624
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2013
Units: Pounds per Year (lbs/LTO)
Generated: 06/24/13 15:51:18

# Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	254.61	99.83	3.09	3.29	3.81	3.79	3.81	80.70
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	2.46	0.97	2.0E-3	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.78
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	166.36	65.23	0.86	0.79	0.91	0.91	0.91	52.73
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	107.55	42.17	1.31	1.39	1.61	1.60	1.61	34.09
				TOTAL	530.98	208.18	5.26	5.47	6.33	6.29	6.33	168.30

# Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	0.29	0.10	0.10	0.10	0.0E+0	8.0E-3	9.1E-2
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	9.0E-3	1.0E-3	3.0E-3	3.0E-3	0.0E+0	0.0E+0	3.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	0.40	6.8E-2	9.0E-3	9.0E-3	0.0E+0	5.0E-3	4.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	0.12	4.4E-2	4.2E-2	4.2E-2	0.0E+0	4.0E-3	3.8E-2
				TOTAL	0.82	0.22	0.15	0.15	0.00	0.02	0.14

SUMMARY

40 Roundtrips/week

Fuel	NOx		PM		CO		VOC		SOx	
gal/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season
115,404	0.20	0.28	0.04	0.05	1.25	1.80	1.50	2.16	0.05	0.07

Conversions

120	days/season
17.1	weeks/season
24	hr/day
2,000	lbs/ton

blue values are input, black values are calculated or linked

Summary

	Capacity Values		MMBtu/hr	FUEL gal/hr	gal/day	gal/season
Man Camp Generators	1,396	kW	7	58	1,231	206,799
Hangar/Storage Building Boiler	5	MMBtu	5			

	NOx		PM		CO		VOC		Pb	
	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season
Man Camp Generators	7.73	12.76	0.36	0.64	6.30	11.16	2.34	4.15	-	-
Hangar/Storage building Boiler	0.49	0.35	0.04	0.03	0.41	4.88	0.02	0.01	2.5E-06	1.8E-06

Assumptions		Reference
Diesel heat rate		
7,000	Btu/hp-hr	AP42 Table 3.3-1, 10/96
0.007	MMBtu/hp-hr	
Diesel heat value		AP42, Appendix A
131,200	Btu/gal	
0.1312	MMBtu/gal	

Conversion(s):

1,020	Btu/scf natural gas	453.592	g/lb
1.34	hp/kW	24	hr/day
1.00E+06	Btu/MMBtu	2,000	lb/ton
0.95	kWe/kW		

blue values are input, black values are calculated or linked

Man Camp

Proposed Equipment at New 200-bed Man Camp

Make	Model	Rating	EPA Certified	Notes
John Deere	6135HF485/HF475	448 kW	Tier 3	2 generators currently at existing camp
John Deere	VD500-01	500 kW	Tier 2	200-bed camp back-up generator

Man camp season	168 days	(24 weeks)
Max hourly capacity	80%	
Backup Generator use	15 min/week	

Maximum Hourly Emissions

Description	Model	Rating	Hourly Capacity	Fuel gal/hr	NOx lb/hr	PM lb/hr	CO lb/hr	VOC lb/hr
Generator #1	6135HF485/HF475	448 kW	80%	25.62	3.16	0.16	2.77	1.03
Generator #2	6135HF485/HF475	448 kW	80%	25.62	3.16	0.16	2.77	1.03
Backup Generator	VD500-01	500 kW	20%	7.15	1.41	0.04	0.77	0.29
TOTAL		1,396 kW	59%	58.40	7.73	0.36	6.30	2.34

Seasonal Emissions

Description	Model	Rating	Daily Load/Use	Fuel gal/season	NOx tps	PM tps	CO tps	VOC tps
Generator #1	6135HF485/HF475	448 kW	80%	103,314	6	0.32	6	2.07
Generator #2	6135HF485/HF475	448 kW	80%	103,314	6	0.32	6	2.07
Backup Generator	VD500-01	500 kW	0.1%	172	1.69E-2	5.29E-4	9.26E-3	3.44E-3
TOTAL		1,396 kW	51%	206,799	12.76	0.64	11.16	4.15

Emission Factors

Tier 3 225<kW<450			Reference
NOx	4.0 g/kW-hr	0.123 lb/gal	40 CFR 89.112 Nonroad, Tier 3 225<kW<450
PM	0.2 g/kW-hr	6.2E-3 lb/gal	40 CFR 89.112 Nonroad, Tier 3 225<kW<450
CO	3.5 g/kW-hr	0.108 lb/gal	40 CFR 89.112 Nonroad, Tier 3 225<kW<450
VOC	1.3 g/kW-hr	0.040 lb/gal	40 CFR 89.112 Nonroad, Tier 1 225<kW<450
Tier 2 450<kW<560			**Reference**
NOx	6.4 g/kW-hr	0.197 lb/gal	40 CFR 89.112 Nonroad Tier 2 450<kW<560
PM	0.2 g/kW-hr	6.2E-3 lb/gal	40 CFR 89.112 Nonroad Tier 2 450<kW<560
CO	3.5 g/kW-hr	0.108 lb/gal	40 CFR 89.112 Nonroad Tier 2 450<kW<560
VOC	1.3 g/kW-hr	0.040 lb/gal	40 CFR 89.112 Nonroad, Tier 1 450<kW<560

Total Emissions

NOx		PM		CO		VOC	
lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season	lb/hr	ton/season
7.73	12.76	0.36	0.64	6.30	11.16	2.34	4.15

Hangar/Storage Building Heat Boiler

Rating	5	MMBtu/hr
Fuel Consumption	0.005	10^6scf/hr
	7.06	10^6scf/season
Heater use	50%	
	120	days/season

Emissions Factors			Reference
Boilers <100 MMBtu/hr - Natural Gas Combustion			
Filterable PM	1.9 lb/10^6 scf	1.86E-3 lb/MMBtu	AP42 Table 1.4-2, 9/98
Condensable PM	5.7 lb/10^6 scf	5.59E-3 lb/MMBtu	AP42 Table 1.4-2, 9/98
Total PM	7.6 lb/10^6 scf	7.45E-3 lb/MMBtu	AP42 Table 1.4-2, 9/98
NOx	100 lb/10^6 scf	9.80E-2 lb/MMBtu	AP42 Table 1.4-1, Small Boilers - Uncontrolled. Ver. 7/98
CO	84 lb/10^6 scf	8.24E-2 lb/MMBtu	AP42 Table 1.4-1, Small Boilers - Uncontrolled. Ver. 7/98
SO_2	0.6 lb/10^6 scf	5.88E-4 lb/MMBtu	AP42 Table 1.4-2, 9/98
VOC	3.2 lb/10^6 scf	3.14E-3 lb/MMBtu	AP42 Table 1.4-2, VOC - Methane. Ver. 7/98
Pb	0.0005 lb/10^6 scf	4.90E-7 lb/MMBtu	AP42 Table 1.4-2, 9/98

Emissions

NOx		PM		CO		VOC		Pb		SO2	
lb/hr	tps	lb/hr	tps	lb/hr	tps	lb/hr	tps	lb/hr	tps	lb/hr	tps
0.49	0.35	0.04	0.03	0.41	4.88	0.02	0.01	2.5E-06	1.8E-06	2.9E-03	2.1E-03

Assumptions		Reference
Natural Gas heat value		
1,020	MMBtu/10^6 scf	AP-42 Table 1.4-1 footnote a
7,700	MMBtu/gal	
Sulfur Content		AP-42 Table 1.4-2 footnote d
2000	gr/10^6 scf	

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: D. Steen		
	PROJECT NO: 180-23-1	PAGE: 1	OF: 1	SHEET: 5
ENGINEERING CALCULATIONS	SUBJECT: Vehicle Emissions	DATE: October 11, 2013		

AIR SCIENCES INC.

DENVER • PORTLAND

Truck Assumptions

2012
Ford F250
6.7 l
8 Cyl
Semi-Automatic
PT 4WD
Diesel
Alaska

Reference http://www.epa.gov/greenvehicles/Detailsresult.do?vehicle_ID=154854

MPG: 15 http://www.fuelly.com/car/ford/f-250%20super%20duty/2012

Given:

200	gal/wk
1	quantity
3,000	mi/wk

Emission Factors

NOx	0.2	g/mi
PM	0.02	g/mi
CO	7.3	g/mi
NMHC	0.195	g/mi

Reference http://www.epa.gov/greenvehicles/Detailsresult.do?vehicle_ID=154854

Pollutant	g/wk	ton/season
NOx	600	1.2E-2
PM	60	1.2E-3
CO	21,900	4.2E-1
NMHC	585	1.1E-2

Conversions

907,185	g/ton
17.57	wk/season

Attachment B: Engine Certificates

Certificate No. 85941-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

"F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00137**	**E2 / D2**	**1101** **1200**	**85941-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL

Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer	**Caterpillar, Inc.** **100 N.E. Adams Street** **Peoria, USA**
1.2	Place of engine build	**Lafayette, USA**
1.3	Date of engine build	**2012**
1.4	Place of pre-certification survey	**Lafayette, USA**
1.5	Date of pre-certification survey	**2012**
1.6	Engine type and model number	**3512**
1.7	Engine serial number	**LLB00137**
1.8	If applicable, the engine is a parent engine ☐ of the following engine family ☑	or a member engine ☑ engine group ☐
		3500PA10001
	As approved with GL approval no.	**97436-10 HH**
1.9	Individual engine or engine family / engine group details:	
1.9.1	Approval reference	**85941-13 HH**
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges	**1101 kW at 1200 rpm**
1.9.3	Test cycle(s)	**E2 / D2**
1.9.4	Parent engine(s) test fuel oil specification	**ISO-F-DMA**
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4	**9.9, 7.8 / 9.9, 7.8**
1.9.6	Parent engine(s) emission value (g/kWh)	**6.6 / 7.0**

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85941-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85941-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans-Jürgen Rein   Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Certificate No. 85942-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

"F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00138**	**E2 / D2**	**1101** **1200**	**85942-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer		**Caterpillar, Inc. 100 N.E. Adams Street Peoria, USA**	
1.2	Place of engine build		**Lafayette, USA**	
1.3	Date of engine build			**2012**
1.4	Place of pre-certification survey		**Lafayette, USA**	
1.5	Date of pre-certification survey			**2012**
1.6	Engine type and model number			**3512**
1.7	Engine serial number			**LLB00138**
1.8	If applicable, the engine is a parent engine of the following engine family	☐ ☑	or a member engine engine group	☑ ☐
				3500PA10001
	As approved with GL approval no.			**97436-10 HH**
1.9	Individual engine or engine family / engine group details:			
1.9.1	Approval reference			**85942-13 HH**
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges			**1101 kW at 1200 rpm**
1.9.3	Test cycle(s)			**E2 / D2**
1.9.4	Parent engine(s) test fuel oil specification			**ISO-F-DMA**
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4			**9.9, 7.8 / 9.9, 7.8**
1.9.6	Parent engine(s) emission value (g/kWh)			**6.6 / 7.0**

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85942-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85942-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

Issued at **Hamburg** the **12th** day of **September, 2013**

Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Certificate No. 85943-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

"F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00139**	**E2 / D2**	**1101** **1200**	**85943-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer	**Caterpillar, Inc.** **100 N.E. Adams Street** **Peoria, USA**
1.2	Place of engine build	**Lafayette, USA**
1.3	Date of engine build	**2012**
1.4	Place of pre-certification survey	**Lafayette, USA**
1.5	Date of pre-certification survey	**2012**
1.6	Engine type and model number	**3512**
1.7	Engine serial number	**LLB00139**
1.8	If applicable, the engine is a parent engine ☐ or a member engine ☑ of the following engine family ☑ engine group ☐	**3500PA10001**
	As approved with GL approval no.	**97436-10 HH**
1.9	Individual engine or engine family / engine group details:	
1.9.1	Approval reference	**85943-13 HH**
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges	**1101 kW at 1200 rpm**
1.9.3	Test cycle(s)	**E2 / D2**
1.9.4	Parent engine(s) test fuel oil specification	**ISO-F-DMA**
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4	**9.9, 7.8 / 9.9, 7.8**
1.9.6	Parent engine(s) emission value (g/kWh)	**6.6 / 7.0**

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85943-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85943-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans Jürgen Rein　　Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Certificate No. 85944-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

"F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00140**	**E2 / D2**	**1101** **1200**	**85944-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL

Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer	**Caterpillar, Inc.** **100 N.E. Adams Street** **Peoria, USA**
1.2	Place of engine build	**Lafayette, USA**
1.3	Date of engine build	**2012**
1.4	Place of pre-certification survey	**Lafayette, USA**
1.5	Date of pre-certification survey	**2012**
1.6	Engine type and model number	**3512**
1.7	Engine serial number	**LLB00140**
1.8	If applicable, the engine is a parent engine ☐ or a member engine ☑ of the following engine family ☑ engine group ☐	**3500PA10001**
	As approved with GL approval no.	**97436-10 HH**
1.9	Individual engine or engine family / engine group details:	
1.9.1	Approval reference	**85944-13 HH**
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges	**1101 kW at 1200 rpm**
1.9.3	Test cycle(s)	**E2 / D2**
1.9.4	Parent engine(s) test fuel oil specification	**ISO-F-DMA**
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4	**9.9, 7.8 / 9.9, 7.8**
1.9.6	Parent engine(s) emission value (g/kWh)	**6.6 / 7.0**

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85944-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85944-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Certificate No. 85945-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE "F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00141**	**E2 / D2**	**1101** **1200**	**85945-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer	**Caterpillar, Inc.** **100 N.E. Adams Street** **Peoria, USA**
1.2	Place of engine build	**Lafayette, USA**
1.3	Date of engine build	**2012**
1.4	Place of pre-certification survey	**Lafayette, USA**
1.5	Date of pre-certification survey	**2012**
1.6	Engine type and model number	**3512**
1.7	Engine serial number	**LLB00141**
1.8	If applicable, the engine is a parent engine ☐ or a member engine ☑ of the following engine family ☑ engine group ☐	**3500PA10001**
	As approved with GL approval no.	**97436-10 HH**
1.9	Individual engine or engine family / engine group details:	
1.9.1	Approval reference	**85945-13 HH**
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges	**1101 kW at 1200 rpm**
1.9.3	Test cycle(s)	**E2 / D2**
1.9.4	Parent engine(s) test fuel oil specification	**ISO-F-DMA**
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4	**9.9, 7.8 / 9.9, 7.8**
1.9.6	Parent engine(s) emission value (g/kWh)	**6.6 / 7.0**

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85945-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85945-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans Jürgen Rein

Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Certificate No. 85946-13 HH

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

"F"

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the
INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973,
as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention")

under the authority of the Government of the

REPUBLIC OF LIBERIA

by

GERMANISCHER LLOYD

Engine Manufacturer	Model Number	Serial Number	Test Cycle	Rated Power (kW) and Speed (rpm)	Engine Approval Number
Caterpillar, Inc.	**3512**	**LLB00142**	**E2 / D2**	**1101 1200**	**85946-13 HH**

THIS IS TO CERTIFY:

1. That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2. That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine, subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at **Hamburg** the **12th** day of **September, 2013**

GL

Germanischer Lloyd

Hans-Jürgen Rein

Benjamin Witt

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

RECORD OF CONSTRUCTION, TECHNICAL FILE, AND MEANS OF VERIFICATION

1 PARTICULARS OF THE ENGINE

1.1	Name and address of manufacturer	**Caterpillar, Inc.** **100 N.E. Adams Street** **Peoria, USA**		
1.2	Place of engine build	**Lafayette, USA**		
1.3	Date of engine build		**2012**	
1.4	Place of pre-certification survey	**Lafayette, USA**		
1.5	Date of pre-certification survey		**2012**	
1.6	Engine type and model number		**3512**	
1.7	Engine serial number		**LLB00142**	
1.8	If applicable, the engine is a parent engine ☐ of the following engine family ☑	or a member engine ☑ engine group ☐		
			3500PA10001	
	As approved with GL approval no.		**97436-10 HH**	
1.9	Individual engine or engine family / engine group details:			
1.9.1	Approval reference		**85946-13 HH**	
1.9.2	Rated power (kW) and rated speed (rpm) values or ranges		**1101 kW at 1200 rpm**	
1.9.3	Test cycle(s)		**E2 / D2**	
1.9.4	Parent engine(s) test fuel oil specification		**ISO-F-DMA**	
1.9.5	Applicable NOx emission limit (g/kWh), regulation 13.3, 13.4		**9.9, 7.8 / 9.9, 7.8**	
1.9.6	Parent engine(s) emission value (g/kWh)		**6.6 / 7.0**	

2 PARTICULARS OF THE TECHNICAL FILE

The technical file, as required by chapter 2 of the NOx Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1	Technical file identification/approval number	**85946-13 HH**
2.2	Technical file approval date	**2013-09-12**

3 SPECIFICATIONS FOR THE ON-BOARD NOX VERIFICATION PROCEDURES FOR THE ENGINE PARAMETER SURVEY

The specifications for the on board NOx verification procedures, as required by chapter 6 of the NOx Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1	Engine parameter check method:	
3.1.1	Identification/approval number	**85946-13 HH**
3.1.2	Approval date	**2013-09-12**
3.2	Direct measurement and monitoring method:	
3.2.1	Identification/approval number	-
3.2.2	Approval date	-

Alternatively the simplified measurement method in accordance with 6.3 of the NOx Technical Code 2008 may be utilized.

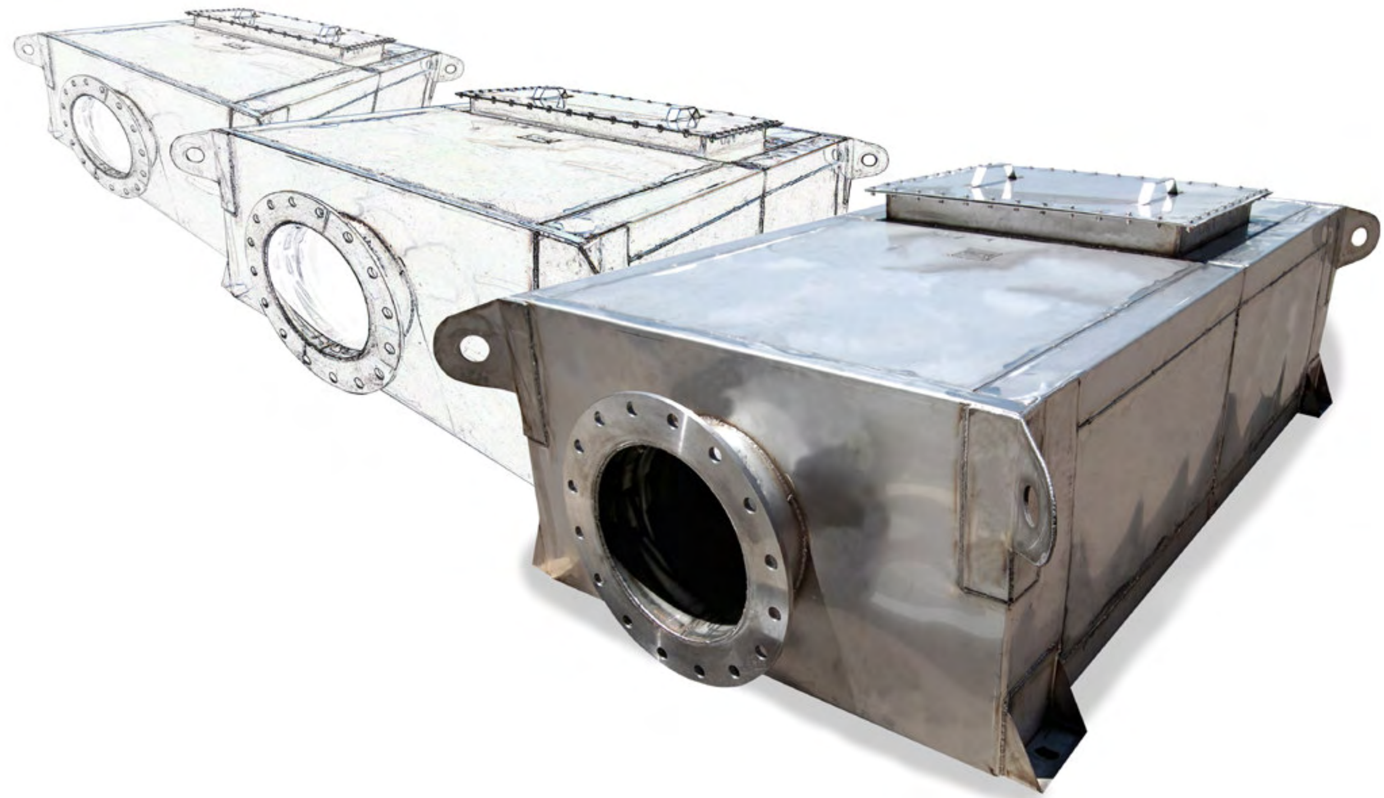
Issued at **Hamburg** the **12th** day of **September, 2013**

GL Germanischer Lloyd

Hans-Jürgen Rein   Benjamin Witt

Notes:
1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.
2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.
3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the NOx Technical Code 2008.

Attachment C: Vendor Specification Sheets



The CleanAIR PERMIT™ Filter System

Reduces PM, CO and HC

The CARB verified PERMIT™ Filter for diesel engines is designed to reduce diesel particulate matter (PM), carbon monoxide (CO) and hydrocarbons (HC). Applications for the passively-regenerating PERMIT™ Filter system include stationary diesel engines used for power generation and pumps.

The wall-flow filter is coated with a unique, high performance catalyst and housed within a stainless steel canister. The PERMIT™ Filter is available in standard add-on designs, muffler combination, and silencer configurations. In many large diesel engine applications, multiple PERMIT™ Filters are integrated into a silencer design, taking the place of a standard exhaust silencer. Filter/Silencer designs are available with critical and super-critical sound attenuation.

The PERMIT Filter (non-verified) is also available for some on- and off-road mobile applications, such as mining and construction equipment.

Reduces:
- PM greater than 85%
- HC up to 95%
- CO up to 95%

CARB Verified Level 3+
for Prime and Emergency Generators

505-474-4120 800-355-5513 information@cleanairsys.com

CleanAIR SYSTEMS

CARB Level 3+ Verified

- Verified for prime and emergency stationary engines
- PM reductions greater than 85%
- HC and CO reductions up to 95%
- Meets regulation compliance levels for PM reduction on stationary engines
- Passive regeneration with wall-flow ceramic filter
- Low regeneration temperature of 300°C
- Works with diesel engines: generators and pumps
    - Available for some on- and off-road applications that meet regeneration requirements

Customized to Client's Specifications

- Technical product and engineering assistance to determine the correct size and design to fit the application
- Custom engineering to fit space availability or enclosure dimensions
- Compact packaging – filters and silencing in one unit
- Available as standard add-on filter, filter/muffler or filter/silencer design
- Designed to customer inlet/outlet specs
- Choice of Industrial, Critical or Super-Critical Grade Sound Attenuation

Guaranteed Long-Life Construction

- All components produced by CleanAIR
- All stainless steel body using corrosion-resistant 304L steel inside and outside
- Double-walled, insulated construction
- Precious metal-based non-washcoat catalyst

No Health Risk

- Uses non-toxic, non-vanadium particulate filters

How the PERMIT™ Filter Works

The wall-flow design of the CleanAIR PERMIT™ Filter captures diesel PM as soon as the engine is started and continues through operation, dramatically reducing PM and visible black smoke.

Due to the PERMIT™ Filter's unique non-washcoat catalyst incorporated within the wall-flow filter, the captured PM is then oxidized into CO_2 while the engine is operating. This results in a passive, self-cleaning (or regenerating) filter without the need for manual intervention.

Emissions of carbon monoxide and hydrocarbons are also eliminated when exhaust gases interact with the filter's unique catalyst. Regeneration is dependent upon exhaust temperature, fuel sulfur level, duty cycle and engine load.

The easy-to-install, CARB verified CleanAIR PERMIT™ Filter works with all diesel stationary engines for compliance with air quality regulations and is available in many design configurations to meet customer needs and space availability.

Meet CARB Level 3+ Standards

with the

CleanAIR PERMIT Filter

Reduces:

- PM greater than 85%
- HC up to 95%
- CO up to 95%

CleanAIR SYSTEMS

505-474-4120 800-355-5513 information@cleanairsys.com
www.cleanairsys.com

PERMIT™ Filter Emissions Reduction Summary

Control Technology	Fuel	PM	HC	CO
PERMIT™ Filter System for Stationary Engines	ULSD (<15 ppm S)	Greater than 85%	90-95%	90-95%
	Biodiesel (<15 ppm S)	Greater than 85%	90-95%	90-95%

Results are fuel dependent and may vary with application.
Operating the filter using high sulfur fuels may have varying results.

Guidelines for PERMIT™ Filter Passive Regeneration

The following guidelines ensure engine operation adheres to verification parameters specified by ARB for passive regeneration of the PERMIT™ Filter:

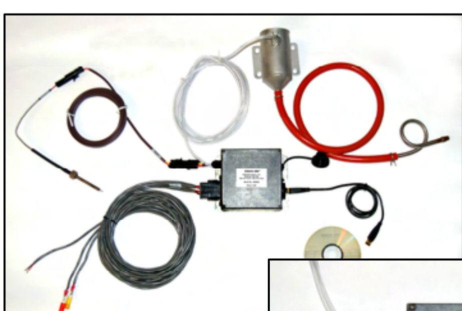
- At least 30% of the operating time the exhaust temperature is above 300°C and the engine load is above 40%
- Fuel sulfur content <15 ppm, ULSD
- Engine PM output of < 0.2 g/bhp-hr

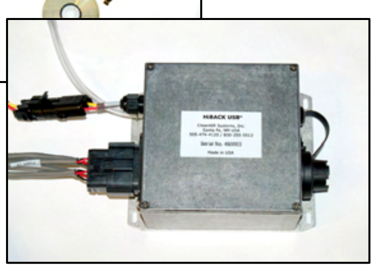
How Sulfur in Fuel Affects the PERMIT™ Filter Performance

The PERMIT™ Filter can operate using high sulfur fuel. However, lower regeneration temperatures and maximum performance are achieved when low sulfur fuels (<15 ppm S) are used. ARB verifications specify the use of ultra-low sulfur fuel with all verified filters.

CleanAIR HiBACK USB™ Data Logging and Alarm System

The HiBACK USB™ is a microprocessor-based data logger and alarm system used in conjunction with the CleanAIR PERMIT™ Filter System as both an alarm and a data logger to record time, backpressure and temperature data. It is the key component to ensuring the PERMIT™ Filter unit is working as intended and that the filter is not plugging up with particulate matter. The HiBACK USB™ unit can warn the operator of possible problems with excessive backpressure, can track the duty cycle of the engine and allow analysis for operation time, exhaust temperature and backpressure profiles. Data collected by the HiBACK USB™ can be downloaded to an Excel spread sheet on a computer for detailed analysis using optional software. *(Optional software sold separately. The HiBACK USB™ is required for warranty and verification of the PERMIT™ Filter.)*





2.

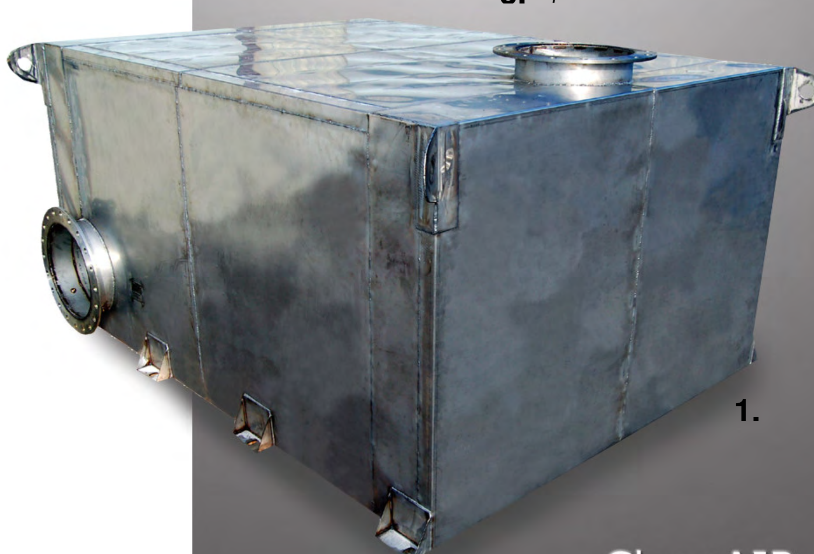
HiBACK™ USB Data logger and alarm system with software

System Components:

1. PERMIT™ Filter Silencer: double-walled, fully insulated stainless steel silencer body
   1a. - includes diesel particulate filters packaged inside of unit
2. HiBACK™ USB Data logger and alarm system with software
3. *Optional:* Custom-designed insulated blanket to reduce heat loss and optimize regeneration performance; available for exhaust piping, filter body and engine housing

1a. *PERMIT Filters inside of silencer unit*

3. *Optional insulated blanket*



1.

505-474-4120 800-355-5513

PERMIT™ Filter Package Designs for Stationary Engines

The CleanAIR Systems' PERMIT™ Filter is packaged in a 304L stainless steel shell and finished by bead blasting to give a highly corrosion-resistant product that will last for years. The packaged filter can be incorporated into many different configurations depending upon the application requirements. The most basic configuration is a packaged filter with cones on both inlet and outlet ends. Typical sound attenuation for this design is 12 dBA.

Replacement muffler designs are used for applications where space is too tight to add the filter separate from the existing muffler. Special inlet or outlet configurations and brackets can be used on the PERMIT™ Filter/Muffler combination that will allow the filter to replace an existing muffler. Typical sound attenuation for this design is 15-20 dBA.

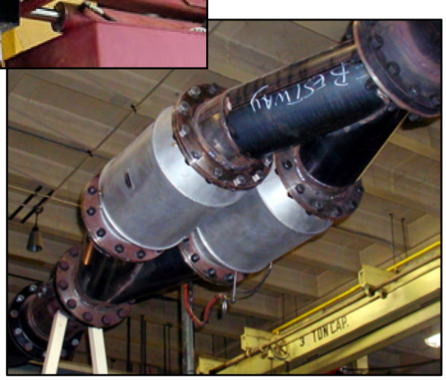
A filter/silencer replacement design is available for applications that require higher levels of sound attenuation or that require multiple PERMIT™ Filters. The corrosion-resistant stainless steel shell has a removable panel allowing complete access to the filters mounted inside. The fully-insulated, double-walled body also helps keeps surface temperature lower. The PERMIT™ Filter/Silencer is available in three sound reduction levels.

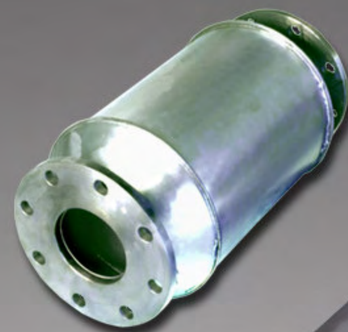
Silencer Type	Typical Attenuation
Industrial Grade	22 – 29 dBA
Critical Grade	27 – 35 dBA
Super Critical Grade	30 – 38 dBA

Optional Equipment for System:

- AeroCLEAN™ Filter Cleaning System for built up non-combustable ash
- Load Bank - increases engine load, optimizes filter performance
- Custom-designed insulating blankets – reduces heat loss, optimizes filter performance
- Extra filter unit – minimizes system down-time

To submit an online Request for Pricing, go to:
www.cleanairsys.com/rfp.asp





CleanAIR SYSTEMS

505-474-4120   800-355-5513   information@cleanairsys.com
www.cleanairsys.com

Attachment D: Preliminary Source Test Data

EPOD REMOVAL EFFICIENCY SUMMARY

Unit: **3512C**

Date: 4/24/2012

Inlet Stack Area, ft^2: 1.187

Outlet Stack Area, ft2: 0.442

T_{ref} (reference temperature), °F: 68

All loads remained steady, compared to previous testing days and configurations.

Urea Monitoring

	Test condition	985	Test condition	875	Test condition	825	Test condition	775	Test condition	700	Test condition	492	Test condition	775	Test condition	492
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
T_s (stack temperature), °F	736.5	691.5	735.0	680.0	727.5	685.0	724.3	683.1	720.3	682.1	701.8	656.8	724.3	683.1	701.8	656.8
GASEOUS SAMPLE DATA																
%O_2 (oxygen stack gas), % volume dry	11.400	11.300	11.700	11.500	11.800	11.670	12.000	11.800	12.140	11.980	12.700	12.500	11.800	11.600	12.500	12.300
%CO_2 (carbon dioxide stack gas), % volume dry	6.89	7.22	6.70	6.99	6.60	6.94	6.50	6.85	6.35	6.72	5.90	6.30	6.60	6.90	6.00	6.40
CO (carbon monoxide stack gas), ppm volume dry	25.20	2.33	30.00	2.21	34.30	2.30	42.20	2.29	58.00	2.30	153.70	2.20	50.20	2.20	150.30	2.30
NO (nitrogen oxide stack gas), ppm volume dry		105.00		107.00		108.00		113.30		115.60		117.98		119.10		116.90
NO_2 (nitrogen dioxide stack gas), ppm volume dry		25.20		27.00		29.70		30.40		32.33		38.85		33.20		43.40
NO_X (nitrogen oxides stack gas), ppm volume dry.	649.20	130.20	578.00	134.00	546.00	137.70	520.00	143.70	487.30	147.93	396.40	156.83	539.20	152.30	398.50	160.30
VOC (or NMHC, stack gas), ppm volume wet		0.13		0.05		0.06		0.06		0.09		0.13		0.05		0.05
NH3 (ammonia, stack gas), ppm volume wet		22.00		28.00		32.00		33.00		34.00		40.00		33.00		--
NH3 (ammonia, stack gas), ppm volume dry		24.48		31.04		34.53		35.61		36.69		41.94		35.61		--
SAMPLE TRAIN CALCULATIONS																
1j Q_{ds} (stack flow rate), dscfm	3,124	2,821	2,990	2,674	2,896	2,609	2,774	2,499	2,560	2,358	2,001	1,905	2,774	2,499	2,000	1,906
UNIT DATA																
Mechanical power output, kW	1036.8	1036.8	921.1	921.1	868.4	868.4	815.8	815.8	736.8	736.8	517.9	517.9	815.8	815.8	517.9	517.9
Electrical power produced, kWe	985.0	985.0	875.0	875.0	825.0	825.0	775.0	775.0	700.0	700.0	492.0	492.0	775.0	775.0	492.0	492.0
FUEL DATA																
Quantity of fuel used, gallons/hour	67.9	67.9	61.6	61.6	58.3	58.3	54.2	54.2	48.6	48.6	43.6	43.6	66.1	66.1		
GASEOUS EMISSIONS																
2e CO (carbon monoxide, stack gas), g/kW-hr	0.1502	0.0125	0.1926	0.0127	0.2263	0.0137	0.2839	0.0139	0.3986	0.0146	1.1746	0.0160	0.3377	0.0133	1.1484	0.0167
2g CO (carbon monoxide, stack gas), g/kWe-hr	0.1581	0.0132	0.2028	0.0134	0.2382	0.0144	0.2988	0.0146	0.4196	0.0153	1.2364	0.0169	0.3554	0.0140	1.2089	0.0176
2e NO_X (nitrogen oxides, stack gas), g/kW-hr	6.3561	1.1510	6.0967	1.2641	5.9174	1.3442	5.7464	1.4304	5.5008	1.5384	4.9760	1.8750	5.9578	1.5160	5.0017	1.9167
2g NO_X (nitrogen oxides, stack gas), g/kWe-hr	6.6907	1.2116	6.4176	1.3306	6.2289	1.4150	6.0488	1.5057	5.7903	1.6193	5.2379	1.9737	6.2713	1.5958	5.2650	2.0175
2e VOC (or NMHC, stack gas), g/kW-hr		0.0004		0.0002		0.0002		0.0002		0.0004		0.0006		0.0002		0.0002
2g VOC (or NMHC, stack gas), g/kWe-hr		0.0005		0.0002		0.0002		0.0002		0.0004		0.0006		0.0002		0.0002
2e NOX and NMHC (nitrogen oxides and NMHC, sta	6.3561	1.1515	6.0967	1.2643	5.9174	1.3444	5.7464	1.4307	5.5008	1.5387	4.9760	1.8756	5.9578	1.5162	5.0017	1.9169
2a NH_3 (ammonia, stack gas), ppm volume dry		24.48		31.04		34.53		35.61		36.69		41.94		35.61		--

Load	985.00	875.00	825.00	775.00	700.00	492.00	775.00	492.00
	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %
	Based on kW	Based on kW	Based on kW	Based on kW	Based on kW	Based on kW	Based on kW	Based on kW
CO	91.65	93.41	93.96	95.11	96.35	98.64	96.05	98.54
NO	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NO2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NOX	81.89	79.27	77.28	75.11	72.03	62.32	74.55	61.68
VOC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %	Removal Eff, %
	Based on kWe	Based on kWe	Based on kWe	Based on kWe	Based on kWe	Based on kWe	Based on kWe	Based on kWe
CO	91.65	93.41	93.96	95.11	96.35	98.64	96.05	98.54
NO	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NO2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
NOX	81.89	79.27	77.28	75.11	72.03	62.32	74.55	61.68
VOC	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Attachment E: January 11, 2012 Letter from Shell to EPA

Shell Exploration & Production

Shell
3601 C Street, Suite 1000
Anchorage, AK 99503
Tel. (907) 646-7112
Email Susan.Childs@Shell.com
Internet http://www.Shell.com/

Natasha Greaves
OCS/PSD Air Quality Permits
U.S. EPA - Region 10, AWT-107
1200 Sixth Avenue, Suite 900
Seattle, Washington, 98101

January 11, 2012

Re: *Frontier Discoverer* Source Tests
Shell OCS Exploration Program

On September 19, 2011, EPA issued Shell Gulf of Mexico Inc. (Shell) Prevention of Significant Deterioration Permits to Construct for the Noble Discoverer drill ship operations in the Chukchi and Beaufort seas. The PSD permits require measurement of emissions from most of the emission units on the Discoverer and on the Discoverer's associated fleet via source testing.

The purpose of this letter is two-fold. First, we request EPA concurrence with Shell's intent to measure at on-shore facilities emissions from certain engines not now on the Discoverer. Secondly, we request EPA concurrence that physical or contractual limitations imposed on engine operating capacity can be considered when defining 100 percent load (and, correspondingly, fractions of that 100 percent load). As explained below, we believe Shell's approach meets the intent of the permit while ensuring a safer and equally realistic testing process.

On-shore testing

Shell intends to test the main generator engines, the port crane engine, the boilers, and the incinerator on the Discoverer because these emission units are permanently installed. However, none of the other engines that require testing are currently onboard the drill ship; in fact, most of the other engines are portable and routinely removed from the drill rig at the end of each drill season.

The PSD permits require Shell to test certain engines prior to the beginning of the drill season. Because of other construction activities that will be undertaken at the same time on the Discoverer, and the limited deck space available for those activities as well as source test equipment, testing certain engines at an on shore site will simply allow for a higher level of safety for testing, and personnel during testing. Shell would maintain that the physical location of the equipment during testing should not be an issue here, as the operating range necessary to be maintained to confirm accurate testing will need to be maintained whether the engine is physically located on the Discoverer at the time of testing or not.

Shell therefore proposes to test the starboard crane engine, the Mud Line Cellar Hydraulic Power Unit engines, the Mud Line Cellar Air Compressor engines, the cementing engines and the C7 logging winch engine at an on-shore facility. It is likely that testing will take place at NC Machinery, south of Tukwila, Washington. Although engine-specific information will be included in test protocols, dynamometers or hydraulic flow restrictors are likely to be used to load these engines to the operating rates required by the permits.

Definition of engine load

The Discoverer PSD permits require Shell to measure emissions from the engines powering the main generators, mud line cellar compressor engines, hydraulic pressure unit engines, crane engines, and cementing and logging engines at multiple loads. However, a number of these engines power equipment that, for various reasons, preclude operating, and as an extension testing, the engine to its full rated capacity. In some other cases, where the emissions units are owned by others, there are contractual restrictions on the maximum allowable engine operating loads.

In both cases, Shell proposes to redefine the maximum operating rate of the engine (100 percent load) to reflect those restrictions. Partial load testing (e.g., 50% load or 80% load) would also be correspondingly adjusted relative to this redefined maximum load condition. Below please find explanations of why, and examples of how, this would work for the subject engines.

FD 1-6. Main Generators

Noble, the owner of the Discoverer, has established 800 kW as the maximum operating rate for the generators, and has installed an electrical distribution system with controls that limit the engines' operating rate accordingly. This operating rate is nearly 20 percent lower than the 988 kW nameplate rating on the engine. With this contractual and operational restriction in place, Shell submits that an engine operating rate that results in 800 kW output reflects the true 100 percent engine load to be encountered during our OCS drilling operations, and that the "100% load" source tests should take place at this restricted engine operating rate. Similarly, source tests at 75% and 50% load should be conducted at engine operating rates that generate 600 and 400 kW, respectively.

FD 14-15. Deck Cranes

Each of the deck cranes engines are rated at 365 HP. The PSD permit requires testing at 60-80% and 80-100% loads.

Crane engine testing is challenging, as the engine is only one part of the crane hoisting system. The maximum load on the system is defined by the boom capacity, which for the cranes on the Discoverer is much less than the hoisting capacity of the corresponding engine and winch. One hundred percent boom capacity for the cranes to be used on the Discoverer translates to about 310-320 HP of engine/winch capacity, which is below their nameplate capacity. Because the cranes cannot physically exceed the boom capacity, the engines are functionally limited to a lower load than their name plate rating. There is a boom radius-load indicator and alarm in the crane cabs that indicates when the load is approaching 100 percent of boom capacity. In this case, then, it is appropriate to consider the maximum load the engines will operate to be 320 HP. Thus, Shell proposes to define 100 percent load for these engines as 320 HP.

FD 12-13. Mud Line Cellar Hydraulic Power Unit Engines.

The MLC HPU engines are rated at 322 HP. The PSD permit requires testing at 50-70% and 80-100% loads.

These engines power hydraulic pumps that operate hydraulic motors on the MLC bit. The hydraulic motor capacity is limited to 150 gallons per minute at 2500 PSI, which translates to an engine load of about 218 HP. The energy load into the hydraulic motor cannot exceed this value. Given this physical limitation, Shell believes the functional maximum load the engine can operate is at 218 HP, and that we should consider this to be 100% load for testing.

We request EPA's written concurrence that testing the starboard crane engine, the Mud Line Cellar Hydraulic Power Unit engines, the Mud Line Cellar Air Compressor engines, the cementing engines and the C7 logging winch engine at an on-shore facility is consistent with the requirements of the Noble Discoverer PSD permits. We also request EPA's written concurrence that we can redefine 100 percent load for the main generators, the crane engines, and the Mud Line Cellar Hydraulic Power Unit engines as proposed above. Please contact Pauline Ruddy (907.771.7243) if you have questions or require additional information regarding these proposals.

Thank you,

Susan Child

Susan Childs
AK Venture Support Integrator, Manager

Cc: Pauline Ruddy, Shell
Lance Tolson, Shell
Keith Craik, Shell
Eric Hansen, ENVIRON