Willow Master Development Plan

Appendix E.3B
Air Quality Technical Support Documents

January 2023

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Willow Master Development Plan

Appendix E.3B.1
Air Quality Technical Appendix

January 2023

Air Quality Technical Support Document

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Willow Master Development Plan
Final Supplemental Environmental Impact Statement
Air Quality Technical Support Document

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United States Bureau of Land Management

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ACRONYMS AND ABBREVIATIONS

AAAQS	Alaska Ambient Air Quality Standards
AAB	Ambient Air Boundary
AAQS	Ambient Air Quality Standards
ACF	Alpine Central Processing Facility
ADEC	Alaska Department of Environmental Conservation
ANC	acid neutralizing capacity
ANCSA	Alaska Native Claims Settlement Act
AQRVs	air quality related values
AQTSD	Air Quality Technical Support Document
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BT1	Drill Site BT1
BT2	Drill Site BT2
BT3	Drill Site BT3
BT4	Drill Site BT5
BT5	Drill Site BT5
BTU	Bear Tooth Unit
CAMx	Comprehensive Air Quality Model with Extensions
CCF	cloud cover fraction
CD1	Colville Delta 1
CD4	Colville Delta 4
CD4N	Colville Delta 4 North
CD8	Colville Delta 8
CH_4	methane
CMAQ	Community Multiscale Air Quality
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPAI	ConocoPhillips Alaska, Inc.
CPF2	Central Processing Facility 2
DAT	deposition analysis threshold
ddv	delta deciview
DS3S	Drill Site 3S
DS3T	Drill Site 3T
dv	deciview
DVC	current design values
DVF	future-year design values
EC	elemental carbon
EDGAR	Emissions Database for Global Atmospheric Research
EPS3	Emissions Processing System version 3
EIS	Environmental Impact Statement
ENEWS	Eastern Northeast West Sak
FB	fractional bias
FE	fractional error
FLAG	Federal Land Mangers' Air Quality Related Values Work Group
FINN	Fire Inventory

g	gram
GEOS	Goddard Earth Observing System
GIS	Geographical Information System
GHG	greenhouse gas
GMT1	Greater Mooses Tooth – 1
GMT2	Greater Mooses Tooth – 2
GMTU	Greater Mooses Tooth Unit
HAP	hazardous air pollutant
HDD	Horizontal Directional Drilling
HI	Haze Index
IOA	Index of Agreement
ICBC	initial and lateral boundary conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
IP	infrastructure pad
kbbl/day	thousand barrels per day
kg/ha-yr	kilograms per hectare per year
km	kilometer
kmile	thousand miles
kWe	thousand watts
LSM	land surface model
m/s	meters per second
MCICA	Monte-Carlo Independent Column Approximation
MCY	million cubic yards
MEGAN	Model of Emissions of Gases and Aerosols from Nature
MEI	maximally exposed individual
MI	miscible injectant
mg/m^3	milligrams per cubic meter
MLE	most likely exposure
MISR	Multi-angle Imaging Spectro-Radiometer
Mm-1	inverse megameters
MPE	model performance evaluation
MTI	Module Transfer Island
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NCAR	National Center for Atmospheric Research
NCDC	National Climate Data Center
NEPA	National Environmental Policy Act
NH_4	ammonium
NMB	normalized mean bias
NME	normalized mean error
NO_2	nitrogen dioxide
NO_3	nitrate
NODC	National Oceanographic Data Center
NP	National Park
NSB	North Slope Borough
NPS	National Park Service
NPR-A	National Petroleum Reserve - Alaska
NPRPA	Naval Petroleum Reserve Production Act
NWS	National Weather Service

O_3	ozone
OC	organic carbon
OLM	ozone limiting method
OMI	ozone monitoring system
PBL	planetary boundary layer
PGM	photochemical grid model
PM_{10}	particulate matter with an aerodynamic diameter less than or equal to 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than or equal to 2.5 microns
POI	periods of interest
ppb	parts per billion
ppm	parts per million
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PSD	Prevention of Significant Deterioration
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
REL	reference exposure level
RfC	Reference Concentrations for Chronic Inhalation
RFFA	reasonably foreseeable future action
RMSE	root mean square error
RRF	relative response factor
RRTMG	Rapid Radiative Transfer Model for GCMs
SCAS	Spatial Climate Analysis Service
SEIS	Supplemental Environmental Impact Statement
sigma-w	vertical wind speed
sigma-theta	horizontal wind direction
SIP	State Implementation Plan
SMAT-CE	Software for Model Attainment Test - Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	sulfur dioxide
TOMS	Total Ozone Mapping Spectrometer
tpy	tons per year
TSD	Technical Support Document
TUV	total ultraviolet
URBOPT	urban option
US	United States
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VMT	vehicle miles traveled
VOC	volatile organic compound
WRF	Weather Research and Forecasting model
Willow MDP	Willow Master Development Plan
TAPS	Trans Alaska Pipeline System
WPF	Willow Processing Facility
WOC	Willow Operations Center
YSU	Yonsei University
$\mu g/m^3$	micrograms per cubic meter

1.0 INTRODUCTION

The Bureau of Land Management (BLM) is preparing an Environmental Impact Statement (EIS) for the Willow Master Development Plan (Willow MDP, or simply 'Project') in compliance with the National Environmental Policy Act (NEPA). The Alaska State Office serves as the lead office for the EIS. The EIS for the Willow MDP analyses the Project's environmental consequences.

The Willow MDP could result in air emissions from construction, drilling and completion of new wells, operation and maintenance activities, and processing, storage, and transfer of liquid and gas products. Willow MDP's impacts on air quality and air quality related values (AQRVs) are analyzed by Ramboll under the direction of BLM Alaska. This Air Quality Technical Support Document (AQTSD) for the Willow MDP provides a detailed description of the Project's estimated emissions, air quality impact assessment methods, analysis and resulting impacts. The intent of the AQTSD is to supplement the information provided in the EIS.

1.1 Willow Master Development Plan

The Willow MDP is an oil and natural gas development project proposed by ConocoPhillips Alaska, Inc. (CPAI). The CPAI notified BLM that they propose to explore and develop hydrocarbon resources from oil and gas leases owned by CPAI within the Northeast Planning Area of the National Petroleum Reserve – Alaska (NPR-A). The Willow MDP EIS addresses a series of infrastructure components that would be constructed over an approximately 10-year period for oil and gas development in the NPR-A. With the Project area, CPAI may submit permit applications for up to five drill sites, a central processing facility, an operations center (previously referred to as infrastructure pad), gravel access roads, an airstrip, module delivery via sealift barges, import/export pipelines, and gravel mine sites on federal land in the NPR-A. The construction and operation of these facilities require permits from BLM.

CPAI's purpose for the Project is the economic production and transportation to market of oil and gas resources from Bear Tooth Unit (BTU), while protecting important surface resources and ensuring safe operations. To serve this purpose, CPAI needs permit approval to enable construction of drill sites, access and infield roads, pipelines, a processing plant, and other ancillary facilities. The Willow MDP would produce multiphase product (oil, gas, and water) that would be carried by pipeline to new processing facilities at the Willow Processing Facility (WPF). Sales-quality crude oil produced at WPF would be transported to Colville Delta 4 North (CD4N) at Alpine, where it would tie into the existing Alpine Sales Oil Pipeline. From the tie-in point, it would be transported to the Kuparuk Sales Pipeline and to the Trans-Alaska Pipeline System (TAPS) for shipment to market.

The BLM Alaska State Office manages the affected public lands in accordance with the Federal Land Policy and Management Act of 1982 (FLPMA), which mandates that BLM consider multiple uses for the lands it administers. FLPMA requires BLM to consider the land's natural and cultural resources as well as its mineral resources when making land management decisions. BLM's responsibility extends to environmental protection, public health, and safety associated with oil and gas operations on public lands. In compliance with NEPA, BLM evaluates a range of alternatives and analyzes and discloses the environmental effects of the alternatives. For the Willow MDP, BLM has developed five alternatives and three options related to the Module Delivery[1]:

- Alternative A (No Action)
- Alternative B (Proponent's Project)
- Alternative C (Disconnected Infield Roads)
- Alternative D (Disconnected Access)
- Alternative E (Three-Pad Alternative)
- Module Delivery Option 1 (Atigaru Point Module Transfer Island)
- Module Delivery Option 2 (Point Lonely Module Transfer Island)
- Module Delivery Option 3 (Colville River Crossing)

Action alternatives (B, C, and D) presented in the Final EIS include variations on specific Willow MDP components (e.g., project access). The Willow MDP Supplemental EIS (SEIS) also includes Alternative E, a Three-Pad Alternative discussed below. Either of the three module delivery options could be combined with any of the action alternatives to provide the modules for the Project. The range of alternatives was developed to address the resource impact issues and conflicts identified during internal scoping with the BLM Interdisciplinary Team and external scoping with the public and cooperating agencies. Alternative E was developed to respond to the Alaska District Court's August 18, 2021 summary judgment order in the Willow litigation. The EIS analyzes and discloses impacts that would result from all four alternatives and three module delivery options. This AQTSD supplements information on the air quality and climate change impacts analyses reported in the EIS.

For the purposes of optimizing production efficiency in the future, CPAI evaluated connecting GMT2 with the WPF (CPAI, 2021). The Willow EIS air quality impact analysis accounts for the effect of potentially processing GMT2 produced fluids at the WPF as described below. If the development concept of connecting GMT2 to the WPF is implemented, during Willow construction, new infield pipelines would be constructed between GMT2 and the WPF. Additionally, power and fiber optic cables would be suspended beneath the pipelines from the WPF to GMT2 via messenger cable. There would be an increase in vehicular traffic during construction due to the additional construction of pipelines and vertical support members. The Willow EIS near-field air dispersion modeling accounts for the construction traffic increases to implement the additional processing capacity. There would be no change to the WPF size or to the capacity of fuel burning equipment at the WPF due to processing GMT2 production at the WPF (CPAI, 2021) as the equipment already account for the potential for additional production.

1.1.1 Alternative A (No Action)

Under the No Action Alternative, the Willow MDP would not be constructed; however, oil and gas exploration in the area would continue. The analysis of this alternative is included to provide a baseline

[1] Project modules would be transported to the vicinity of the Project Area by sea barge in the summer and stored until winter when the modules can be transported to the Project area over ice road. The exact location and method to store the modules are not yet finalized. Three module delivery options are assessed as part of the analysis and either option could be selected for any of the analyzed action alternatives.

for the comparison of impacts of the action alternatives (Section 6.6.2 of BLM NEPA Handbook H-1790-1; 40 CFR 1502.14(d)) (BLM, 2008).

1.1.2 Alternative B (Proponent's Project)

Under Alternative B, CPAI plans to drill 251 wells over a period of 10 years on five multi-well pads and to conduct drilling and development operations within the Project area on a year-round basis. The Project area shown in Figure 1.1-1 includes the full extent of the BTU and portions of the Greater Mooses Tooth Unit (GMTU) east toward the Colville River and north to include the offshore waters of Harrison Bay. Most of the proposed facilities associated with the Willow MDP are on leased federal lands within the northeastern portion of the NPR-A.

Supporting infrastructure would be in the GMTU, on un-unitized lands within the NPR-A, on lands owned by the Kuukpik Corporation, the Alaska Native Claims Settlement Act (ANCSA) village corporation for Nuiqsut, and on lands owned and managed by the State of Alaska. The proposed road corridor would tie into the access road in the GMTU to the east. Proposed pipelines would tie into existing pipeline infrastructure at CD4N, the Alpine Central Processing Facility (ACF), and the Kuparuk River Unit Central Processing Facility 2 (CPF2). Proposed pipelines cross lands owned by Kuukpik Corporation and the State of Alaska. A gravel site is proposed on federally managed lands within the GMTU and in un-unitized lands. In addition, infrastructure modules for the Project would be transported to the North Slope via sea barge. The method and location to transport the modules to the Project area still is under development. None of the proposed Willow facilities would be located on or near Native allotments or private land, except that the pipelines would use existing pipeline corridors, some of which are on private land.

Alternative B (Proponent's Project) would extend an all-season gravel road from the CPAI Greater Mooses Tooth-2 (GMT2) development southwest, paralleling Judy Creek toward the Project area (Figure 1.1-1). The access road would end at the WPF, and adjacent to an airstrip and Willow Operation Centre (WOC). Gravel infield roads would extend north and south of the access road to connect drill sites and Project infrastructure. Alternative B would construct 7 bridges (one on the access road extending from GMT2 and six on the infield roads). Infield (multiphase) pipelines would connect individual drill sites to the WPF and export/import pipelines would connect the WPF to existing infrastructure on the North Slope.

The proposed road alignment provides the shortest road access from the existing gravel road network in the GMTU to the Project facilities.

1.1.3 Alternative C (Disconnected Infield Roads)

Alternative C would have the same gravel access road between GMT2 and the Project area as Alternative B but would not include a gravel road connection from the WPF to Drill Site BT1 (BT1) (Figure 1.1-1).

With no gravel infield road between these two facilities, there would be no bridge across Judy Creek. A gravel infield road would connect BT1 with Drill Site BT2 (BT2) and Drill Site BT4 (BT4).

As there would not be a gravel road connection between the northern drill sites (BT1, BT2 and BT4) and the WPF and GMTU, additional equipment and infrastructure would be required under this Alternative.

A second operation center (North WOC) and associated airstrip, storage and staging facilities, and camp would be located near BT1 or BT2 to accommodate the personnel and materials transport between the North WOC and BT1, BT2, and BT4. A seasonal ice road would be constructed annually to allow for the movement of large equipment and consumable materials to the northern three drill sites. Infield pipelines would connect all drill sites to the WPF; an import pipeline would connect BT1, BT2, and BT4 to the WPF and export/import lines would connect the WF to existing infrastructure on the North Slope.

Under Alternative C, the WPF, South WOC, and airstrip would be located approximately 5 miles east of their location in Alternative B, near the GMTU and BTU boundary. The gravel access road would end at the WPF and a gravel infield road would continue to BT3, WOC, Project airstrip, and BT5.

1.1.4 Alternative D (Disconnected Access)

Alternative D would not be connected by an all-season gravel access road to GMTU (Figure 1.1-1); however, it would employ the same gravel infield roads as proposed under Alternative B. Under this alternative the WPF is co-located with drill site BT3. All other Project components would be the same as those described under Alternative B (e.g., drill sites, airstrip, water source) with variations to roads and only 6 bridges.

Due to the lack of gravel access road to GMTU, a seasonal ice road would be required to transport materials and supplies into the Project area. Also, since the Project area would not be connected to Alpine, additional facilities including a grind and inject facility; additional warehouse space; a wireline/coil maintenance shop; a light duty fleet shop; storage and equipment laydown space; and biocide, methanol, and corrosion inhibitor tanks at the WOC would be required. There would be two additional Class I injection wells required at the WOC in addition to the two required for all alternatives. Larger permanent gravel pad space would also be required at both the WPF and WOC.

1.1.5 Alternative E (Three-Pad Alternative [Fourth Pad Differed])*

Alternative E includes a WPF and four drill sites. Should BLM select Alternative E in its ROD, only three drill site pads (BT1, BT2, and BT3) would be authorized for construction, though a fourth drill site pad (BT5) may be authorized at a later time. Alternative E includes all four drill site pads for analysis to identify the most significant impact case and to prevent segmenting the Willow MDP Supplemental EIS' NEPA analysis.

Additional support facilities include a WOC, four valve pads, four pipeline pads, five water source access pads at lakes, a gravel mine, gravel roads connecting the project to GMTU and all drill sites to the WPF, an airstrip, and three subsistence boat ramps (Figure 1.1-1).

Project facilities proposed at the WPF, drill sites, gravel pads, and WOC for Alternative E are generally the same as Alternative B, except that Alternative E would not include construction of drill site BT4, and drill site BT2 would be located farther north than under Alternative B. Also, BT5 would be located east of the location proposed for other action alternatives to avoid two yellow-billed loon nest setbacks; this would also reduce the length of the BT5 road and infield pipelines.

Alternative E would have a total of approximately 219 wells (CPAI, 2021). Eliminating drill site BT4 from the project design would reduce the gravel footprint, although the BT1 and BT2 drill sites would be approximately 100 feet longer to accommodate additional wells (up to 80 wells) to access portions of the resource that would otherwise be accessed from BT4. Eliminating BT4 from the project design would reduce the total length of infield lines, gravel and ice roads, and reduce freshwater use.

1.1.6 Module Delivery Options

Sealift barges would be used to deliver processing and drill site modules to the North Slope. Two of the three module delivery options analyzed would deliver modules to a nearshore staging area (NSA) referred to as a Module Transfer Island (MTI) west of the Colville River, either at Atigaru Point or Point Lonely, and use ice roads to reach the Willow Development. The third module delivery option (Colville River Crossing) would use existing gravel roads and land-based ice road for delivery.

Option 1: Atigaru Point MTI

Option 1 (Atigaru Point Module Transfer Island) would include the construction of a gravel MTI, with a design life of 5 to 10 years, near Atigaru Point in Harrison Bay (Figure 1.1-2). The MTI would be in State of Alaska-owned waters approximately 2 miles north of Atigaru Point. Modules would be offloaded onto the MTI and then transported to the Plan Area on ice roads.

Option 2: Point Lonely MTI

Option 2 (Point Lonely Module Transfer Island) would include the construction of an MTI, with a design life of 5 to 10 years, at Point Lonely (Figure 1.1-2). The MTI would be in State of Alaska-owned waters approximately 15 miles east of Smith Bay near the Point Lonely Distant Early Warning site. Key differences from Option 1 (Atigaru Point Module Transfer Island) include the length of ice road needed to reach the MTI location, and the use of existing gravel at Point Lonely to facilitate module offload.

Option 3: Colville River Crossing

Option 3 (Colville River Crossing) would use the existing Oliktok Dock for sealift module delivery and then move the modules to the Plan Area via an ice-road crossing of the Colville River near Ocean Point (Figure 1.1-3). Option 3 would use existing gravel roads and land-based ice roads for transporting modules along a southerly route from Oliktok Dock, via Kuparuk drill site 2P (DS2P) and GMT2, to the WPF.

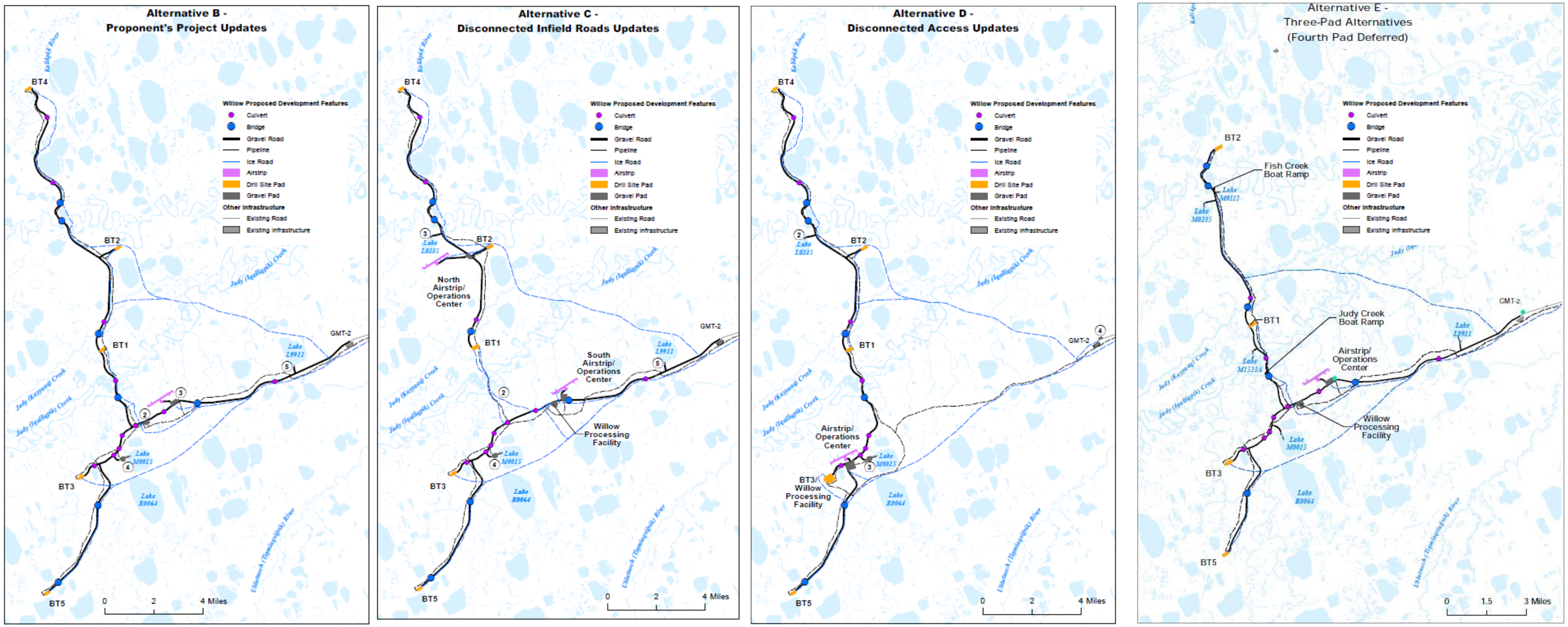

Figure 1.1-1 Project Features Map for Alternatives B, C, D and E

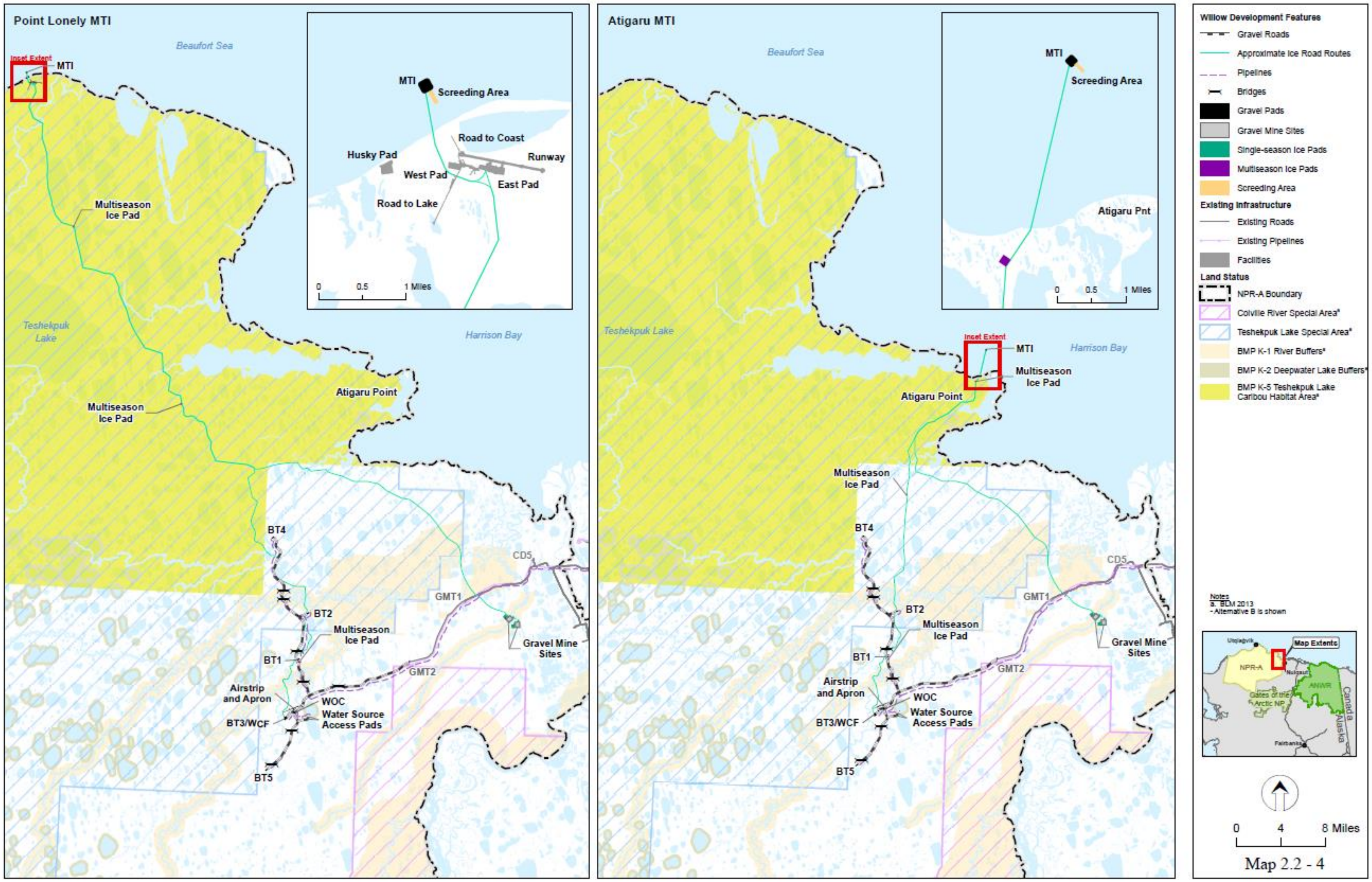

Figure 1.1-2 Module Delivery Options 1 and 2 Map

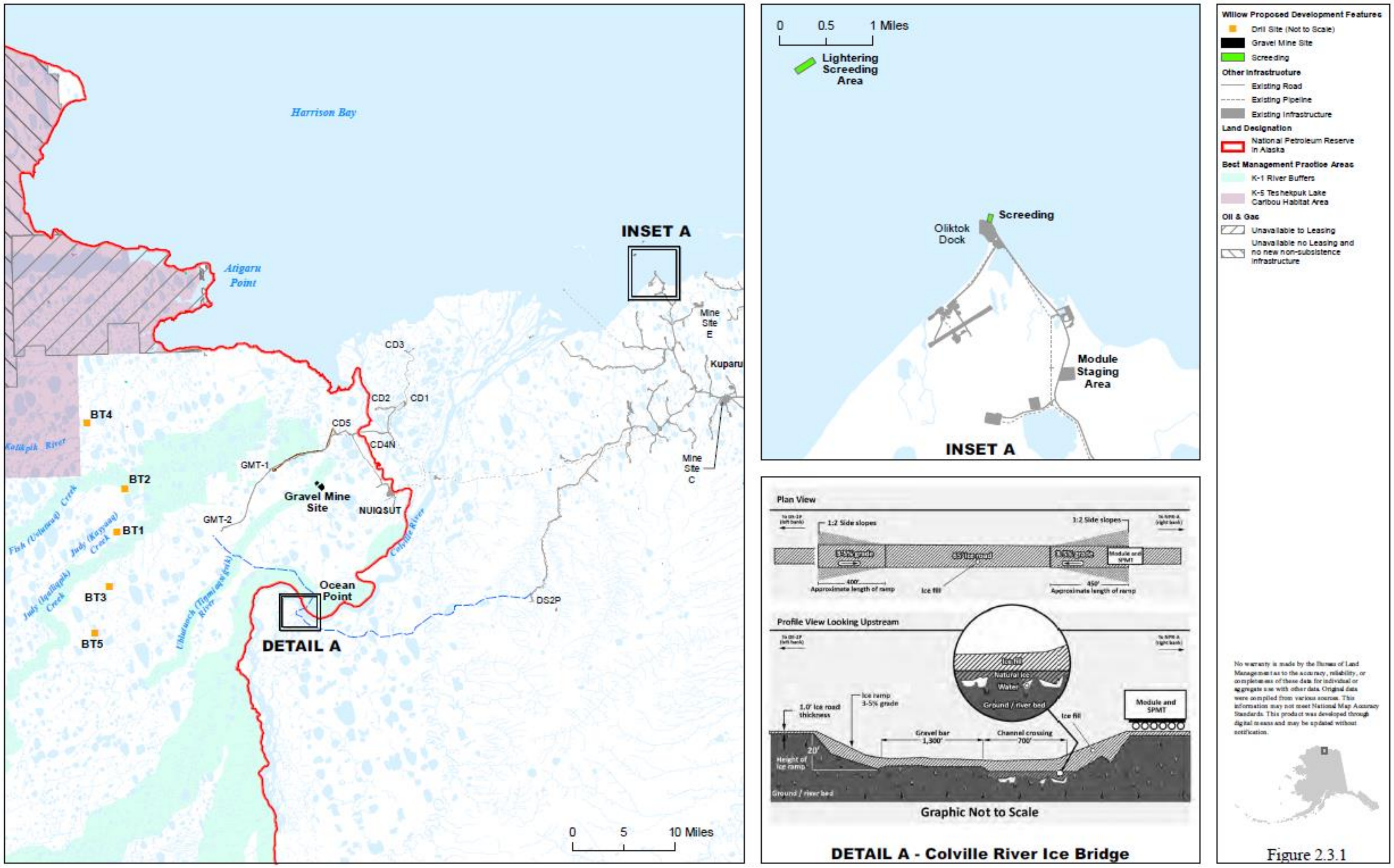

Figure 1.1-3 Module Delivery Options 3 Map

1.2 Air Quality Assessment Overview

BLM Alaska convened Air Resource Specialists at key cooperating agencies to review and comment on the analyses for the Willow MDP EIS. The Agency Air Resource Specialists included representatives from USEPA, National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), Alaska State Department of Environmental Conservation (ADEC), the Bureau of Ocean and Energy Management (BOEM) and others. The Agency Air Resource Specialists reviewed and commented on the Willow MDP Air Modeling and Assessment Protocol, referred to hereafter as "Willow MDP Protocol (Ramboll 2018)". Some air resource specialists also participated in the review of air quality and AQRV impact analyses documented in this AQTSD for the Willow MDP.

As prescribed in the Willow MDP Protocol (Ramboll 2018), the USEPA guideline air quality model, AERMOD, is used to estimate air quality impacts in the near-field (within 50 kilometers (km)) of the Willow MDP while the Comprehensive Air Quality Model with Extensions (CAMx) modeling system is used to estimate regional impacts (approximately within 300 km). AERMOD is used to predict the potential localized impacts while CAMx is to predict the potential impacts on larger spatial scales that reflect the long-range transport and chemical reaction of atmospheric pollutants. This section provides an overview of the modeling objectives and the approach used to assess impacts to air quality and AQRVs for the Willow MDP.

1.2.1 Modeling Objective

The objective of this analysis is to estimate the potential Willow MDP and cumulative air quality and ARQV impacts for each action alternative. Air quality and AQRV impacts were assessed within the vicinity of the Project area, at discrete sensitive receptor locations, and at three federally managed areas with receptor locations of interest, referred to hereafter as the "three assessment areas": Arctic National Wildlife Refuge (ANWR), Gates of the Arctic National Park, and Noatak National Preserve. Specifically, the air quality modeling includes:

- An assessment of air quality impacts for criteria pollutants, including ozone (O_3), particulate matter (PM) with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$), PM with an aerodynamic diameter less than or equal to 10 microns (PM_{10}), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO)
- Hazardous Air Pollutant (HAP) impact assessment of benzene, toluene, ethylbenzene, xylene (collectively referred to as BTEX), n-hexane, and formaldehyde[2]; and
- An AQRV analysis to assess changes in visibility and atmospheric deposition.[3]

The near-field impact assessment is conducted with the AERMOD model to assess criteria pollutants (excluding ozone and lead) and the hazardous air pollutants (HAPs) listed above within 50 km of the Willow MDP. The regional impact assessment is conducted with the CAMx modeling system to assess

[2] These six HAPs were selected for analysis as BTEX and n-hexane are present in the raw natural gas and oil. Formaldehyde is formed from the combustion of small chain alkanes that predominate in natural gas.
[3] An analysis of the change to ANC of sensitive lakes is not conducted since lake data to assess the change in ANC are not currently available.

criteria pollutants (except lead) and AQRVs within the vicinity of the Project area and at three assessment areas within 300 km of the Project area.

In accordance with Required Operating Procedure (ROP) A-7 described in Table 3.3.4 in Section 3.3 *Air Quality*, BLM may require additional air quality modeling for analyzing project direct, indirect, or cumulative impacts on air quality, air quality-related values, and hazardous air pollutants. BLM may require air quality modeling depending on the following:

* The magnitude of potential air emissions from the project

* Proximity to a federally mandated Class I area

* Proximity to a population center

* Proximity to a non-attainment or maintenance area

* Meteorological or geographic conditions

* Existing air quality conditions

* Magnitude of existing development in the area

* Issues identified during the NEPA process

BLM will determine the information required for a project-specific modeling analysis through the development of a modeling protocol for each analysis.

BLM may require the proponent to provide an emissions reduction plan that includes a detailed description of permittee-committed measures to reduce project-related air pollutant emissions.

1.2.2 Modeling Description

*Near-Field Modeling**

AERMOD (USEPA 2017 and 2018) is the current USEPA-approved regulatory model to assess near-source effects of primary pollutants. The AERMOD model was developed by the American Meteorological Society/USEPA Regulatory Model Improvement Committee (AERMIC) and was intended to incorporate an improved understanding of the planetary boundary layer (PBL) meteorology into air dispersion calculations. The AERMOD modeling system also includes the meteorological preprocessor AERMET, which was used for processing the meteorological data for the Project analysis. AERMOD is a refined dispersion model for simple and complex terrain for receptors within 50 km of a modeled source. For the Willow MDP EIS, AERMOD has been used to assess near-field impacts of criteria pollutants (except ozone and lead), and a subset of HAPs (as listed in Section 1.2.1 “Modeling Objective”) near the Project area for comparison to applicable National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS) (collectively referred to as Ambient Air Quality Standards [AAQS]) and Prevention of Significant Deterioration (PSD) Class II increments.

The most recent version of AERMOD available at the time of the Project analysis (version 22112) (USEPA 2022a) was used for the near-field modeling analysis of Alternative E. Although the near-field modeling analyses performed for Alternatives B, C, and D and for the Module Delivery scenarios that are presented in the AQTSD (Appendix E.3B) utilized AERMOD version 19191, the changes made to AERMOD version 22112 as documented by USEPA (2022b) are expected to have negligible differences on model-predicted Project impacts, from those that were modeled using AERMOD version 19191, given the modeled Project sources and model settings.

Action alternatives (Alternative B, C, D and E) were modeled in the near-field modeling analysis. The modeled Project features represented the actual features under each of those alternative with one exception. The proponent (CPAI) included some design changes in Alternatives B and D that resulted in small changes to the locations (moved by 0.25 miles or less) and size, shape and orientation of the WPF, Willow Operations Center (WOC), and airstrip. Following discussions with the Agency Air Resource Specialists, the original configuration was modeled as it was determined that it would provide an acceptable assessment of the revised Project design because the changes were expected to have a minimal effect on the air quality assessment conclusions.

*Regional Modeling**

CAMx is a publicly available state-of-the-art photochemical modeling system. It has been used to analyze air quality impacts in previous modeling studies in the U.S., including State Implementation Plans (SIPs), NAAQS assessments (Tyler Fox 2017) and other EISs, and to support USEPA rulemaking. The BOEM Arctic Air Quality Modeling Study (referred to as the BOEM modeling platform or BOEM study) offers a CAMx modeling platform that serves as the starting point to assess regional air quality and AQRVs for the Willow MDP EIS. The BOEM study is intended to facilitate air resource analyses for federal and state stakeholders as part of the NEPA process for offshore oil and gas development activities. The BOEM modeling platform was selected for this project since it provides input photochemical modeling data for the region suitable for this study. The Weather Research and Forecast (WRF) Model and the Sparse Matrix Operator Kernel Emissions (SMOKE) models provide meteorological and emissions inputs respectively to the CAMx photochemical grid model. Collectively, these three models are referred as the CAMx modeling system. The CAMx modeling system applied for this assessment includes:

- WRF (version 3.6.1): State-of-science mesoscale numerical weather prediction system capable of supporting urban- and regional-scale photochemical and regional haze regulatory modeling studies.
- SMOKE (version 3.6): Emissions modeling system that generates hourly, gridded, and speciated emissions inputs of onroad, nonroad, area, point, fire, biogenic emissions and other sources for photochemical grid models.

CAMx (version 6.5): State-of-science 'One-Atmosphere' photochemical grid model capable of addressing ozone and other criteria pollutants, visibility, and atmospheric deposition. The latest version of CAMx (v7.20) was not available at the time the regional modeling was performed. The changes made to CAMx version 7.20 (Ramboll 2022) are expected to have negligible effects on the model-predicted Project impacts given the model settings and Project sources considered in this analysis.

The CAMx modeling system is applied to model the air quality in the following emissions scenarios:

- **2012 Base Year**. The 2012 Base Year is based on the BOEM emissions inventory, described in more detail in Section 2.3.2 "Regional Emissions Inventories". The 2012 Base Year simulation provides a retrospective assessment of model performance relative to measured 2012 ambient air quality conditions. Results from this simulation are also used in the estimation of future year cumulative visibility impacts (see Section 4.5.4.2 "Cumulative Impacts").

- **Cumulative No Project Scenario**. This is a scenario with all cumulative sources except the Project sources. The Cumulative No Project Scenario is based on the future year scenario developed for the BOEM modeling platform and includes updated estimates of Reasonably Foreseeable Future Action (RFFA) emissions without the contribution from the Project-specific emissions. This scenario includes emissions from all projects other than the Willow MDP to provide a baseline for the comparison of impacts of the action alternatives. The emissions inventory for this analysis is described in more detail in Section 2.2 "Cumulative Emissions for the Willow Alternatives". The effects of long-range transport are modeled through the use of boundary conditions (background concentrations).
- **Cumulative Alternative B (Proponent's Project) Scenario**. CPAI developed a project-specific emissions inventory for the Willow MDP EIS. BLM reviewed and revised the emissions inventory. To assess future cumulative impacts in Alternative B, the Alternative B emissions inventory is modeled along with the RFFAs and regional sources included in the Cumulative No Project Scenario. The effects of long-range transport are modeled through the use of the same boundary conditions used in the previous scenario.
- **Cumulative Alternative C (Disconnected Infield Access) Scenario**. BLM developed an emissions inventory for Alternative C (see Section 2.1.4 "Alternative C") based on the emissions inventory for Alternative B. To assess future cumulative impacts for Alternative C, the Alternative C emissions inventory is modeled along with the RFFAs and regional sources included in the Cumulative No Project Scenario. The effects of long-range transport are modeled through the use of the same boundary conditions used in the other scenarios.

BLM developed an emissions inventory for Alternatives D and E as well (see Sections 2.1.5 "Alternative D" and 2.1.6 "Alternative E"). Willow MDP NOx emissions in Alternative D are lower than Alternative C (see Sections 2.1.4 "Alternative C" and 2.1.5 "Alternative D"). Willow MDP NOx emissions in Alternative E are lower than Alternative B (see Sections 2.1.3 "Alternative B" and 2.1.6 "Alternative E"). Therefore, as discussed with the Agency Air Resource Specialists, Alternatives D and E were not modeled in the regional modeling and their impacts are expected to be lower than those of Alternative C and B respectively. Similarly, Alternative E was not modeled in the regional modeling as its regional impacts are expected to be lower or comparable to those of Alternative B considering the differences in emissions between those two alternatives (see Sections 2.1.3 and 2.1.6).

The potential air quality impacts due to the Project are derived using a "brute force" method by subtracting the Cumulative No Project Scenario from the Cumulative Alternative B or C Scenario. The CAMx model results were used to assess Project and cumulative effects on:

1. NAAQS, AAAQS and PSD Class II increments
2. Visibility
3. Atmospheric deposition rates of sulfur (S) and nitrogen (N)

1.2.3 Overview of Modeling Approach and Thresholds for Comparison

National and Alaska Ambient Air Quality Standards

NAAQS and AAAQS are shown in Table 1.2-1 for all applicable criteria pollutants and averaging periods.[4] Note that the standards are either in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) and micrograms per cubic meter (µg/m^3).

Table 1.2-1 NAAQS and AAAQS Values

Pollutant	Average Time	NAAQS[a]	AAAQS[b]	Form of the Standard
CO	1-hour	35 (ppm) (40,000 µg/m^3)	40 (mg/m^3) (40,000 µg/m^3)	Not to be exceeded more than once per year
	8-hour	9 ppm (10,000 µg/m^3)	10 mg/m^3 (10,000 µg/m^3)	Not to be exceeded more than once per year
NO_2	1-hour	100 (ppb) (188 µg/m^3)	188 µg/m^3	98th percentile of 1-hour daily maximum concentrations, averaged over three years
	Annual	53 ppb (100 µg/m^3)	100 µg/m^3	Annual mean
SO_2	1-hour	75 ppb (196 µg/m^3)	196 µg/m^3	99th percentile of 1-hour daily maximum concentrations, averaged over three years
	3-hour	0.5 ppm (1300 µg/m^3)	1300 µg/m^3	Not to be exceeded more than once per year
	24-hour	NA	365 µg/m^3	Not to be exceeded more than once per year
	Annual	NA	80 µg/m^3	Annual mean
Ozone	8-hour	0.070 ppm (137 µg/m^3)	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
PM_{10}	24-hour	150 µg/m^3	150 µg/m^3	Not to be exceeded more than once per year on average over three years
$PM_{2.5}$	24-hour	35 µg/m^3	35 µg/m^3	98th percentile avg over three years
	Annual	12 µg/m^3	12 µg/m^3	Annual mean averaged over three years

[a] 40 CFR Part 50
[b] 18 AAC 50.010

Prevention of Significant Deterioration Increments

Project impacts were assessed relative to PSD increments (shown in Table 1.2-2) for informational purposes. It is important to note that a PSD increment assessment is the jurisdiction of ADEC and the proposed analysis differs from a formal increment consumption assessment in several important ways:

[4] As described in the Willow MDP Protocol (Ramboll 2018), both federal and state ambient air quality standards include lead and state standards include ammonia; however, neither lead nor ammonia was assessed due to low emission rates of these pollutants. Willow MDP combustion sources are either diesel- or natural gas-fired. Diesel fueled combustion sources contain only trace amounts of lead, if any at all. Natural gas fueled combustion sources do not contain any lead. Lastly, the proposed Willow MDP equipment produces negligible ammonia emissions.

1. It has not been determined that Project emissions would trigger PSD permitting requirements. Such an assessment would be conducted as part of the air quality permitting preconstruction process as part of New Source Review Clean Air Act permitting requirements.
2. If PSD permitting and associated modeling analyses are required, the increment consumption analysis would only assess Project emissions that are required to be assessed; however, this assessment of Project impacts includes all Project emissions sources which would result in a conservatively high estimate of potential increment consumption.

Modeled Project impacts due to the action alternatives are compared to PSD increments shown in Table 1.2-2. Near-field Project impacts at the Nuiqsut receptor location and far-field Project impacts at three assessment areas were compared to PSD increments.

Table 1.2-2 PSD Increments for Class II Areas

Pollutant	Average Time	Class II PSD Increment[1]
NO_2	Annual	25 μg/m^3
SO_2	3-hour	512 μg/m^3
	24-hour	91 μg/m^3
	Annual	20 μg/m^3
PM_{10}	24-hour	30 μg/m^3
	Annual	17 μg/m^3
$PM_{2.5}$	24-hour	9 μg/m^3
	Annual	4 μg/m^3

[1]Referenced from 40 CFR Part 52 Subpart A

Hazardous Air Pollutant Thresholds of Comparison

Model-predicted and background measured 1-hour concentrations of HAPs were assessed against the USEPA Reference Exposure Levels (RELs) shown in

. Emissions were calculated for benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde. Acute RELs are defined as concentrations at, or below which, no adverse health effects are expected. No RELs are available for ethylbenzene or n-hexane; instead, Acute Exposure Guideline Levels (AEGLs) have been used as thresholds. In addition, exposures were assessed for 8-hour average impacts. RELs and relevant exposure guidelines were obtained from USEPA's Air Toxics Database (USEPA 2021b).

Table 1.2-3 Air Toxic Acute and Reference Exposure Levels[1]

Select HAPs	Acute REL (mg/m^3)	AEGLs (mg/m^3)
Benzene	0.027	29
Toluene	5	250
Ethyl benzene	--[2]	140[2]
Xylene	22	560
n-Hexane	--[2]	10,000[2]
Formaldehyde	0.055	1.1

1 USEPA Dose-Response Assessment for Assessing Health Risks Associated with Exposure to Hazardous Air Pollutants - Table 2 (USEPA 2021b).

2 No REL available for these HAPs. Values shown are from acute exposure guideline levels for mild or moderate effects (USEPA 2021b).

In addition, modeled long-term (annual) concentrations were assessed against non-carcinogenic RfCs for chronic inhalation (USEPA 2021c). A Reference Concentration for Chronic Inhalation (RfC) is defined by the USEPA as the threshold at which no long-term adverse health effects are expected. Annual modeled air toxic concentrations were compared directly to the non-carcinogenic chronic RfCs shown in Table 1.2-4. For the carcinogenic HAPs being analyzed (benzene, ethylbenzene, and formaldehyde), cancer risks were also calculated and assessed against a 1-in-1 million cancer threshold. The threshold range was determined from the Superfund National Oil and Hazardous Substances Pollution Contingency Plan (U.S. Government Printing Office 2011), which states that “For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response.” The thresholds 10^{-4} and 10^{-6} correspond to a level of 1 in 10,000 and 1 in 1 million, respectively.

Cancer inhalation risk due to long-term exposure to respective air toxic was calculated by multiplying the annual modeled concentration by the cancer unit risk factor and multiplying this product by an applicable exposure adjustment factor, as shown in Table 1.2-5. These exposure factors are intended to represent the ratio of projected exposure time to 70 years. The adjustment factors represent two assessments: the maximum exposed individual (MEI) and the maximum likelihood estimate (MLE). To estimate impacts for the MEI, the maximum annual concentration from all modeled meteorological years were used to calculate the cancer inhalation risk while to estimate impacts for the MLE, the average annual concentration from all modeled meteorological years were used to calculate the cancer inhalation risk. The only receptor where the cancer risk was calculated is the community of Nuiqsut where individuals would be potentially exposed on a long-term basis. The calculated cancer risk was compared to a risk range of one in a million (USEPA, 2006a).

Table 1.2-4 Air Toxic Non-Carcinogenic Chronic Reference Concentrations

Select HAPs	Non-Carcinogenic Chronic RfC (mg/m^3)[1]
Benzene	0.03
Toluene	5.0
Ethyl benzene	0.26
Xylenes	0.1
n-Hexane	0.7
Formaldehyde	0.0098

1 USEPA Dose-Response Assessment for Assessing Health Risks Associated with Exposure to Hazardous Air Pollutants - Table 1 (USEPA 2021c).

Table 1.2-5 Cancer Unit Risk factors and Exposure Adjustment Factors for Select HAPs

Pollutant	Cancer Unit Risk Factors ($1/(\mu g/m^3)$)[1]	Exposure Adjustment Factor[2]
Benzene	7.8E-06	0.43
Ethylbenzene	2.5E-06	
Formaldehyde	1.3E-05	

[1]Values referenced from USEPA, 2021c

[2]The MLE scenario assumes the same exposure as the MEI. The MEI scenario assumes that the individual is at home 100% of the time for the life of the Project. The life of the Project is assumed to be 30 years (i.e., an assumed typical life of a project), corresponding to an adjustment factor of 30/70 =0.43

In addition to the individual HAP carcinogenic assessment discussed in above sections, a cumulative carcinogenic assessment was performed. The assessment described in this section is unique in that it considered the potential combined effects of multiple carcinogenic agents emitted. It is possible that cancer risks due to the individual carcinogens emitted (benzene, ethylbenzene, and formaldehyde) may compound and overlap during specific meteorological conditions. The assessment included calculating a total cancer risk (for comparison to the 1-in-1 million threshold). For each HAPs impact assessment modeled configuration, the following process was used with these calculations:

1. For each of the three carcinogenic pollutants (benzene, ethylbenzene, and formaldehyde), the maximum modeled annual concentration over the 5 years modeled at the Nuiqsut receptor was determined.
2. The individual cancer risk for each of the three pollutants was obtained by multiplying the maximum concentration by the pollutant's respective unit risk factors and exposure adjustment factors (found in Table 1.2-5).
3. The individual cancer risks from each pollutant were added to estimate the total cancer risk.

This assessment conservatively takes the highest modeled impact over five years' worth of meteorology data. However, it is important to remember that it is uncertain how cancer risks associated with multiple carcinogens would actually compound (i.e., combine). Here, it is assumed that they would be additive.

Air Quality Related Values

Cumulative and Project impacts on AQRVs were assessed at three assessment areas with the far-field model.

<u>Deposition</u>

Project nitrogen and sulfur impacts were compared to Deposition Analysis Thresholds (DAT) of 0.005 kilograms per hectare per year (kg/ha-yr). Cumulative nitrogen deposition impacts were compared to critical load of atmospheric nitrogen deposition thresholds for Alaskan tundra which range from 1.0-3.0 kg/ha-yr (Sullivan 2016). More background information is provided in Section 4.5.5.

<u>Visibility</u>

Project visibility impacts were compared to 0.5 delta deciview (dv) and 1.0 delta dv consistent with Federal Land Manager Air Quality Related Values Work group (FLAG) guidance (2010). Cumulative visibility impacts are not compared with a specific threshold, rather are qualitatively assessed relative to baseline visibility conditions. More background information is provided in Section 4.5.4 "Visibility".

1.3 AQTSD Organization

The air quality impacts for the Project alternatives are evaluated by estimating the air emissions and using near-field and regional modeling. The model results are then compared with applicable standards and thresholds. The AQTSD presents this information organized in the following chapters:

- **Chapter 2** provides a summary of the emissions inventory for the Willow MDP alternatives and describes how the emissions inventory was prepared for near-field and far-field modeling. This chapter also describes the cumulative and regional emissions inventories used for modeling.
- **Chapter 3** describes the near-field model configuration, meteorological data, scenarios, assessment receptors, emissions rates, and corresponding impact assessment.
- **Chapter 4** provides an overview of the regional system configuration, the domains and assessment areas, meteorological data, emissions inputs, and assessment methods used to derive the air quality and AQRVs impacts.
- **Chapter 5** presents the regional model impacts to ozone, $PM_{2.5}$ and other criteria pollutants. This chapter also provides impacts on visibility as well as atmospheric deposition of nitrogen and sulfur compounds.
- **Chapter 6** provides a complete list of the references cited in the main body of the AQTSD.

2.0 EMISSIONS INVENTORIES

In this section, we describe the emission inventories that were used in the air quality and greenhouse gas impacts analysis. Willow MDP emission inventories are used to estimate impacts to air quality and AQRVs using the near-field model, AERMOD (described in Chapter 3) and the regional, photochemical grid model, Comprehensive Air Quality Model with Extensions (CAMx, described in Chapter 4). In addition, Willow MDP emission inventories include estimates of greenhouse gas (GHG) emissions that are reported in the Section on Climate and Climate Change in the EIS. Emissions inventories developed for the project are shown in Section 2.1, cumulative sources and emissions are described in Section 2.2, and Section 2.3 describes how these emissions are processed for modeling. Note that the project emissions inventories used for near-field modeling are consistent with Section 2.1 while emissions inventories used for regional modeling are described in Section 2.3.

Near-field models and photochemical grid models are used for different air quality analysis purposes and as a result require different information on air emissions. For near-field modeling, only emissions from sources proximate to planned operations are required as input to the model and very detailed information about the activities and surrounding environment is necessary. For photochemical modeling, the analysis incorporates information for a much larger area and requires emissions for all sources included in the modeling domain. Therefore, in addition to the Willow MDP emissions inventory, regional emissions inventories were developed for the CAMx model for the model scenarios: the 2012 Base Year, the Cumulative No Action Alternative, the Cumulative Alternative B Scenario, and the Cumulative Alternative C Scenario (see Chapter 4). Alternative C was selected for the far-field modeling analysis rather than Alternatives D or E because the peak annual emissions for Alternative C is greatest of these three action alternatives. The following sections discuss the Willow MDP emissions inventory and the regional inventories.

Emission inventories were developed for Willow MDP Alternatives B, C, D and E. Emissions were also developed for the three Module Delivery options because a final determination of Module Delivery transportation routes had not yet been made. An emission inventory was not necessary for Alternative A (No Action).

Willow MDP emissions were developed for criteria pollutants, volatile organic compounds (VOCs), HAPs, and GHGs. Criteria pollutants include NO_x, CO, SO_2, particulate matter less than 10 microns in diameter (PM_{10}), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). VOCs include “any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions”[5].

Lead was not modeled because emissions would be low resulting in very small air quality impacts. The emission inventory includes lead emission estimates from diesel- and natural gas-fueled combustion sources; lead emissions from these sources are small because diesel and natural gas fuel and exhaust contain only trace amounts of lead, if any at all. Likewise, lead emissions from flaring and incinerator activities are expected to be small. The only potential for a lead additive would be in aviation gasoline for piston-engine aircraft. Piston-engine aircraft used in the proposed project and alternatives are not expected to use gasoline with lead additive.

[5] 40 CFR Part 51.100(s)

HAPs analyzed include those commonly emitted from oil and gas development – benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde. The Oil and Natural Gas Production Facilities: National Emission Standards for Hazardous Air Pollutants (NESHAP; 40 CFR Part 63, subpart HH, Table 2) includes several additional HAPs[6]; impacts from additional HAPs, not included in this analysis, are expected to be less substantial than those from the six included HAPs.

GHGs analyzed include those commonly emitted from oil and gas development – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Detailed emission inventory calculation spreadsheets are provided separately.

2.1 Willow Alternatives Emissions Inventories

2.1.1 Emission Inventory Summary

Table 2.1-1, Table 2.1-2, and Table 2.1-3 present total life-of-Project emissions for each alternative by Module Delivery option (Option 1 – Atigaru Point, Option 2 – Point Lonely, and Option 3 – Colville River Crossing). The emissions shown are the sum of Project and Module Delivery emissions. Alternative A (No Action) has zero emissions. For all three Module Delivery Options, Alternative C has the highest emissions across all three action alternatives for all criteria pollutants (except PM_{10}), primarily because of increased equipment and infrastructure requirements required because a gravel road between the Willow Processing Facility (WPF) and drill site Bear Tooth (BT) 1 is not developed under this Alternative. Instead, Alternative C will feature an ice road between BT1 and BT3. In Alternative D, a gravel road is not constructed connecting GMT-2 to the project area. For all three Module Delivery Options, Alternative D has slightly higher PM_{10} emissions than Alternative C as a result of higher routine operations traffic activity for Alternative D and Alternative D has slightly higher emissions (except VOC and HAPs) than Alternative B as a result of the extended Project schedule for Alternative D[7]. For all three Module Delivery Options, Alternative E emissions of VOC, CO, SO_2 and HAPs are slightly lower than Alternative B while NOx, PM_{10} and $PM_{2.5}$ emissions are slightly higher in. The main difference affecting the emissions inventory between Alternative E than and Alternative B is that drill site BT4 would not be constructed under Alternative E. A complete description of each Alternative is available in Chapter 2 of the SEIS.

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6 acetaldehyde, carbon disulfide, carbonyl sulfide, ethylene glycol, naphthalene, and 2,2,4-trimethylpentane
7 The emission inventory for Alternative D was extended one year longer than Alternative B and Alternative C to account for the delayed production schedule for Alternative D

Table 2.1-1 Total Life-of-Project Emissions due to the Project and Module Delivery Option 1 (Atigaru Point) in each Alternative

Alternative	Total Criteria Emissions (tons)						Total HAPs (tons)	Total CO_2e (thousand metric tons)
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC		
Alternative A (No Action)	0	0	0	0	0	0	0	0
Alternative B (Proponent's Project)	20,270	19,593	1,364	6,549	2,394	16,626	2,286	24,120
Alternative C (Disconnected Infield Roads)	24,328	23,064	1,458	7,213	2,858	17,139	2,302	25,419
Alternative D (Disconnected Access)	20,694	19,743	1,367	7,883	2,575	16,519	2,272	23,356
Alternative E (Three-Pad Alternative)	20,287	19,505	1,362	6,626	2,405	15,541	2,187	23,277

* Total CO2e emissions due to the Project are zero in the No Action Alternative. Emissions from substitute energy sources are discussed in the EIS Section on Climate Change.

Table 2.1-2 Total Life-of-Project Emissions due to the Project and Module Delivery Option 2 (Point Lonely) in each Alternative

Alternative	Total Criteria Pollutant Emissions (tons)						Total HAPs (tons)	Total CO_2e (thousand metric tons)
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC		
Alternative A (No Action)	0	0	0	0	0	0	0	0
Alternative B (Proponent's Project)	20,836	20,239	1,365	6,596	2,420	16,719	2,297	24,321
Alternative C (Disconnected Infield Roads)	24,894	23,710	1,460	7,260	2,885	17,233	2,313	25,619
Alternative D (Disconnected Access)	21,260	20,389	1,369	7,930	2,602	16,612	2,283	23,556
Alternative E (Three-Pad Alternative)	20,853	20,151	1,364	6,673	2,432	15,635	2,199	23,478

* Total CO2e emissions due to the Project are zero in the No Action Alternative. Emissions from substitute energy sources are discussed in the EIS Section on Climate Change.

Table 2.1-3 Total Life-of-Project Emissions due to the Project and Module Delivery Option 3 (Colville River Crossing) in each Alternative

Alternative	Total Criteria Emissions (tons)						Total HAPs (tons)	Total CO_2e (thousand metric tons)
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC		
Alternative A (No Action)	0	0	0	0	0	0	0	0
Alternative B (Proponent's Project)	19,903	19,131	1,361	6,581	2,382	16,562	2,277	24,020
Alternative C (Disconnected Infield Roads)	23,961	22,601	1,455	7,245	2,846	17,076	2,294	25,318
Alternative D (Disconnected Access)	20,342	19,285	1,364	7,915	2,564	16,457	2,264	23,258
Alternative E (Three-Pad Alternative)	19,920	19,042	1,359	6,657	2,393	15,478	2,179	23,177

* Total CO2e emissions due to the Project are zero in the No Action Alternative. Emissions from substitute energy sources are discussed in the EIS Section on Climate Change.

Table 2.1-4 shows the key activity metrics for each Project phase (construction, drilling, and routine operations) for each alternative. These activities are the basis for the emissions inventory calculations and resulting emission inventories summarized in Table 2.1-1, Table 2.1-2, and Table 2.1-3 and presented in detail in Section 2.1.2 "Alternative A (No Action)" to Section 0 "Module Delivery Options."

Table 2.1-4 Activity Inputs by Alternative for each Project Phase

Phase	Activity	Parameter	Alternative B (Proponent's Project)	Alternative C (Disconnected Infield Roads)	Alternative D (Disconnected Access)	Alternative E (Three-Pad Alternative)	Unit
Construction	All Drill Pads	Total Acres	79.9	88.3	62.9	68.1	acres
	All Bridge	Total Length	0.22	0.15	0.21	0.21	miles
	Gravel Roads, Valve Pads, and Water Access Pads	Total Acres	272	257	208	228	acres
	Ice Pads*	Total Acres	1,037	1,266	1,341	901	acres
	Ice Roads	Total Miles	495	650	962	431	miles
	Total Powerline and Fiber Optics	Total Length	40	40	40	40	miles
	Pipelines	Total Length	153	206	243	151.6	miles
	Willow Processing Facility	Total Acres	23	23	48	22.8	acres
	WOC+ Airstrip	Total Acres	73	138	107	73.4	acres
	Gravel Mining	Total Gravel Requirement	5,874,260	6,816,260	6,902,260	4,740,200	million cubic yards (MCY)
	Construction Total Traffic	Vehicle Miles Travelled (VMT)	28,031	36,724	39,274	25,850	thousand miles (kmile)
	Power at WOC	Total Rating Output of Power Generation	14,600	29,200	14,600	14,600	thousand watts (kWe)
Drilling	Total Wells Drilled	Number of Wells	251	251	251	219	number
	Drilling Total Traffic	VMT	4,815	3,267	3,149	5,248	kmile
Operations	All Drill Pads	Number of Well Pads	5	5	5	4	number
	Willow Processing Facility	Operating Capacity**	200	200	200	200	thousand barrels per day (kbbl/day)
	All Aircraft	Total Flights	14,522	16,071	21,570	14,404	number
	Operations Total Traffic	VMT	13,594	14,957	21,076	13,540	kmile
	Power Generation at Willow Processing Facility	Total Rating Output of Power Generation	84,500	84,500	84,500	84,500	kWe

Phase	Activity	Parameter	Alternative B (Proponent's Project)	Alternative C (Disconnected Infield Roads)	Alternative D (Disconnected Access)	Alternative E (Three-Pad Alternative)	Unit
	Injection Turbine at Willow Processing Facility	Total Rating of Injection Turbine power	50,579	50,579	50,579	50,579	kWe
	Power at WOC	Total Rating Output of Power Generation	14,600	29,200	14,600	14,600	kWe

*Ice pad total acres are for all Project years including single season and multi-season ice pads

** This conservatively also includes capacity required to process fluids from GMT2 which is an option being considered by the project proponent (see additional information provided in Section 1.1 of the AQTSD). Willow peak annual production is estimated at 131 kbbl/day.

Table 2.1-5 shows key operational and control inputs for each Project phase (construction, drilling, and routine operations) for each alternative. These operational and control inputs are used in emission inventory calculations and have substantial impacts on emission magnitudes. Comprehensive emission inventory inputs and calculations may be found in emission inventory calculation spreadsheets, which are provided separately.

Table 2.1-5 Key emission inventory operational and control inputs.*

Source Category	Source Type	Operational / Control Input	Alternative B	Alternative C	Alternative D	Alternative E
Fugitive Dust (All Phases)						
Fugitive Dust	Wind Erosion	Watering	50%	50%	50%	50%
	Road Dust	Watering	50%	50%	50%	50%
Construction Phase						
Temporary Stationary Engines[a]	Power Generation Turbine	Rated-power (HP)	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)
	Power Generation Reciprocating Internal Combustion Engine	Rated-power (HP)	3 engines X 1609 HP	3 engines X 1609 HP	3 engines X 1609 HP	3 engines X 1609 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD

Source Category	Source Type	Operational / Control Input	Alternative B	Alternative C	Alternative D	Alternative E
		Annual Activity (hr/engine)	4,380	4,380	4,380	4,380
		Certification Level/Control	Tier IV interim	Tier IV interim	Tier IV interim	Tier IV interim
Traffic	On-road Vehicles	Total trips LOP	1,501,890	1,881,980	1,973,440	1,431,410
		Total miles travelled LOP	28,031,115	36,724,275	39,273,598	25,849,718
	Air Traffic	Total trips LOP	1,943	5,904	4,011	2,320
	Ocean-going Vessels	Total trips LOP	319	319	319	319
Pre- Drilling Phase						
Pre- Drilling Equipment	Primary Engines	Rated-power (HP)	3 engines X 1476 HP	3 engines X 1476 HP	3 engines X 1476 HP	3 engines X 1476 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Tier IV gen set	Tier IV gen set	Tier IV gen set	Tier IV gen set
	Cement Pump Units	Rated-power (HP)	2 engines X 241 HP	2 engines X 241 HP	2 engines X 241 HP	2 engines X 241 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	500	500	500	500
		Certification Level/Control	Tier IV final	Tier IV final	Tier IV final	Tier IV final
	Support Engines	Rated-power (HP)	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Tier II or Tier III	Tier II or Tier III	Tier II or Tier III	Tier II or Tier III
Hydraulic Fracturing	Well Frac Engines	Rated-power (HP)	1 engine X 120 HP 1 engine X 990 HP 1 engine X 14400 HP	1 engine X 120 HP 1 engine X 990 HP 1 engine X 14400 HP	1 engine X 120 HP 1 engine X 990 HP 1 engine X 14400 HP	1 engine X 120 HP 1 engine X 990 HP 1 engine X 14400 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	1,920	1,920	1,920	1,920
		Certification Level/Control	Tier IV final	Tier IV final	Tier IV final	Tier IV final

Source Category	Source Type	Operational / Control Input	Alternative B	Alternative C	Alternative D	Alternative E
Development Drilling Phase						
Drilling Equipment	Primary Engines	Rated-power (HP)	1 engine X 1476 HP	1 engine X 1476 HP	1 engine X 1476 HP	1 engine X 1476 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Tier IV gen set	Tier IV gen set	Tier IV gen set	Tier IV gen set
	Cement Pump Units	Rated-power (HP)	2 engines X 241 HP	2 engines X 241 HP	2 engines X 241 HP	2 engines X 241 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	500	500	500	500
		Certification Level/Control	Tier IV final	Tier IV final	Tier IV final	Tier IV final
	Support Engines	Rated-power (HP)	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP	2 engines X 706 HP 10 engine X 11 HP 1 engine X 71 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Tier II and Tier III	Tier II and Tier III	Tier II and Tier III	Tier II and Tier III
Hydraulic Fracturing	Well Frac Engine	Rated-power (HP) Number of engines Annual Activity (hr/engine) Tier Standard	Highline Power Source, Zero Direct Emissions	Highline Power Source, Zero Direct Emissions	Highline Power Source, Zero Direct Emissions	Highline Power Source, Zero Direct Emissions
Traffic[b]	On-road Vehicles	Total trips LOP	327,720	401,790	318,360	365,030
		Total miles travelled LOP	4,815,054	3,267,163	3,149,251	5,247,886
	Air Traffic	Total trips LOP	1,248	1,875	2,496	3,404
Routine Operation Phase						
Fugitive Components		Control	LDAR	LDAR	LDAR	LDAR
Stationary Engines at WOC[a]	Power Generation Turbine	Rated-power (HP)	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP

Source Category	Source Type	Operational / Control Input	Alternative B	Alternative C	Alternative D	Alternative E
		Fuel Type	Fuel Gas	Fuel Gas	Fuel Gas	Fuel Gas
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)
	Power Generation Reciprocating Internal Combustion Engine	Rated-power (HP)	3 engines X 1609 HP	3 engines X 1609 HP	3 engines X 1609 HP	3 engines X 1609 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	4,380	4,380	4,380	4,380
		Certification Level/Control	Tier IV interim	Tier IV interim	Tier IV interim	Tier IV interim
Stationary Engines at WPF	Injection/Compression Turbine	Rated-power (HP)	2 engines X 33900 HP	2 engines X 33900 HP	2 engines X 33900 HP	2 engines X 33900 HP
		Fuel Type	Fuel Gas	Fuel Gas	Fuel Gas	Fuel Gas
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)
	Power Generation Turbines	Rated-power (HP)	3 engines X32855 HP	3 engines X32855 HP	3 engines X32855 HP	3 engines X32855 HP
		Fuel Type	Fuel Gas	Fuel Gas	Fuel Gas	Fuel Gas
		Annual Activity (hr/engine)	8,760	8,760	8,760	8,760
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)
	Backup Power Generation Turbines (Fuel Gas)	Rated-power (HP)	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP
		Fuel Type	Fuel Gas	Fuel Gas	Fuel Gas	Fuel Gas
		Annual Activity (hr/engine)	8,260	8,260	8,260	8,260
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)

Source Category	Source Type	Operational / Control Input	Alternative B	Alternative C	Alternative D	Alternative E
	Backup Power Generation Turbines (Diesel Fuel)	Rated-power (HP)	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP	2 engines X 7376 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	500	500	500	500
		Certification Level/Control	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)	Dry Low NOx and Inlet Air Conditioning (Pre-Heat)
	Black Start Engines	Rated-power (HP)	1 engine X 805 HP	1 engine X 805 HP	1 engine X 805 HP	1 engine X 805 HP
		Fuel Type	ULSD	ULSD	ULSD	ULSD
		Annual Activity (hr/engine)	500	500	500	500
		Certification Level/Control	Tier II	Tier II	Tier II	Tier II
Traffic	On-road Vehicles	Total trips LOP	1,359,300	1,928,740	2,085,090	1,349,430
		Total miles travelled LOP	13,594,275	14,956,585	21,075,829	13,540,217
	Air Traffic	Total trips LOP	11,331	14,705	15,034	8,680

[a] For Alternative C, applicable to both the North and South WOC
[b] Includes traffic for pre- and developmental drilling phases

2.1.2 Alternative A (No Action)

Under this alternative, the BLM and/or other federal permitting agencies would not issue permits for the Willow Development, and no development would occur. As a result, no oil in the Project area would be produced in the near future, and no new roads, airstrips, pipelines, or other oil facilities would be constructed. Therefore, there are no direct Project emissions anticipated to result under the No Action Alternative.

2.1.3 Alternative B (Proponent's Project)*

Alternative B (Proponent's Project) would consist of the development and operation of 251 wells over a period of 10 years on five multi-well pads and associated facilities in the Project area needed to support extraction of hydrocarbons including a Central Processing Facility, Operations Center, Airstrip, pipelines, roads and bridges, and module transfer island. Section 1.1.2 "Alternative B: Proponent's Project" provides a description of Alternative B.

A general description highlighting emission generating activities and sources under Alternative B is provided below. AECOM documented the Alternative B emission inventory, which is included as Attachment C to this Air Quality Technical Support Document. A more detailed description of emission generating activities and sources can be found in Attachment C. The Alternative B emission inventory from the Project proponent was reviewed and revised by the BLM; therefore, the emission inventories presented in this section differs from the inventory presented in Attachment C.[8]

Criteria pollutants, VOCs, HAP, and GHG emissions are emitted during construction, drilling, and routine operation Project phases. Emissions would result from activities such as well installation, development, and operation; operation of engines and boilers; and vehicle transportation of equipment and service crews in the Project area. Project emission sources would include non-mobile combustion sources, mobile on-road and nonroad tailpipe combustion sources, fugitive dust sources, fugitive leak sources, venting sources, ships, and aircraft sources.

Emissions estimates presented herein were developed using Willow-specific data and information from CPAI's other North Slope projects including the GMT2 Drill site in the GMTU and the ACF in the Colville River Unit. Willow-specific input design data from CPAI were used where available and these were supplemented by information from the GMT2 EIS emissions inventory (BLM, 2018b). The emissions inventory for the WPF, WOC and module delivery and transport activities are based on similar facilities and activities supporting the construction and operation of the ACF, supplemented by equipment sizing information, newer emissions control and equipment technologies, and other Willow-specific design information developed by CPAI.

CPAI plans to construct 251 wells at five drill sites, approximately evenly split between production and injection wells. Production wells are hydraulically fractured and then undergo a well cleanout process known as a flowback in which the fluids and solids produced during the drilling process are allowed to flow out until no excessive solids or drilling fluids are left. Injection wells only go through the flowback process and are not hydraulically fractured. Gas produced from the flowback will be captured, flared, or

[8] Revisions to the Attachment C emission inventory were limited to the supplementation of hazardous air pollutant emissions for drilling flowback flaring and WPF low pressure and high pressure flaring for completeness.

vented depending on available infrastructure. Oil, gas, and water extracted from production wells will be sent to the WPF for processing. Injection wells will be used to inject gas, produced water, seawater, and miscible injectant (MI) back into the producing formation.

After the wells are developed, processing, transport, and storage of the produced oil and natural gas will emit criteria pollutants, VOCs, HAPs, and GHGs. Heaters, generators, pumps, well intervention (i.e., workover), and other support equipment used at well sites emit criteria pollutants, VOCs, HAPs, and GHGs. Storage tanks and fugitive leaks from valves, flanges, open-ended lines, connectors, and other connection points at well pads will emit VOCs, HAPs, and GHGs.

The WPF would separate and process production fluids and produce sales-quality crude oil. Produced water would be processed at the WPF and reinjected to the subsurface as part of pressure maintenance/water flood for secondary recovery. Emission sources at the WPF would include turbine and internal combustion engine generators, compressors, storage tanks, pumps, and other treating equipment. CPAI is evaluating whether to connect GMT2 with the WPF. As discussed in Section 1.1, the Willow EIS air quality impact analysis accounts for the effect of potentially processing GMT2 produced fluids at the WPF.

The base of operations for the Willow Development would be at the WOC. The WOC would be near to but separated from the WPF and adjacent to the airstrip. Emission sources at the WOC would include internal combustion engine generators, turbines, non-mobile support equipment (e.g., boilers, incinerators), storage tanks, and aircraft from the adjacent airstrip.

Fugitive dust emissions estimates assume a conservative (low) 50% control efficiency for watering, consistent with the BOEM Arctic modeling study (Fields Simms et al 2018, Stoeckenius et al 2017). Fugitive dust emissions are only calculated for months from May through October, consistent with the months for which fugitive dust emissions were estimated in the BOEM Arctic modeling study (Fields Simms et al 2018, Stoeckenius et al 2017). Fugitive dust emissions may also occur in other months, especially during dry snowless conditions or when the ground is dry and frozen. Although fugitive dust emissions during such months may affect air concentrations of particulate matter, these would be to a smaller extent than fugitive dust emitted from May through October when there is much less (or no) snow cover.

Table 2.1-6 shows annual criteria pollutant, VOCs, HAP, and GHG emissions in Alternative B for construction activities by year. The "Year 0" refers to the first year of construction which is a partial year. Table 2.1-7 shows annual Alternative B criteria pollutant, VOCs, HAP, and GHG emissions for drilling (including pre-drilling and developmental drilling) activities. Table 2.1-8 shows annual Alternative B criteria pollutant, VOCs, HAP, and GHG emissions for routine operation activities. Table 2.1-9 shows annual Alternative B criteria pollutant, VOCs, HAP, and GHG emissions summed across all Project activities. Alternative B annual emissions are shown graphically for each criteria pollutant by Project phase in Figure 2.1-1 to Figure 2.1-6.

Construction emissions increase from project start to year 4, then, generally, decrease to the end of construction activities in year 9. From year 5 to year 6, there is an increase in gaseous pollutant construction emissions and a decrease in particulate matter emissions. Increases in non-vehicle construction phase activities from year 5 to year 6 result in increased gaseous emissions while decreases in on-road vehicle activity reduce on-road fugitive dust emissions (the largest particulate matter emissions source category).

The drilling phase includes three different activities: disposal well drilling at the WOC in year 3, pre-drilling from years 4 to 5, and developmental drilling from years 6 to -9. For most pollutants, the largest drilling phase emissions occur during pre-drilling when diesel engines are used to power drill rigs, prior to developmental drilling during which highline electricity is used to power drill rigs. PM_{10} and $PM_{2.5}$ emissions are highest in year 7 and year 9 when drilling phase on-road vehicle activity and hence fugitive dust emissions are highest.

Routine operations at the WPF are expected to commence in the fourth quarter of year 5 with commissioning of the WPF and the first drill site (BT1). Subsequent drill sites will be commissioned in the following years and continue operating until the end of field life in year 30. Routine operation emissions generally increase as routine operation facilities (e.g., WOC, WPF, and drill sites) are brought online and thereafter remain relatively constant.

Table 2.1-6 Alternative B (Proponent's Project) Annual Emissions from Construction Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	20.5	32.7	0.9	1.3	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.3	3,503
1	440.4	376.8	3.8	81.5	20.6	26.5	0.4	0.4	0.1	0.4	0.1	3.2	142,632
2	461.7	384.4	4.8	102.3	23.2	26.5	0.4	0.4	0.1	0.4	0.0	3.0	138,742
3	535.8	418.4	4.4	212.4	37.6	35.9	0.5	0.6	0.1	0.6	0.1	4.8	169,070
4	591.2	431.9	3.5	213.8	41.2	44.6	0.6	0.7	0.1	0.6	0.1	5.2	187,533
5	150.6	92.6	1.3	183.2	26.8	16.1	0.4	0.4	0.1	0.3	0.0	3.3	55,912
6	166.1	144.8	3.2	109.5	18.4	16.1	0.4	0.4	0.1	0.4	0.1	3.5	55,924
7	92.7	92.2	1.9	93.4	13.0	9.6	0.2	0.2	0.0	0.2	0.0	1.9	31,811
8	29.5	14.2	0.1	39.7	5.5	3.4	0.1	0.1	0.0	0.1	0.0	0.6	10,810
9	6.2	1.8	0.0	0.3	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.1	1,697
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-7 Alternative B (Proponent's Project) Annual Emissions from Drilling Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
3	3.8	5.3	0.0	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1,728
4	142.1	372.1	1.0	106.1	18.5	60.4	1.0	0.8	0.1	0.3	4.9	20.6	88,339
5	143.7	372.7	1.0	138.5	21.8	60.6	1.0	0.8	0.1	0.3	4.9	20.6	89,053
6	101.9	142.2	0.5	178.3	24.1	45.1	1.1	1.0	0.1	0.3	5.9	28.9	49,098
7	106.6	141.3	0.5	291.9	35.7	36.2	0.8	0.7	0.1	0.2	4.2	20.5	50,516
8	99.9	138.5	0.5	147.4	20.9	35.3	0.8	0.7	0.0	0.2	4.2	20.4	47,383
9	106.6	141.3	0.5	291.9	35.7	36.2	0.8	0.7	0.1	0.2	4.2	20.5	50,516
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-8 Alternative B (Proponent's Project) Annual Emissions from Routine Operation Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49
2	0.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86
3	1.7	3.1	0.2	0.1	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.1	502
4	5.2	7.3	0.6	2.1	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.2	1,714
5	251.5	238.2	16.8	51.2	30.5	89.8	0.2	0.5	0.7	1.5	3.1	3.1	305,518
6	635.7	606.9	52.4	165.0	78.6	405.9	0.8	1.9	5.4	10.7	18.8	11.6	947,941
7	643.4	612.7	52.6	169.1	79.4	507.1	0.9	2.2	8.0	15.8	25.1	11.6	952,920
8	644.3	613.4	52.6	171.5	79.7	507.1	0.9	2.2	8.0	15.8	25.1	11.6	953,071
9	650.1	618.1	52.6	177.7	80.7	587.7	1.0	2.4	10.0	19.8	30.1	11.6	957,174
10	654.5	620.7	52.6	178.0	80.9	666.7	1.0	2.6	12.0	23.8	35.1	11.5	960,918
11	654.5	620.7	52.6	178.0	80.9	666.7	1.0	2.6	12.0	23.8	35.1	11.5	960,918
12	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
13	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
14	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
15	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
16-30	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918

Table 2.1-9 Alternative B (Proponent's Project) Annual Emissions from All Project Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	20.5	32.7	0.9	1.3	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.3	3,503
1	440.9	377.0	3.8	81.5	20.6	26.5	0.4	0.4	0.1	0.4	0.1	3.2	142,681
2	462.2	385.9	4.8	102.4	23.3	26.5	0.4	0.4	0.1	0.4	0.0	3.0	138,828
3	541.3	426.8	4.6	212.7	38.0	37.1	0.6	0.6	0.1	0.6	0.1	4.9	171,300
4	738.5	811.3	5.1	322.0	60.1	106.4	1.7	1.5	0.2	0.9	5.0	26.0	277,586
5	545.7	703.6	19.0	372.9	79.1	166.5	1.6	1.7	0.9	2.1	8.1	27.0	450,483
6	903.8	893.9	56.2	452.9	121.1	467.1	2.3	3.3	5.6	11.4	24.8	43.9	1,052,963
7	842.7	846.2	55.1	554.3	128.1	552.9	1.9	3.2	8.1	16.3	29.3	34.0	1,035,247
8	773.6	766.2	53.2	358.5	106.1	545.8	1.8	3.0	8.0	16.1	29.3	32.6	1,011,263
9	762.9	761.1	53.1	469.8	116.6	624.4	1.8	3.2	10.1	20.0	34.3	32.2	1,009,386
10	654.5	620.7	52.6	178.0	80.9	666.7	1.0	2.6	12.0	23.8	35.1	11.5	960,918
11	654.5	620.7	52.6	178.0	80.9	666.7	1.0	2.6	12.0	23.8	35.1	11.5	960,918
12	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
13	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
14	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
15	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918
16-30	654.5	620.7	52.6	170.0	79.7	666.3	1.0	2.6	12.0	23.8	35.1	11.5	960,918

Figure 2.1-1 Alternative B (Proponent's Project) Annual NOx Emissions by Project Phase*

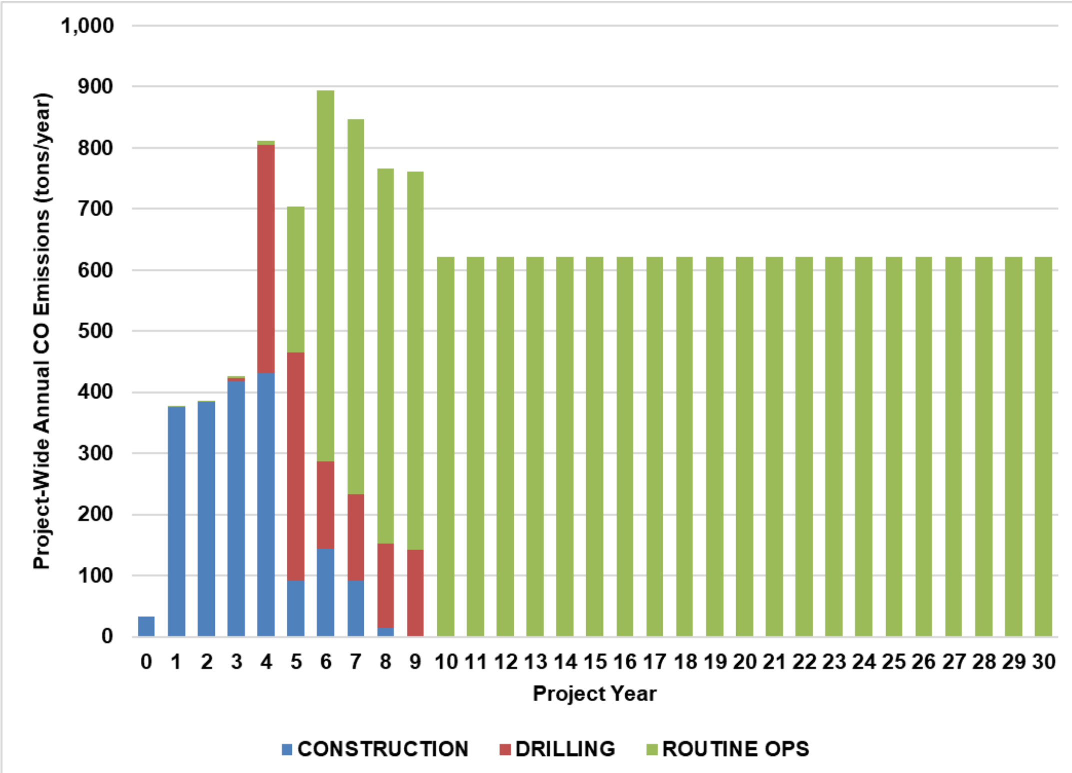

Figure 2.1-2 Alternative B (Proponent's Project) Annual CO Emissions by Project Phase*

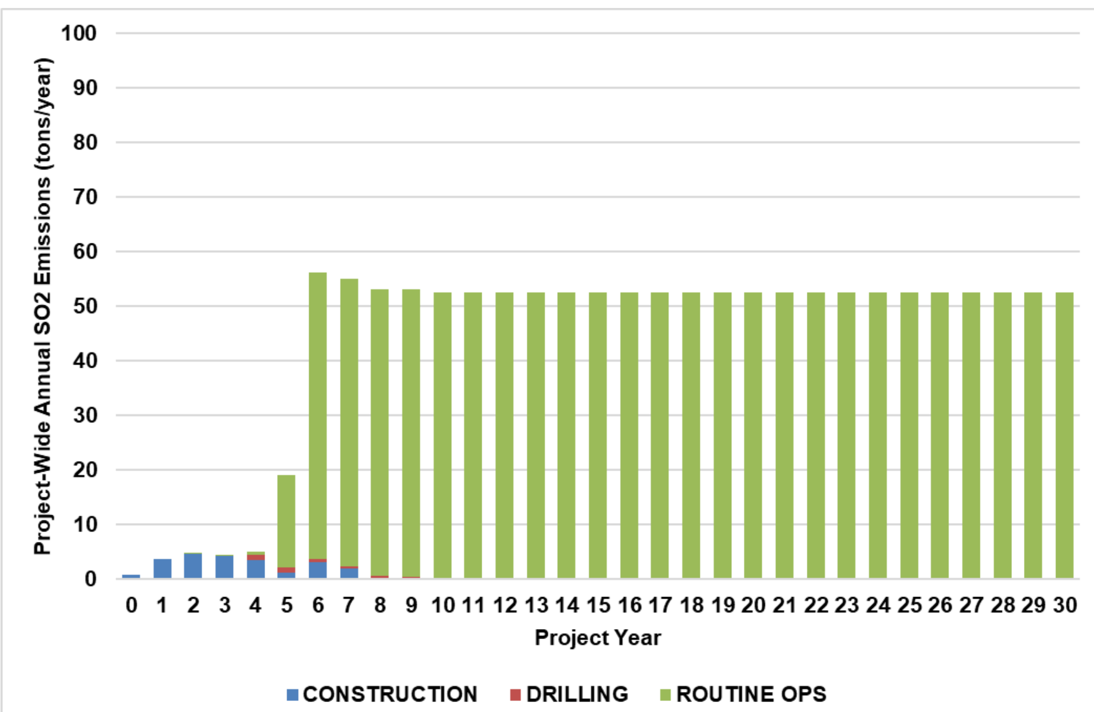

Figure 2.1-3 Alternative B (Proponent's Project) Annual SO_2 Emissions by Project Phase*

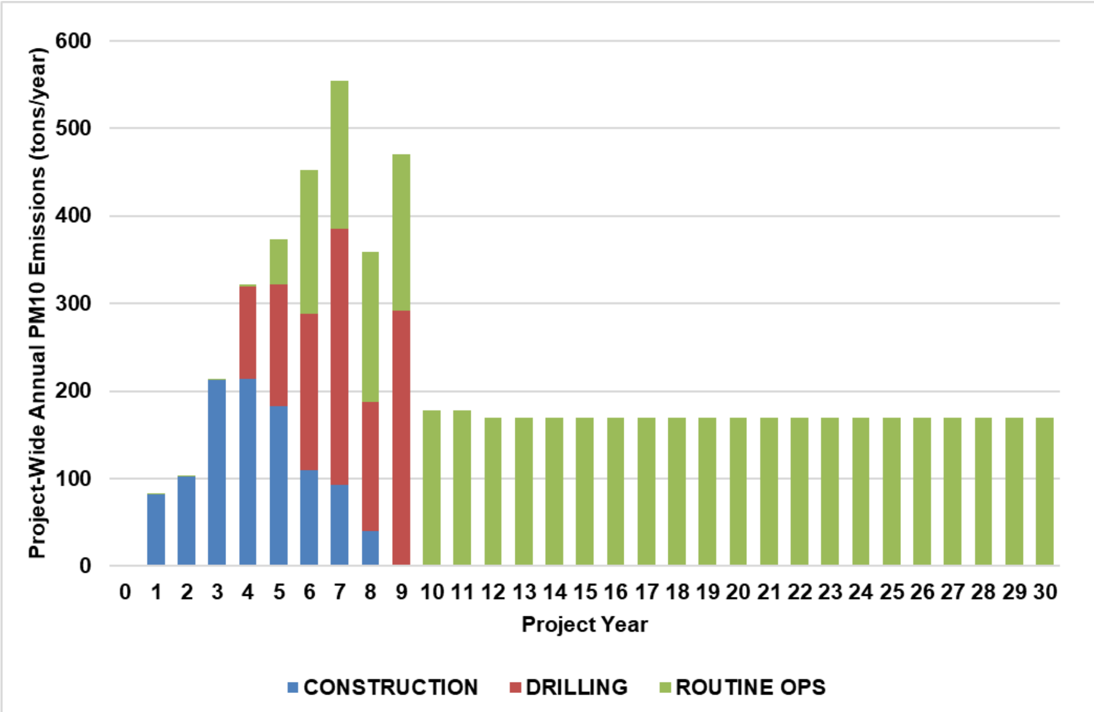

Figure 2.1-4 Alternative B (Proponent's Project) Annual PM_{10} Emissions by Project Phase*

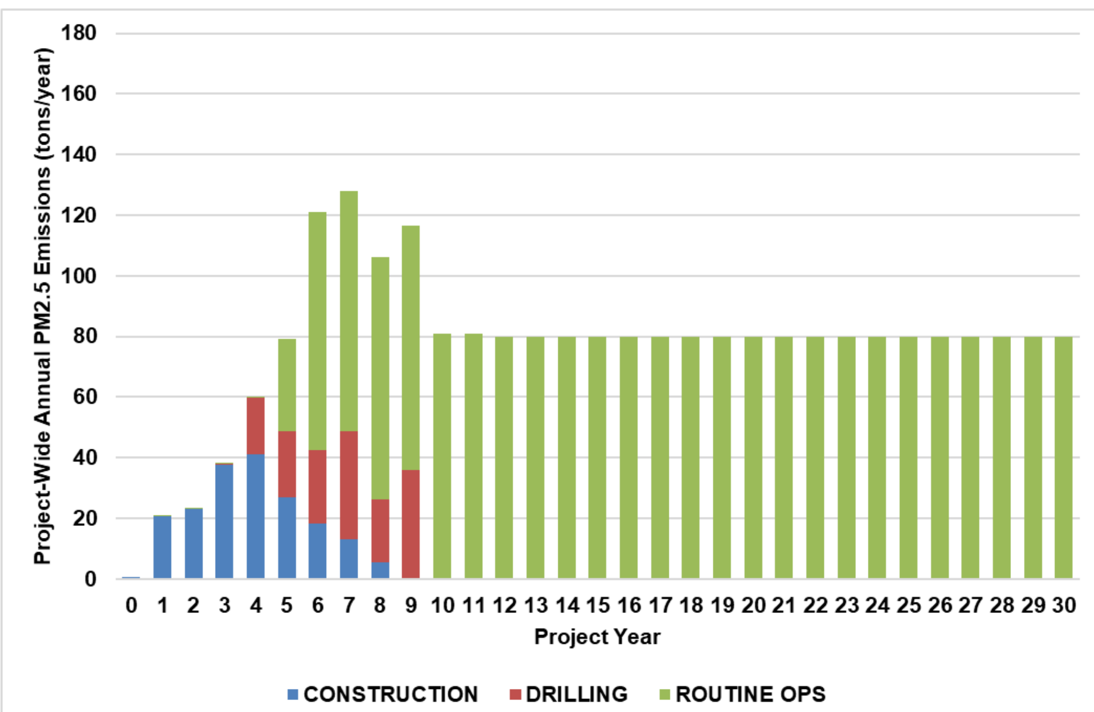

Figure 2.1-5 Alternative B (Proponent's Project) Annual $PM_{2.5}$ Emissions by Project Phase*

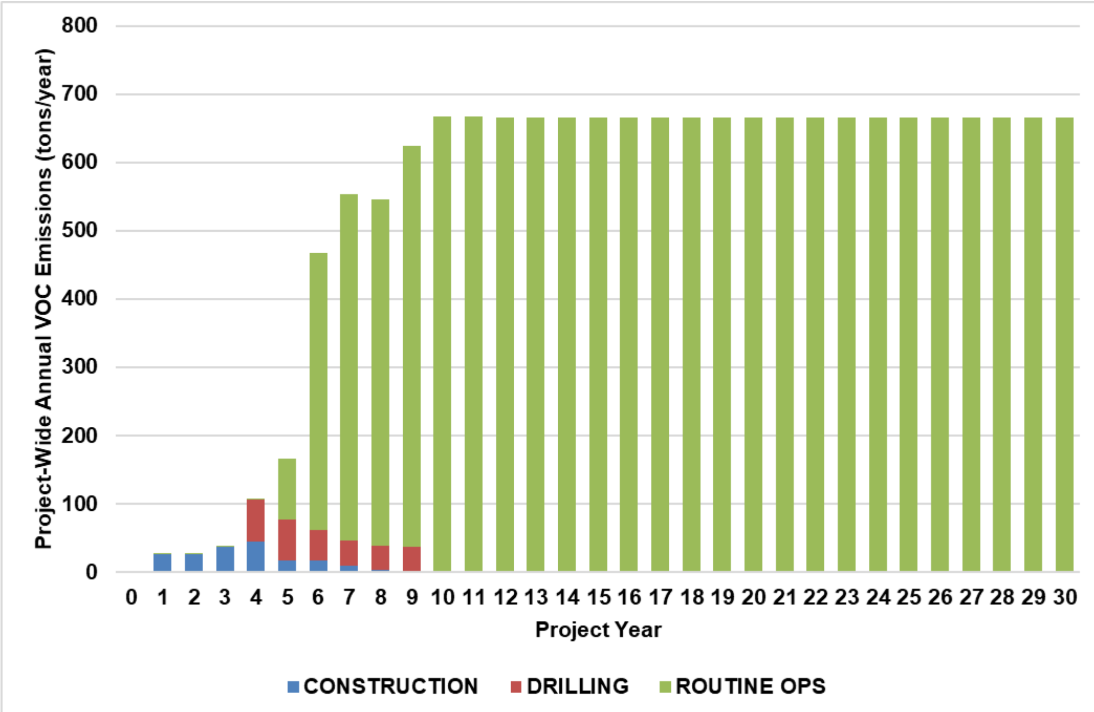

Figure 2.1-6 Alternative B (Proponent's Project) Annual VOC Emissions by Project Phase*

Alternative B flaring activities are limited to a low-pressure flare and high-pressure flare at the WPF and flowback flaring at drill sites. Flares are safety devices that are operated to prevent over pressurizing piping and equipment, to handle gas removal from systems during maintenance, and to deal with gas released during an emergency rapid depressurization of WPF gas handling systems (SLR 2022). For Alternative B, flares would be operated at the WPF starting in project year 5 through end of project.

This Supplemental EIS analyzes both the low-pressure and high-pressure year-round flare emissions at the WPF for a pilot light and purge assist. Both the low-pressure and the high-pressure flare heat rating for pilot light and purge assist activities is estimated to be 4 million British Thermal Units per hour (MMBTU/hour). The heat rating is converted into volume of gas flared (also referred to as flow rate) based on the average natural gas heating value of 1,020 Btu per standard cubic feet (BTU/SCF). The flare flow rate for the low-pressure and the high-pressure flare pilot light and purge assist is based on the annual average flow rate of the Alpine Central Facility low-pressure and high-pressure flares from 2009-2018. Emissions for the low-pressure and the high-pressure flare pilot light and purge assist were calculated based on standard emission factors in pounds of emissions per MMSCF of gas burned and converted into pounds of emissions per year assuming year-round operation.

In addition to pilot light and purge assist flaring emissions, the Project emissions estimates assumes flare operation for 10 hours per year at a maximum flow rate of 9 million standard cubic feet per hour (MMSCF/hour) for the low-pressure flare and 11 MMSCF/hour for the high-pressure flare. The flare events emissions were determined based on an analysis of the amount of gas flared at Alpine from 2015 to 2017 during large safety events. For the low-pressure flare, the flow rate is converted into energy of gas flared based on a high heating value of 1,702 BTU/SCF of gas combusted.[9] For the high-pressure flare, the flow rate is converted into energy of gas flared based on the average natural gas heating value of 1,020 BTU/SCF. Emissions were then calculated based on standard emission factors in pounds of emissions per MMBtu of gas burned, or other units of measure as relevant based on the emission factor for each pollutant. Emissions were converted into pounds of emissions per year assuming 10 hours of operation per year for each flare.

Permanent infrastructure would not be in place immediately following the construction of most drill sites that handle gas from flowbacks. Until the necessary gas transmission and processing infrastructure is constructed and operational, flowback gas will be routed to a portable flare located at the active drill site. Once the gas transmission and processing infrastructure is operational, flowback gas would be routed from drill sites to the WPF and processed for on-site use or reinjected back into the producing reservoir. Flowback flaring emissions from drill sites are accounted for in this SEIS as follows. Flaring at drill sites would occur from project year 4 to 9 under Alternatives B. Typically, there would be 1 flowback event per well drilled with a duration of 3 days of flaring per flowback event. There would be 4 flowbacks per month during project years 4 and 5; in project year 6, 4 flowbacks per month would occur from January through May; and from June in project year 6 to end of project year 9, there would be 2 flowbacks per month.

Assumed WPF flaring volumes were compared to recent flaring operations at the Alpine Central Facility. Table 2.1-10 shows Alpine Central Facility flared volumes for recent years 2020 and 2021 as well as

[9] During flare events, it is anticipated that the low-pressure flare will predominately combust gas that contains a higher proportion of heavy hydrocarbons than facility fuel gas. Examples of gas sources for the low-pressure flare include gas from 3-phase fluid pipeline blowdowns, the inlet (primary) separator, and low-pressure separator gas.

annual WPF flared volume under Alternative B. The annual event flared volume from the Alpine Central Facility in 2020 and 2021 was 176.2 million standard cubic-feet per year (MMSCF/year) and 304.0 MMSCF/year, respectively. The volume of gas flared at Alpine Central Facility in 2021 was higher than 2020 due to facility upgrades which resulted in multiple startups and shutdowns of the gas compression turbine requiring depressurization and gas flaring. The 2021 flaring at Alpine Central Facility is not anticipated to be representative of potential future flaring activities at WPF for two reasons. First, this type of upgrade is an infrequent event. Second, Alpine Central Facility has a single gas compression turbine while the WPF has two (2) gas compression turbines. Multiple gas compression turbines will allow the WRF to better absorb process upsets and equipment failures without flaring gas. Annual event flared volume for the WPF is anticipated to be 197.1 MMSCF/year, which would be approximately 12% higher than Alpine Central Facility 2020 flared volume and about 35% less than 2021 flared volume. The assumed annual flaring volume at WPF is higher than the most recent and representative annual flared volumes at Alpine Central Facility.

Table 2.1-10 Recent years flaring at the Alpine Central Facility and Future Flaring under Alternative B

Flare Type	Alpine Annual Flaring for 2020 and 2021 (MMSCF/yr)		Alternative B WPF Flaring by Year (MMSCF/yr)	
	2020	2021	Year 5	Year 6+
LP Flare Pilot/Purge	34.6	33.0	8.6	34.4
HP Flare Pilot/Purge	40.5	43.7	8.6	34.4
Pilot/Purge Subtotal	**75.1**	**76.6**	**17.2**	**68.7**
Total Flared (All Events) - LP Flare	165.1	260.1	22.1	88.3
Total Flared (All Events) - HP Flare	11.1	43.9	27.2	108.8
Total Flared (All Events) Subtotal	**176.2**	**304.0**	**49.3**	**197.1**

Table 2.1-11 shows the maximum annual flaring emissions under Alternative B for criteria pollutant, VOCs, HAP, and GHG emissions.

The Willow annual flare volume estimate of 197.1 MMSCF/year is a scaled approximation based upon three years (2015 to 2017) of representative actual flare data at the Alpine Central Facility which has a low-pressure flare (used for incoming low-pressure field gas) and a high-pressure flare (used for processed, high-pressure gas). The Alpine Central Facility low-pressure flare three-year average flare volume was 101.3 MMSCF/year, with maximum flare volumes of 173 MMSCF/year, 44 MMSCF/year, and 87 MMSCF/year in 2017, 2016, and 2015 respectively. Applying these values to a Willow Equivalent Average approximates the flare maximum rate to 11.5 hours/year for low-pressure flaring. Similarly, The Alpine Central Facility high-pressure flare three-year average flare volume was 76.9 MMSCF/year, with maximum flare volumes of 24.9 MMSCF/year, 160.4 MMSCF/ year, and 45.3 MMSCF/year in 2017, 2016, and 2015 respectively. Applying these values to a Willow Equivalent Average approximates the flare maximum rate to 7.1 hours/year for high-pressure flaring (CPAI, 2022). The low-pressure flare rating (maximum specification) for the project is 212 MMSCF/day and the high-pressure flare rating is 261 MMSCF/day (SLR, 2022); therefore, the scaled, annual average for each of the flares is 10 hours and 197.1 MMSCF per year. This basis for flare volumes and events is applicable to Alternative B as well as all other action Alternatives.

Table 2.1-11 Alternative B Maximum Annual Flaring Emissions.

Location	Maximum Annual Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
WPF	12.3	41.1	0.9	2.9	2.9	114.5	0.3	0.3	0.0	0.1	5.7	9.5	31,989
Drill sites	2.7	14.7	0.2	0.0	0.0	46.1	1.5	1.3	0.1	0.4	8.3	40.5	5,630
Total	**15.0**	**55.8**	**1.1**	**2.9**	**2.9**	**160.6**	**1.8**	**1.6**	**0.1**	**0.5**	**14.0**	**50.0**	**37,619**

The following provides the basis for flare volumes for the low-pressure and high-pressure year-round flares described previously for pilot light and purge assist at the WPF. Flare purge to prevent backflow and maintaining a pilot light are safety requirements for flares. Alpine Central Facility pilot and purge data was collected from 2009 (extrapolated with partial data) to 2018 for the high- and low-pressure flares. The high-pressure volumes ranged from 29,826 MSCF in 2012 to 37,584 MSCF in 2015. The low-pressure volumes ranged from 18,766 MSCF in 2016 to 42,490 MSCF in 2017. Incorporating the average pilot/purge gas volumes with the heating value of 1,259 BTU/scf operating 8,760 hours per year yields a pilot/purge heat rating of 3.5 MMBTU/hr for the low-pressure flare and 4.8 MMBTU/hr for the high-pressure flare with a combined average of 4 MMBtu/hr (CPAI, 2022).

The basis for flare volumes described above is applicable to Alternative B as well as all other action Alternatives.

2.1.4 Alternative C (Disconnected Infield Roads)

Alternative C would be identical to Alternative B with respect to the number of wells drilled, main Project features, and oil production. The main differences for Alternative C relative to Alternative B are the elimination of a gravel road connection between the WPF and drill site BT1, and the inclusion of a second airstrip, storage and staging facilities and camp near drill site BT1 or drill site BT2. Additionally, the WPF, WOC, and airstrip would be located approximately 5 miles east of their location in Alternative B, near the GMTU and BTU boundary. Section 1.1.3 “Alternative C: Disconnected Infield Roads” provides a description of Alternative C. Alternative B emission inventory spreadsheets were modified with Alternative C inputs provided by the Project proponent and information from the Project description to estimate Alternative C emissions. More information about the Alternative C emissions inventory is provided in Attachment D to this Air Quality Technical Support Document.

Table 2.1-12 shows annual criteria pollutant, VOCs, HAP and GHG emissions for construction activities by year in Alternative C. The “Year 0” refers to the first year of construction which is a partial year. Table 2.1-13 shows annual Alternative C criteria pollutant, VOCs, HAP, and GHG emissions for drilling (including pre-drilling and developmental drilling) activities. Table 2.1-14 shows annual Alternative C criteria pollutant, VOCs, HAP, and GHG emissions for routine operation activities. Table 2.1-15 shows annual Alternative C criteria pollutant, VOCs, HAP, and GHG emissions summed across all Project activities. Alternative C annual emissions are shown graphically for each criteria pollutant by Project phase in Figure 2.1-7 to Figure 2.1-12.

Construction emissions increase from project start to year 4, then, generally, decrease to the end of construction activities in year 9. There is a substantial decrease in construction emissions from project year 5 to year 6, due primarily to replacement of construction phase temporary power generation in year 5 with production phase generation in year 6 and the slowing down or completion of several key construction activities such as multi-season ice pads, gravel mining, drill site gravel pad construction, WPF construction, pipeline construction, and bridge construction. Emissions increase again from year 6 to year 7 as several construction activities start again including gravel mining, drill site gravel pad construction, and bridge construction.

The drilling phase includes three different activities: disposal well drilling at the North and South WOC in year 3 and year 4, respectively, pre-drilling activities from years 4-5, and developmental drilling activity from years 6-9. For most pollutants, the largest drilling phase emissions occur during pre-drilling during which diesel engines are used to power drill rigs, prior to developmental drilling during which highline electricity is used to power drill rigs. PM_{10} and $PM_{2.5}$ emissions are highest in year 9 when drilling phase on-road vehicle activity and hence fugitive dust emissions are highest.

Routine operations at the WPF are expected to commence in the fourth quarter of year 5 with commissioning of the WPF and the first drill site (BT1). Subsequent drill sites will be commissioned in the following years and continue operating until the end of life in year 30. Routine operation emissions generally increase as routine operation facilities (e.g., WOC, WPF, and drill sites) are brought online and thereafter remain relatively constant.

Table 2.1-12 Alternative C (Disconnected Infield Roads) Annual Emissions from Construction Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	20.4	32.6	0.9	1.2	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.3	3,475
1	434.0	372.1	4.0	65.8	25.6	27.3	0.3	0.3	0.1	0.3	0.0	2.4	137,708
2	805.4	642.9	6.2	136.2	49.4	47.9	0.5	0.4	0.1	0.4	0.1	3.2	252,012
3	901.3	679.7	5.9	274.5	67.6	59.9	0.7	0.7	0.1	0.7	0.1	5.7	291,495
4	913.6	705.2	5.8	301.0	71.2	62.5	0.7	0.6	0.1	0.6	0.1	4.7	289,110
5	496.6	375.3	3.3	261.1	49.4	35.1	0.5	0.5	0.1	0.4	0.1	3.8	167,010
6	75.5	55.8	1.3	55.9	9.3	7.0	0.2	0.2	0.0	0.2	0.0	1.5	24,441
7	124.5	121.5	2.8	170.8	21.1	11.5	0.2	0.3	0.1	0.3	0.0	2.4	37,070
8	112.2	93.4	2.0	176.7	21.9	11.2	0.2	0.3	0.1	0.3	0.0	2.3	37,121
9	23.0	10.1	0.1	48.1	6.0	2.6	0.1	0.1	0.0	0.1	0.0	0.5	8,650
10	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
11	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
12	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
13	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
14	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
15	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583
16-30	2.6	0.7	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	583

Table 2.1-13 Alternative C (Disconnected Infield Roads) Annual Emissions from Drilling Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
3	3.8	5.3	0.0	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1,728
4	146.4	377.6	1.0	118.0	19.9	60.9	1.0	0.8	0.1	0.3	4.9	20.6	90,343
5	141.3	371.7	1.0	95.9	17.4	60.3	1.0	0.8	0.1	0.3	4.9	20.6	88,092
6	98.2	140.5	0.5	113.0	17.4	44.6	1.1	1.0	0.1	0.3	5.9	28.8	47,587
7	99.0	138.1	0.5	134.6	19.6	35.1	0.8	0.7	0.0	0.2	4.2	20.4	47,072
8	98.0	137.6	0.5	118.5	18.0	35.0	0.8	0.7	0.0	0.2	4.2	20.4	46,684
9	106.7	141.6	0.5	245.3	31.1	36.3	0.8	0.7	0.1	0.2	4.2	20.5	49,890
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-14 Alternative C (Disconnected Infield Roads) Annual Emissions from Routine Operation Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49
2	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63
3	0.8	1.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	185
4	1.6	3.5	0.2	0.1	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.1	472
5	135.0	139.1	12.6	23.3	15.1	73.9	0.2	0.4	0.7	1.4	3.1	3.0	222,531
6	663.1	641.1	55.6	129.9	78.7	409.2	0.8	2.0	5.4	10.8	18.8	11.7	1,008,906
7	752.5	717.7	56.1	142.5	89.9	523.3	1.0	2.3	8.0	15.8	25.1	11.7	1,033,261
8	755.8	720.1	56.1	166.6	92.4	543.6	1.0	2.4	8.5	16.8	26.4	11.7	1,034,821
9	763.4	719.3	56.2	205.7	96.7	623.5	1.1	2.6	10.5	20.8	31.4	11.6	1,039,558
10	767.0	721.5	56.3	206.4	97.0	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
11	767.0	721.5	56.3	206.4	97.0	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
12	767.0	721.5	56.3	198.8	95.8	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
13	767.0	721.5	56.3	198.8	95.8	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
14	767.0	721.5	56.3	198.8	95.8	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
15	767.0	721.5	56.3	198.8	95.8	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527
16-30	767.0	721.5	56.3	198.8	95.8	683.0	1.1	2.7	12.0	23.8	35.1	11.6	1,042,527

Table 2.1-15 Alternative C (Disconnected Infield Roads) Annual Emissions from All Project Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	20.4	32.6	0.9	1.2	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.3	3,475
1	434.5	372.4	4.0	65.8	25.6	27.3	0.3	0.3	0.1	0.3	0.0	2.4	137,757
2	805.9	643.4	6.2	136.2	49.4	48.0	0.5	0.4	0.1	0.4	0.1	3.2	252,075
3	905.9	686.1	5.9	274.8	67.8	60.5	0.7	0.7	0.1	0.7	0.1	5.7	293,408
4	1061.6	1086.4	6.9	419.0	91.2	124.0	1.7	1.4	0.2	0.9	5.0	25.4	379,925
5	772.9	886.2	16.9	380.3	81.9	169.3	1.7	1.7	0.9	2.1	8.1	27.4	477,633
6	836.9	837.4	57.4	298.8	105.4	460.8	2.1	3.1	5.5	11.2	24.8	42.0	1,080,934
7	976.0	977.2	59.4	448.0	130.6	569.9	2.0	3.3	8.1	16.4	29.3	34.5	1,117,404
8	966.0	951.1	58.6	461.8	132.2	589.8	2.0	3.3	8.6	17.3	30.6	34.3	1,118,626
9	893.2	870.9	56.8	499.1	133.7	662.4	1.9	3.4	10.6	21.1	35.5	32.6	1,098,098
10	769.6	722.2	56.3	206.5	97.1	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
11	769.6	722.2	56.3	206.5	97.1	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
12	769.6	722.2	56.3	198.9	95.9	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
13	769.6	722.2	56.3	198.9	95.9	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
14	769.6	722.2	56.3	198.9	95.9	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
15	769.6	722.2	56.3	198.9	95.9	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110
16-30	769.6	722.2	56.3	198.9	95.9	683.2	1.1	2.8	12.0	23.8	35.1	11.6	1,043,110

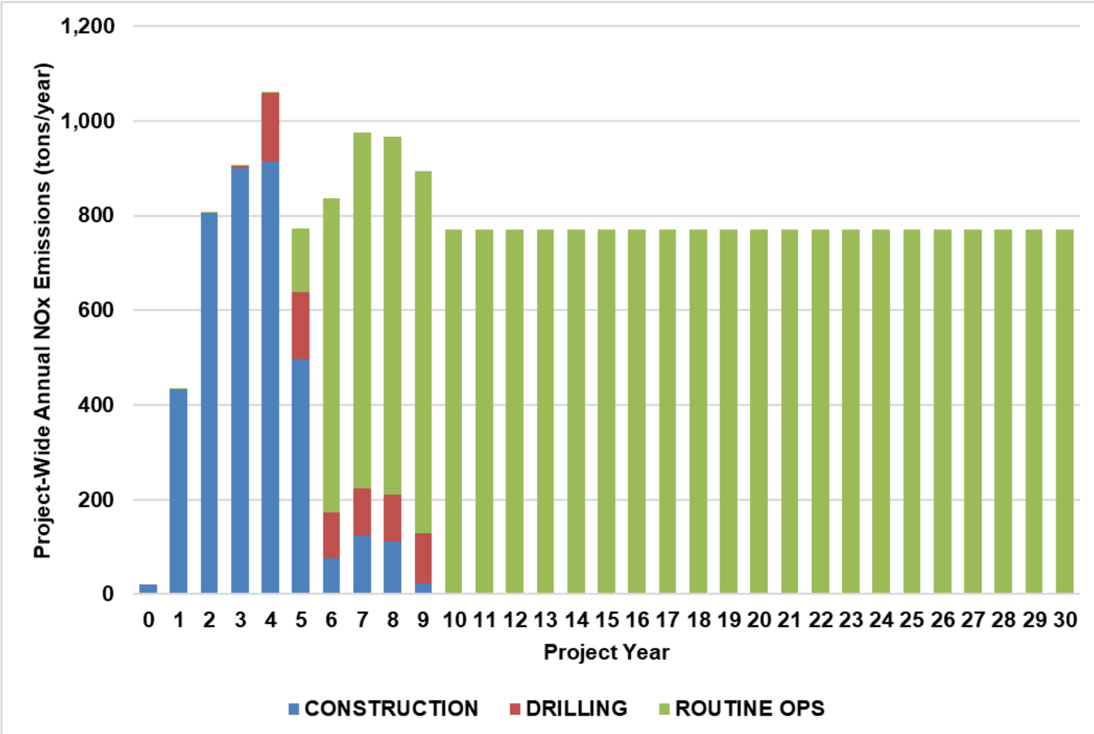

Figure 2.1-7 Alternative C (Disconnected Infield Roads) Annual NOx Emissions by Project Phase*

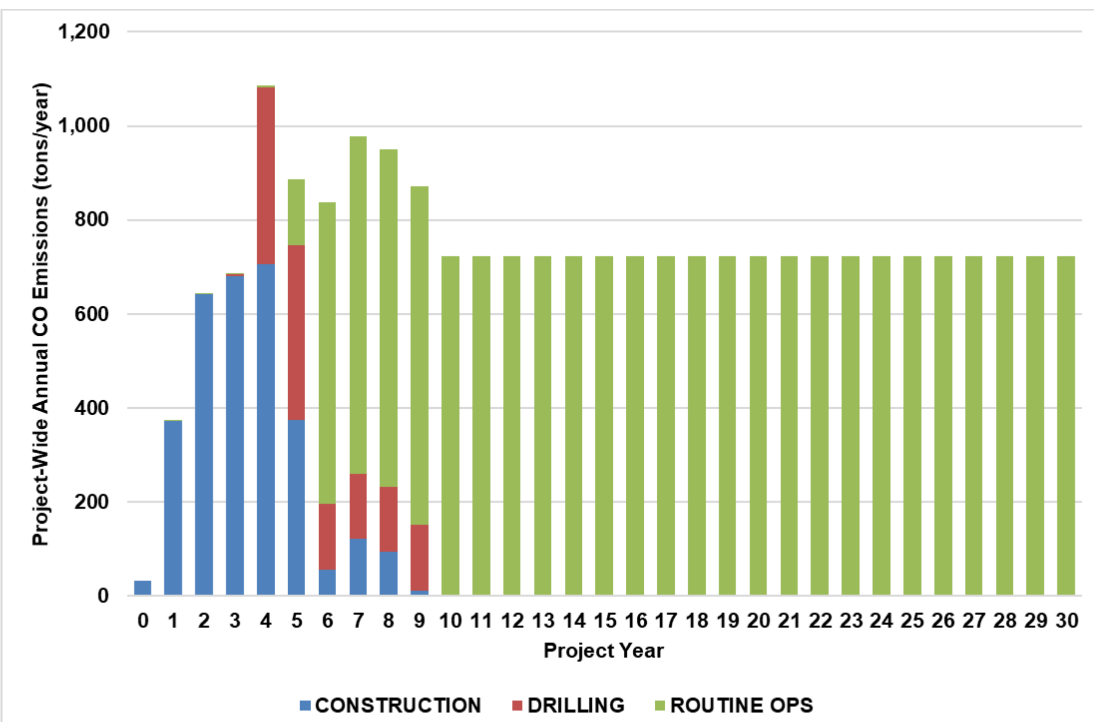

Figure 2.1-8 Alternative C (Disconnected Infield Roads) Annual CO Emissions by Project Phase*

Figure 2.1-9 Alternative C (Disconnected Infield Roads) Annual SO_2 Emissions by Project Phase*

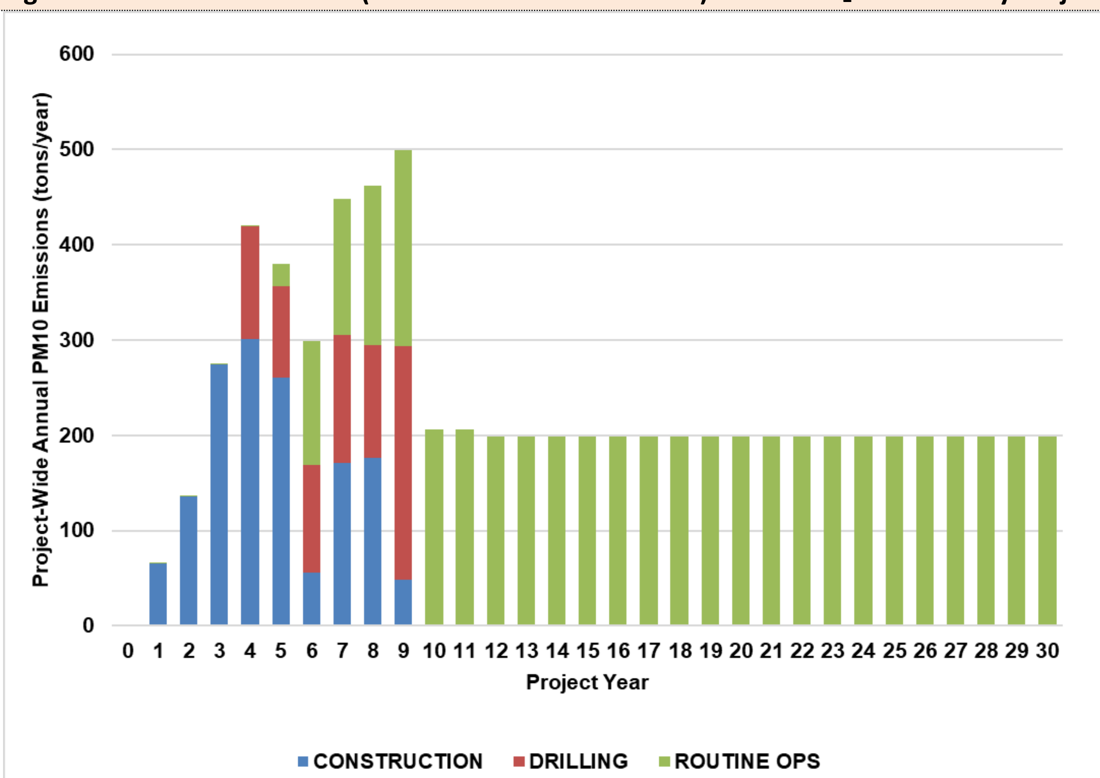

Figure 2.1-10 Alternative C (Disconnected Infield Roads) Annual PM_{10} Emissions by Project Phase*

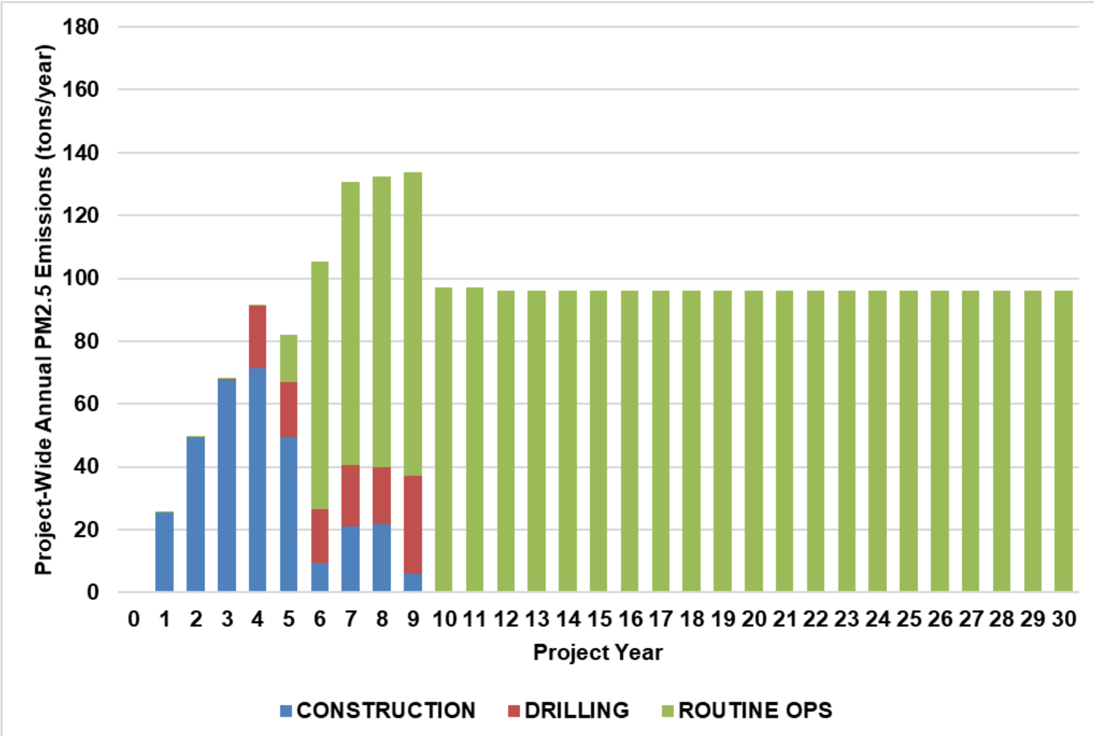

Figure 2.1-11 Alternative C (Disconnected Infield Roads) Annual $PM_{2.5}$ Emissions by Project Phase*

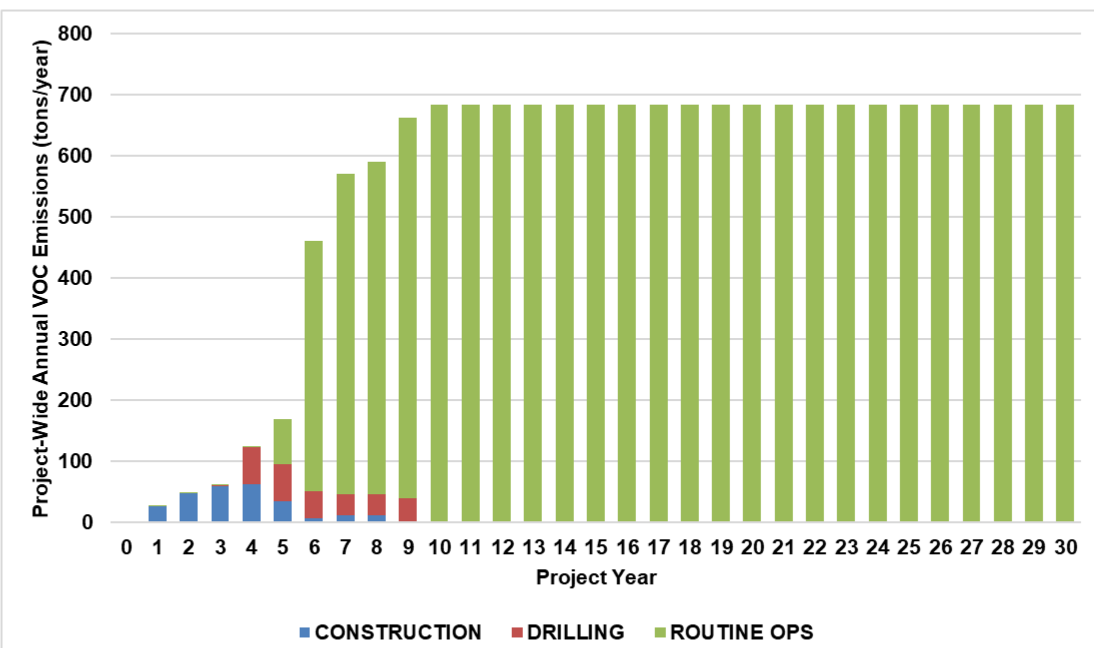

Figure 2.1-12 Alternative C (Disconnected Infield Roads) Annual VOC Emissions by Project Phase*

Alternative C flaring activities are consistent with the methods and input data used for Alternative B and described in Section 2.1.3.

Table 2.1-16 shows maximum annual emissions under Alternative C for criteria pollutant, VOCs, HAP, and GHG emissions, which are identical to the emissions for Alternative B.

Table 2.1-16 Alternative C Maximum Annual Flaring Emissions

Location	Maximum Annual Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
WPF	12.3	41.1	0.9	2.9	2.9	114.5	0.3	0.3	0.0	0.1	5.7	9.5	31,989
Drill sites	2.7	14.7	0.2	0.0	0.0	46.1	1.5	1.3	0.1	0.4	8.3	40.5	5,630
Total	**15.0**	**55.8**	**1.1**	**2.9**	**2.9**	**160.6**	**1.8**	**1.6**	**0.1**	**0.5**	**14.0**	**50.0**	**37,619**

2.1.5 Alternative D (Disconnected Access)

Alternative D would be identical to Alternative B with respect to the number of wells drilled, main Project features, and oil production. The main difference for Alternative D relative to Alternative B is the elimination of all-season gravel access road from the Willow Development Area to GMTU. The emission inventory for Alternative D was extended one year longer than Alternative B and Alternative C to account for the delayed production schedule for Alternative D. Section 1.1.4 “Alternative D: Disconnected Access” provides a description of Alternative D. Alternative B emission inventory spreadsheets were modified with Alternative D inputs provided by the Project proponent and information from the Project description to estimate Alternative D emissions. More information about the Alternative D emissions inventory is provided in Attachment D to this Air Quality Technical Support Document.

Table 2.1-17 shows annual criteria pollutant, VOCs, HAP, and GHG emissions for construction activities by year in Alternative D. The “Year 0” refers to the first year of construction which is a partial year. Table 2.1-18 shows annual Alternative D criteria pollutant, VOCs, HAP, and GHG emissions for drilling (including pre-drilling and developmental drilling) activities. Table 2.1-19 shows annual Alternative D criteria pollutant, VOCs, HAP, and GHG emissions for routine operation activities. Table 2.1-20 shows annual Alternative D criteria pollutant, VOCs, HAP, and GHG emissions summed across all Project activities. Alternative D annual emissions are shown graphically for each criteria pollutant by Project phase in Figure 2.1-13 to Figure 2.1-18.

Construction emissions increase from project start to their peak in year 3 or year 4, then decrease substantially from year 4 to year 5 before increasing to a second, smaller peak in project year 8, then decreasing to year 10 when most construction activities are complete. Alternative D construction emissions peak in year 3 and year 4 when construction activity is highest and temporary power generators are being used exclusively to generate electricity. In year 5, routine operation phase power generation comes online, replacing construction phase temporary power generation. The cessation of construction phase temporary power generation results in substantial construction phase emissions reductions. Additionally, several key construction activities are slowing or have been completed by year 5: multi-season ice pads, gravel mining, drill site gravel pad construction, WOC construction, and bridge construction. In year 8, construction emissions reach a second peak as several construction activities start again: gravel mining, drill site gravel pad construction, bridge construction. Construction activities and emissions decrease after year 8.

The drilling phase includes three different activities: disposal well drilling at the WOC in year 3, pre-drilling from years 5-6, and developmental drilling from years 7-10. For most pollutants, the largest drilling phase emissions occur during pre-drilling when diesel engines are used to power drill rigs, prior to developmental drilling during which highline electricity is used to power drill rigs. PM_{10} emissions are highest in year 10 when drilling phase on-road vehicle activity and hence fugitive dust emissions are highest.

Routine operations at the WPF are expected to commence in the fourth quarter of year 6with commissioning of the WPF and the first drill site (BT1). Subsequent drill sites will be commissioned in the following years and continue operating until the end of field life in year 31. Routine operation emissions generally increase as routine operation facilities (e.g., WOC, WPF, and drill sites) are brought online and thereafter remain relatively constant.

Table 2.1-17 Alternative D (Disconnected Access) Annual Emissions from Construction Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	22.6	33.3	0.9	1.3	0.6	1.5	0.0	0.0	0.0	0.0	0.0	0.3	4,057
1	456.2	379.0	4.0	65.9	26.4	29.7	0.4	0.4	0.1	0.4	0.0	3.0	144,607
2	510.8	397.9	4.1	152.0	37.1	34.4	0.5	0.5	0.1	0.5	0.1	3.8	157,681
3	595.1	429.8	5.3	255.0	51.1	44.4	0.7	0.7	0.1	0.7	0.1	5.9	190,198
4	597.5	422.9	3.9	280.7	54.1	47.2	0.6	0.6	0.1	0.6	0.1	4.9	188,413
5	92.5	36.5	0.5	124.8	16.8	10.0	0.2	0.2	0.1	0.2	0.0	2.0	31,833
6	61.3	26.5	0.2	95.5	13.0	6.7	0.2	0.2	0.0	0.1	0.0	1.4	23,786
7	76.0	55.6	1.3	125.7	16.0	7.2	0.2	0.2	0.0	0.2	0.0	1.4	24,202
8	136.5	129.9	2.9	152.9	20.0	12.9	0.3	0.3	0.1	0.3	0.0	2.7	40,787
9	116.1	95.8	2.0	183.9	22.7	11.7	0.2	0.3	0.1	0.3	0.0	2.4	38,148
10	27.7	11.1	0.1	77.1	9.0	3.0	0.1	0.1	0.0	0.1	0.0	0.6	10,109
11	9.0	2.5	0.0	0.3	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.2	2,025
12	9.0	2.5	0.0	0.3	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.2	2,025
13	7.8	2.2	0.0	0.3	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.2	1,761
14	7.8	2.2	0.0	0.3	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.2	1,761
15	7.8	2.2	0.0	0.3	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.2	1,761
16-31	7.8	2.2	0.0	0.3	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.2	1,761

Table 2.1-18 Alternative D (Disconnected Access) Annual Emissions from Drilling Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
3	3.8	5.3	0.0	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1,728
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
5	142.5	372.3	1.0	131.7	21.0	60.5	1.0	0.8	0.1	0.3	4.9	20.6	88,599
6	142.5	372.3	1.0	131.7	21.0	60.5	1.0	0.8	0.1	0.3	4.9	20.6	88,599
7	98.2	140.6	0.5	129.7	19.0	44.6	1.1	1.0	0.1	0.3	5.9	28.8	47,635
8	97.1	137.1	0.5	99.9	16.0	34.9	0.8	0.7	0.0	0.2	4.2	20.4	46,242
9	97.7	137.5	0.5	129.7	19.0	35.0	0.8	0.7	0.0	0.2	4.2	20.4	46,600
10	98.4	137.9	0.5	146.3	20.7	35.1	0.8	0.7	0.0	0.2	4.2	20.4	46,913
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-19 Alternative D (Disconnected Access) Annual Emissions from Routine Operation Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49
2	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62
3	2.1	4.2	0.2	0.1	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.1	661
4	2.5	4.5	0.3	2.9	0.5	0.8	0.0	0.0	0.0	0.0	0.0	0.1	780
5	119.6	112.5	4.7	17.1	14.7	17.9	0.1	0.1	0.0	0.1	0.0	0.4	84,017
6	250.1	238.1	16.9	45.1	29.9	64.9	0.2	0.4	0.1	0.2	1.6	3.2	304,545
7	633.8	607.3	52.5	136.2	75.6	331.3	0.7	1.7	3.5	7.0	14.1	11.7	945,272
8	637.2	609.4	52.6	136.9	75.9	431.8	0.8	2.0	6.1	12.0	20.4	11.7	948,567
9	642.0	613.4	52.6	140.2	76.4	526.2	0.9	2.3	8.5	16.7	26.2	11.7	951,122
10	648.5	618.3	52.7	146.3	77.4	606.5	1.0	2.5	10.5	20.7	31.2	11.7	955,453
11	653.6	619.7	52.5	240.7	87.2	665.4	1.0	2.6	12.0	23.7	34.9	11.5	959,165
12	653.6	619.7	52.5	234.6	86.2	665.0	1.0	2.6	12.0	23.7	34.9	11.5	959,165
13	653.6	619.7	52.5	234.6	86.2	665.0	1.0	2.6	12.0	23.7	34.9	11.5	959,165
14	653.6	619.7	52.5	234.6	86.2	665.0	1.0	2.6	12.0	23.7	34.9	11.5	959,165
15	653.6	619.7	52.5	234.6	86.2	665.0	1.0	2.6	12.0	23.7	34.9	11.5	959,165
16-31	653.6	619.7	52.5	234.6	86.2	665.0	1.0	2.6	12.0	23.7	34.9	11.5	959,165

Table 2.1-20 Alternative D (Disconnected Access) Annual Emissions from All Project Activities

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	22.6	33.3	0.9	1.3	0.6	1.5	0.0	0.0	0.0	0.0	0.0	0.3	4,057
1	456.7	379.3	4.0	65.9	26.4	29.8	0.4	0.4	0.1	0.4	0.0	3.0	144,656
2	511.3	398.2	4.1	152.0	37.1	34.4	0.5	0.5	0.1	0.5	0.1	3.8	157,744
3	601.0	439.3	5.5	255.3	51.4	45.6	0.7	0.8	0.1	0.7	0.1	6.0	192,587
4	599.9	427.5	4.2	283.6	54.6	47.9	0.6	0.6	0.1	0.6	0.1	5.0	189,193
5	354.6	521.2	6.1	273.6	52.5	88.4	1.3	1.1	0.1	0.6	4.9	23.0	204,449
6	453.9	636.9	18.0	272.3	63.9	132.1	1.4	1.4	0.2	0.6	6.5	25.2	416,930
7	808.1	803.6	54.4	391.7	110.6	383.1	2.0	2.9	3.6	7.4	20.0	42.0	1,017,109
8	870.8	876.4	55.9	389.7	111.9	479.6	1.9	3.0	6.2	12.5	24.6	34.7	1,035,596
9	855.8	846.7	55.1	453.9	118.2	572.9	2.0	3.3	8.6	17.2	30.4	34.4	1,035,870
10	774.5	767.3	53.3	369.6	107.2	644.6	1.9	3.3	10.5	21.0	35.4	32.6	1,012,475
11	662.6	622.2	52.5	241.0	87.5	666.2	1.1	2.7	12.0	23.7	34.9	11.7	961,190
12	662.6	622.2	52.5	234.9	86.5	665.8	1.1	2.7	12.0	23.7	34.9	11.7	961,190
13	661.4	621.9	52.5	234.8	86.5	665.7	1.1	2.7	12.0	23.7	34.9	11.7	960,927
14	661.4	621.9	52.5	234.8	86.5	665.7	1.1	2.7	12.0	23.7	34.9	11.7	960,927
15	661.4	621.9	52.5	234.8	86.5	665.7	1.1	2.7	12.0	23.7	34.9	11.7	960,927
16-31	661.4	621.9	52.5	234.8	86.5	665.7	1.1	2.7	12.0	23.7	34.9	11.7	960,927

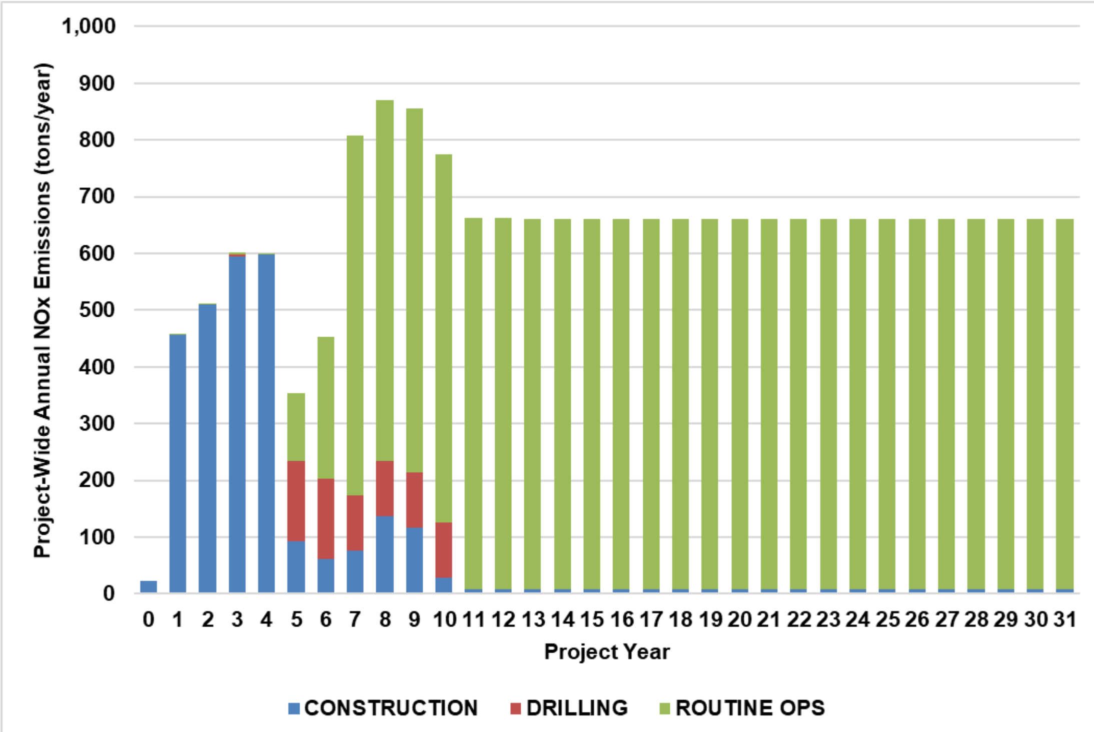

Figure 2.1-13 Alternative D (Disconnected Access) Annual NOx Emissions by Project Phase*

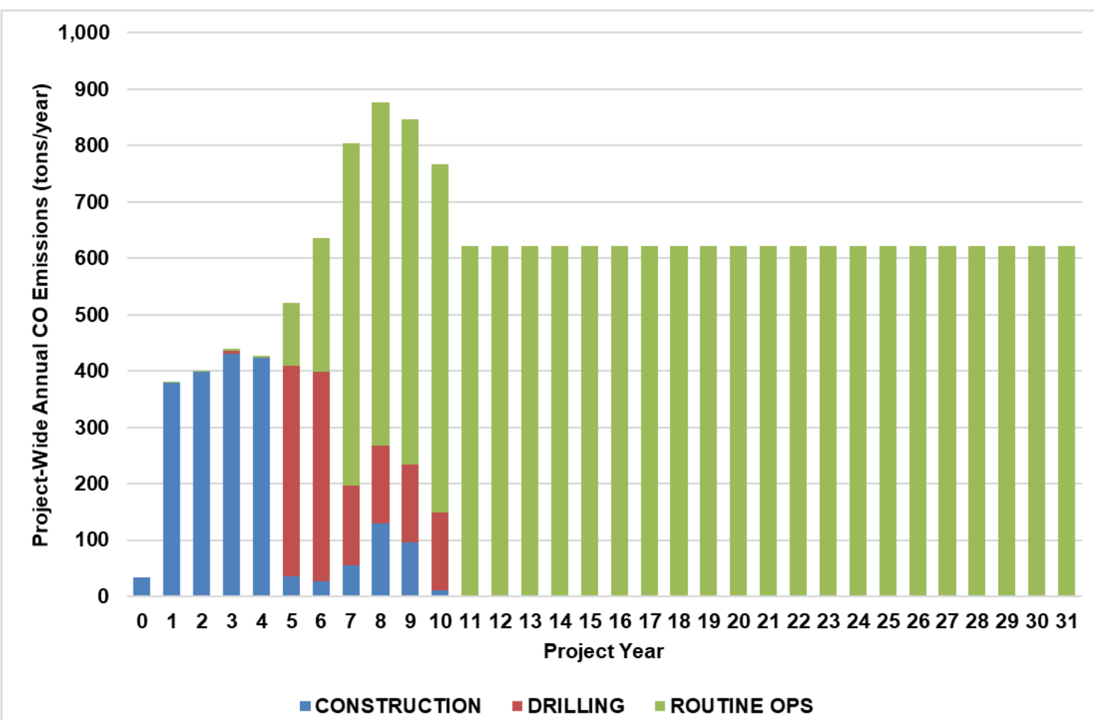

Figure 2.1-14 Alternative D (Disconnected Access) Annual CO Emissions by Project Phase*

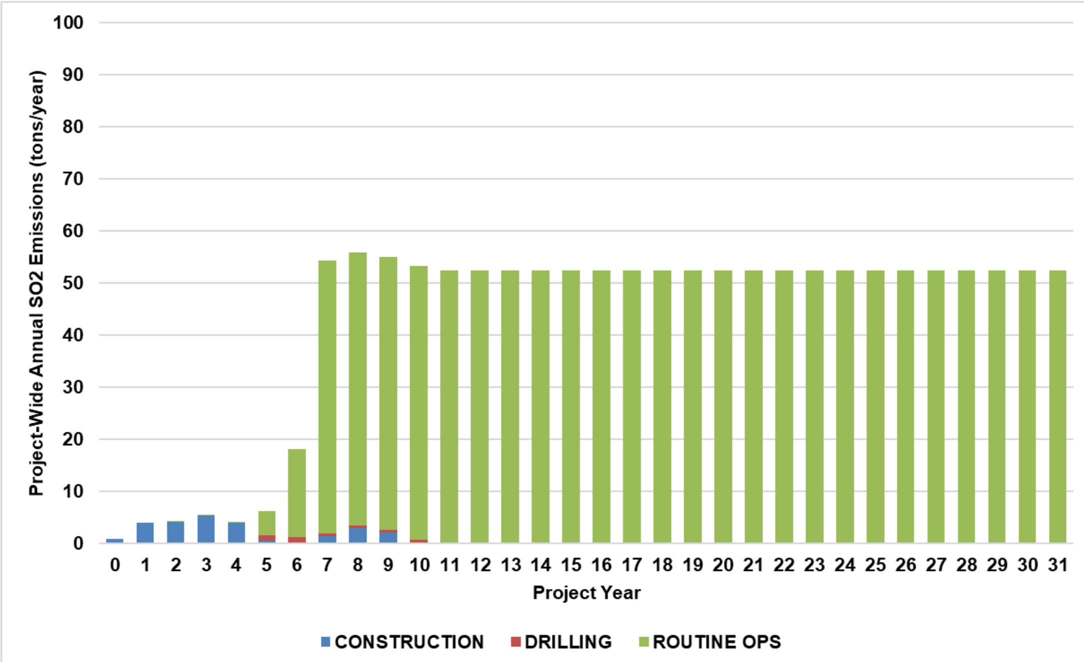

Figure 2.1-15 Alternative D (Disconnected Access) Annual SO_2 Emissions by Project Phase*

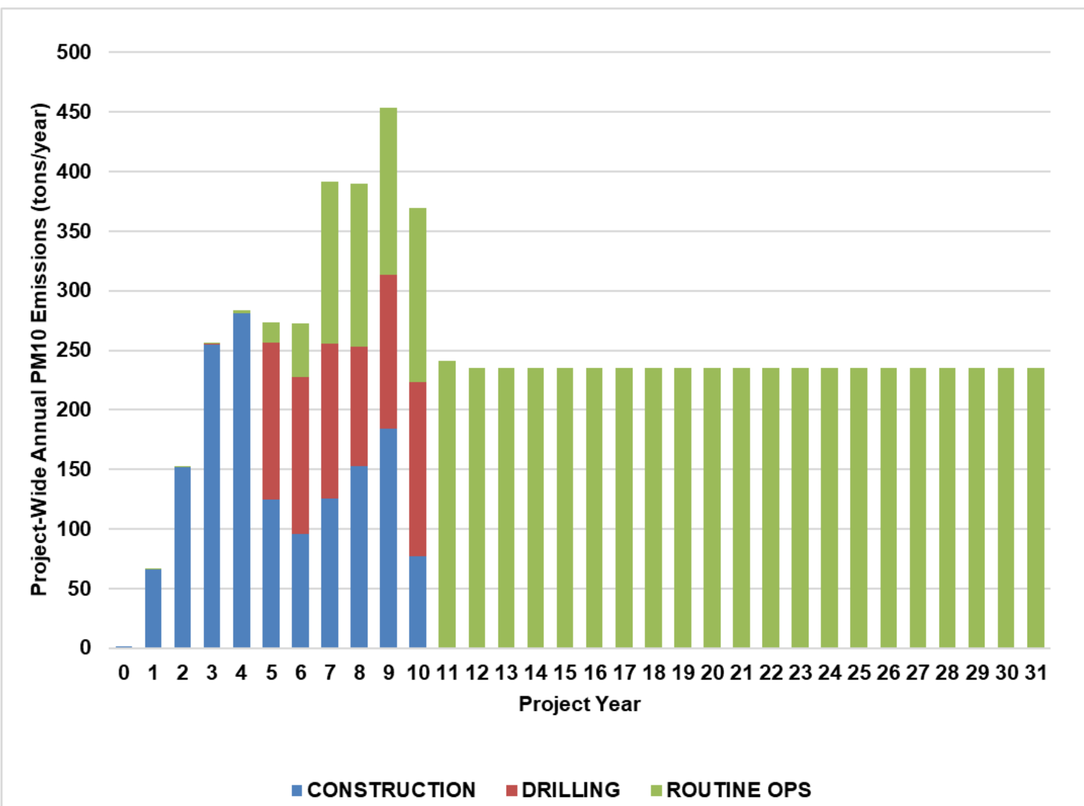

Figure 2.1-16 Alternative D (Disconnected Access) Annual PM_{10} Emissions by Project Phase*

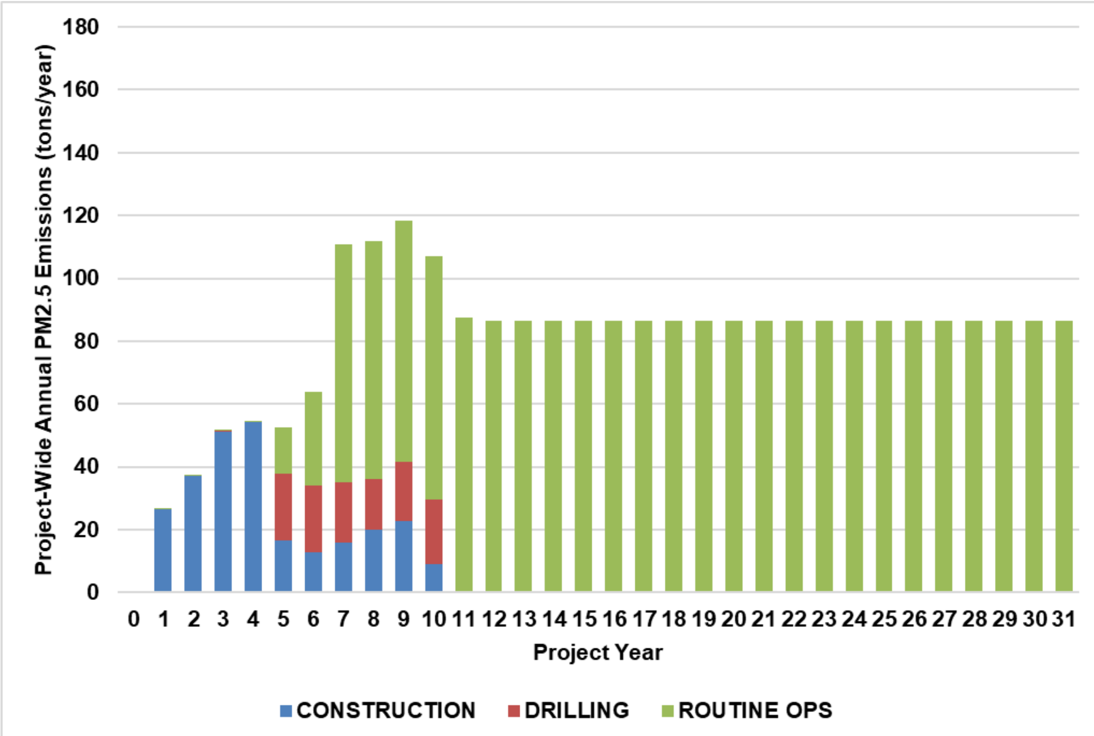

Figure 2.1-17 Alternative D (Disconnected Access) Annual $PM_{2.5}$ Emissions by Project Phase*

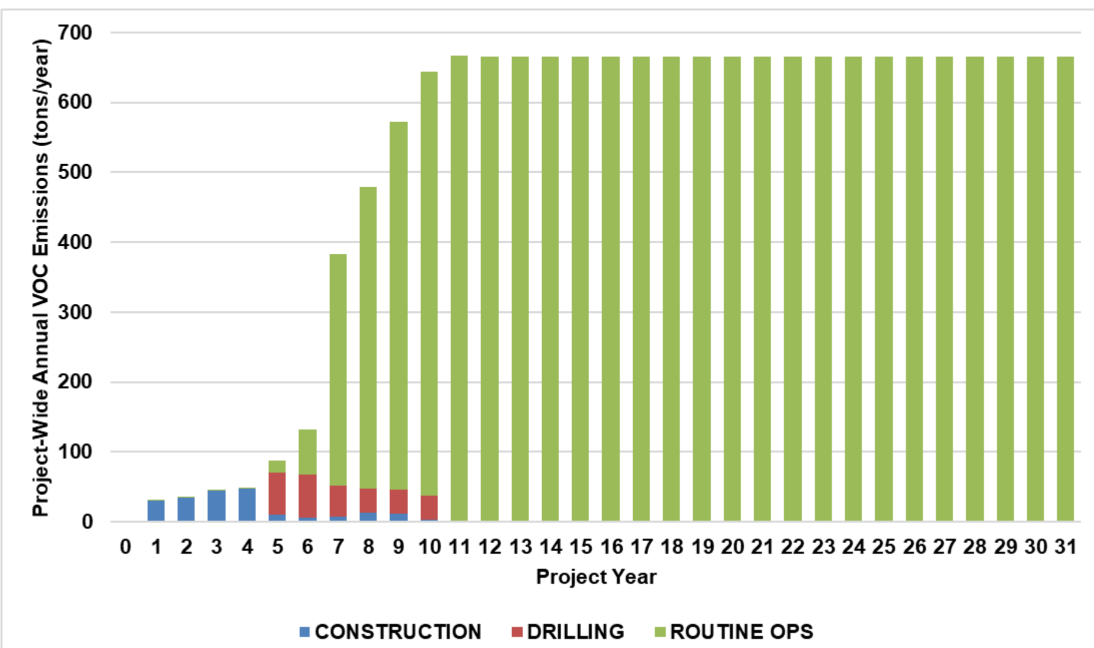

Figure 2.1-18 Alternative D (Disconnected Access) Annual VOC Emissions by Project Phase*

Alternative C flaring activities are consistent with the methods and input data used for Alternative B and described in Section 2.1.3, although the construction schedule for Alternative D varies slightly from Alternative B. Under Alternative D, flaring at drill sites would occur from project year 5 to 10. Typically, there would be 1 flowback event per well drilled with a duration of 3 days of flaring per flowback event. Under Alternative D, there will be 4 flowbacks per month during project years 5 and 6; in project year 7, 4 flowbacks per month will occur from January through May; and from June in project year 7 to end of project year 10, there will be 2 flowbacks per month.

Table 2.1-21 shows maximum annual emissions under Alternative D for criteria pollutant, VOCs, HAP, and GHG emissions, which is identical to Alternative B.

Table 2.1-21 Alternative D Maximum Annual Flaring Emissions

Location	Maximum Annual Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
WPF	12.3	41.1	0.9	2.9	2.9	114.5	0.3	0.3	0.0	0.1	5.7	9.5	31,989
Drill sites	2.7	14.7	0.2	0.0	0.0	46.1	1.5	1.3	0.1	0.4	8.3	40.5	5,629
Total	**15.0**	**55.8**	**1.1**	**2.9**	**2.9**	**160.6**	**1.8**	**1.6**	**0.1**	**0.5**	**14.0**	**50.0**	**37,619**

2.1.6 Alternative E (Three-Pad Alternative)*

Alternative E would be similar to Alternative B with respect to several Project features. The main difference in Alternative E relative to Alternative B that affects the emissions inventory is that drill site BT4 would not be constructed. There would also only be 219 wells under Alternative E compared to 251 wells under Alternative B. Section 1.1.5 "Alternative E: Three-Pad Alternative" provides a description of Alternative E. More information about the Alternative E emissions inventory is provided in Attachment G to this Air Quality Technical Support Document. The Alternative E emission inventory from the Project proponent was reviewed and revised by the BLM; therefore, the emission inventories presented in this section differs from the inventory presented in Attachment G.[10]

Table 2.1-22 shows annual criteria pollutant, VOCs, HAP, and GHG emissions in Alternative E for construction activities by year. The "Year 0" refers to the first year of construction which is a partial year. Table 2.1-23 shows annual Alternative E criteria pollutant, VOCs, HAP, and GHG emissions for drilling (including pre-drilling and developmental drilling) activities. Table 2.1-24 shows annual Alternative E criteria pollutant, VOCs, HAP, and GHG emissions for routine operation activities.

Table 2.1-25Table 2.1-25 shows annual Alternative E criteria pollutant, VOCs, HAP, and GHG emissions summed across all Project activities. Alternative E annual emissions are shown graphically for each criteria pollutant by Project phase in Figure 2.1-19 to Figure 2.1-24.

Construction emissions increase from project start to year 4, then, generally decrease to the end of construction activities in year 8. All pollutants generally follow this trend of increasing emissions until year 4 followed by decreases in emissions, with slight exceptions for sulfur dioxide, carbon monoxide, and certain HAPs (n-hexane and formaldehyde) and.

The drilling phase includes three different activities: disposal well drilling at the WOC in year 3, pre-drilling from years 4 to -5, and developmental drilling from years 6 to 9. For most pollutants, the largest drilling phase emissions occur during pre-drilling when diesel engines are used to power drill rigs, prior to developmental drilling during which highline electricity is used to power drill rigs. PM_{10} and $PM_{2.5}$ emissions are highest in year 7 when drilling phase on-road vehicle activity and hence fugitive dust emissions are highest.

Routine operations at the WPF are expected to commence in the fourth quarter of year 5 with commissioning of the WPF and the first drill site (BT1). Subsequent drill sites will be commissioned in the following years and continue operating until the end of field life in year 30. Routine operation emissions generally increase as routine operation facilities (e.g., WOC, WPF, and drill sites) are brought online and thereafter remain relatively constant.

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[10] Revisions to the Attachment G emission inventory were limited to the supplementation of hazardous air pollutant emissions for drilling flowback flaring and WPF low pressure and high pressure flaring for completeness.

Table 2.1-22 Alternative E (Four-Disconnected Access Four- Pad Alternative) Annual Emissions from Construction Activities*

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	17.1	25.0	0.7	1.0	0.5	1.1	0.0	0.0	0.0	0.0	0.0	0.3	3,082
1	430.6	354.0	3.2	80.3	20.3	26.1	0.4	0.4	0.1	0.4	0.1	3.1	141,826
2	452.3	361.6	4.1	100.6	22.9	26.1	0.4	0.4	0.1	0.3	0.0	2.9	137,855
3	531.3	397.3	3.7	211.1	37.5	36.1	0.6	0.6	0.1	0.6	0.1	4.9	169,815
4	592.4	419.2	3.1	216.7	41.6	45.1	0.6	0.7	0.1	0.6	0.1	5.3	188,910
5	131.3	60.2	0.4	209.4	29.0	14.9	0.3	0.3	0.1	0.3	0.0	3.0	52,746
6	86.2	57.0	1.0	84.7	13.4	8.9	0.2	0.2	0.0	0.2	0.0	1.9	32,591
7	69.1	66.4	1.4	51.7	7.7	7.1	0.1	0.2	0.0	0.2	0.0	1.5	24,016
8	19.2	10.5	0.1	39.4	5.1	2.3	0.0	0.0	0.0	0.0	0.0	0.4	7,950
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-23 Alternative E (Three-Pad Alternative) Annual Emissions from Drilling Activities*

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
3	3.8	5.3	0.0	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1,728
4	142.2	372.1	1.0	116.6	19.5	60.4	1.0	0.8	0.1	0.3	4.9	20.6	88,435
5	143.8	372.8	1.0	152.5	23.2	60.6	1.0	0.8	0.1	0.3	4.9	20.6	89,182
6	102.7	146.5	0.6	191.1	25.4	58.5	1.5	1.4	0.1	0.4	8.3	40.7	50,615
7	108.5	148.9	0.6	324.7	39.0	59.3	1.6	1.4	0.1	0.4	8.3	40.8	53,391
8	54.2	74.5	0.3	153.2	18.6	29.7	0.8	0.7	0.0	0.2	4.2	20.4	26,560
9	54.2	74.4	0.3	161.6	19.4	29.6	0.8	0.7	0.0	0.2	4.2	20.4	26,681
10	54.2	74.4	0.3	161.6	19.4	29.6	0.8	0.7	0.0	0.2	4.2	20.4	26,681
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
16-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

Table 2.1-24 Alternative E (Three-Pad Alternative) Annual Emissions from Routine Operation Activities*

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49
2	0.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86
3	1.7	3.1	0.2	0.1	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.1	502
4	15.0	15.8	0.6	2.6	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.2	3,414
5	261.8	247.2	16.9	51.9	31.1	93.8	0.3	0.5	0.8	1.6	3.3	3.1	307,889
6	649.8	619.0	52.7	165.3	79.3	431.7	0.8	2.0	6.0	11.9	20.4	11.6	955,000
7	657.3	624.6	52.9	169.3	80.1	532.8	0.9	2.3	8.6	17.0	26.7	11.6	959,927
8	656.7	623.6	52.8	171.2	80.3	532.4	0.9	2.3	8.6	17.0	26.7	11.5	959,719
9	656.8	623.6	52.7	177.0	80.9	532.4	0.9	2.3	8.6	17.0	26.7	11.5	959,626
10	662.6	628.2	52.8	177.3	81.2	612.1	1.0	2.5	10.6	20.9	31.7	11.5	963,837
11	661.9	627.2	52.7	177.3	81.2	611.8	1.0	2.5	10.6	20.9	31.7	11.5	963,604
12	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
13	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
14	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
15	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
16-30	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604

Table 2.1-25. Alternative E (Three-Pad Alternative) Annual Emissions from All Project Activities*

Project Year	Total Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
0	17.1	25.0	0.7	1.0	0.5	1.1	0.0	0.0	0.0	0.0	0.0	0.3	3,082
1	431.1	354.2	3.2	80.4	20.4	26.1	0.4	0.4	0.1	0.4	0.1	3.1	141,875
2	452.8	363.1	4.1	100.6	23.0	26.1	0.4	0.4	0.1	0.3	0.0	2.9	137,941
3	536.8	405.7	3.9	211.4	37.9	37.2	0.6	0.6	0.1	0.6	0.1	4.9	172,045
4	749.6	807.2	4.7	335.8	62.1	108.1	1.7	1.5	0.2	0.9	5.0	26.1	280,759
5	536.8	680.1	18.2	413.9	83.3	169.4	1.6	1.6	0.9	2.2	8.3	26.8	449,817
6	838.6	822.5	54.3	441.2	118.1	499.1	2.6	3.6	6.2	12.5	28.7	54.1	1,038,206
7	835.0	839.9	54.9	545.7	126.9	599.1	2.6	3.8	8.7	17.6	35.0	53.8	1,037,335
8	730.1	708.6	53.2	363.8	104.0	564.4	1.7	3.0	8.6	17.2	30.9	32.3	994,228
9	711.0	698.0	53.0	338.6	100.3	562.1	1.7	3.0	8.6	17.2	30.9	31.9	986,307
10	716.8	702.6	53.1	338.9	100.7	641.8	1.8	3.2	10.6	21.2	35.8	31.9	990,519
11	661.9	627.2	52.7	177.3	81.2	611.8	1.0	2.5	10.6	20.9	31.7	11.5	963,604
12	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
13	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
14	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
15	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604
16-30	661.9	627.2	52.7	170.6	80.2	611.4	1.0	2.5	10.6	20.9	31.7	11.5	963,604

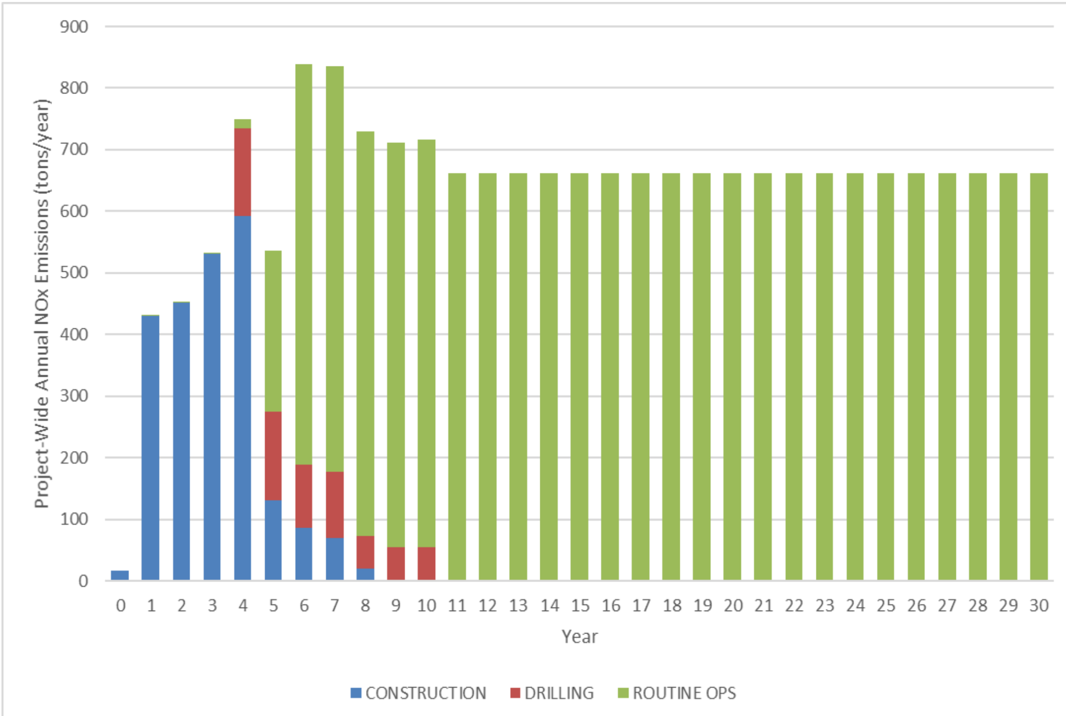


Figure 2.1-19 Alternative E (Three-Pad Alternative) Annual NOx Emissions by Project Phase*

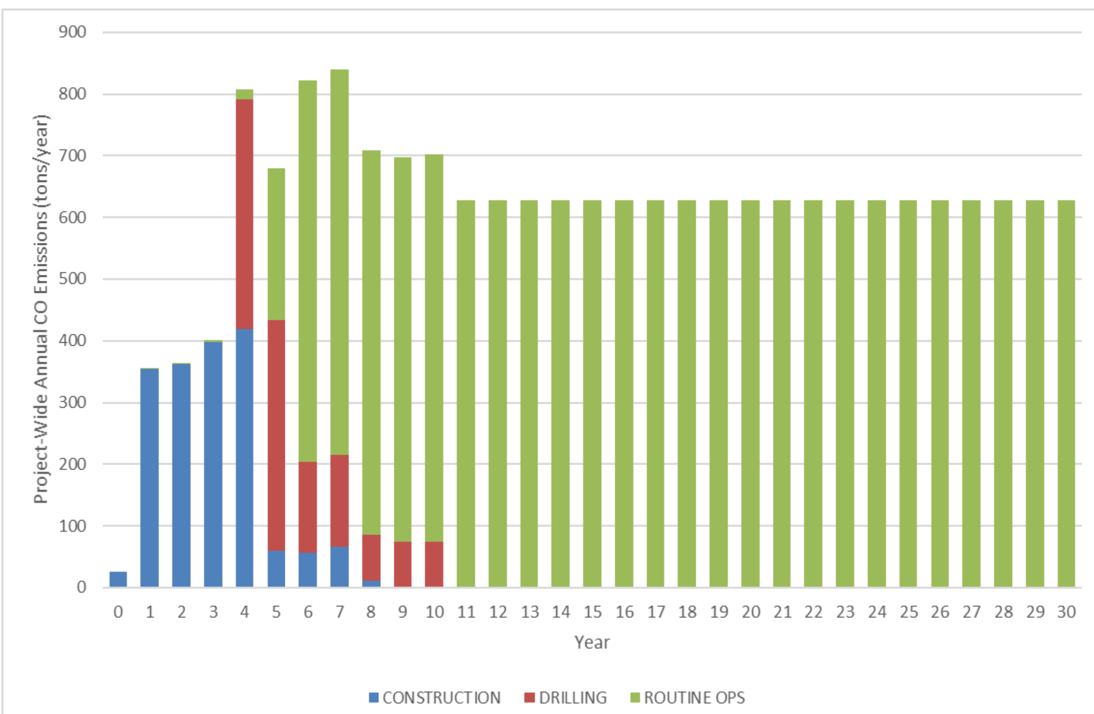


Figure 2.1-20 Alternative E (Three-Pad Alternative) Annual CO Emissions by Project Phase*

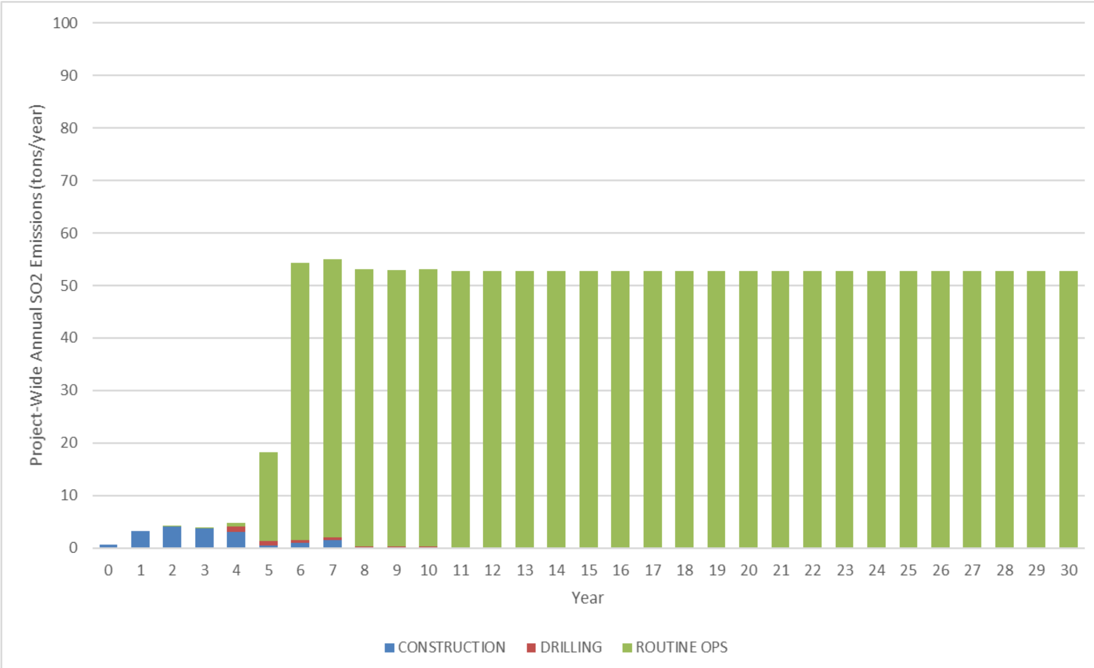


Figure 2.1-21 Alternative E (Three-Pad Alternative) Annual SO_2 Emissions by Project Phase*

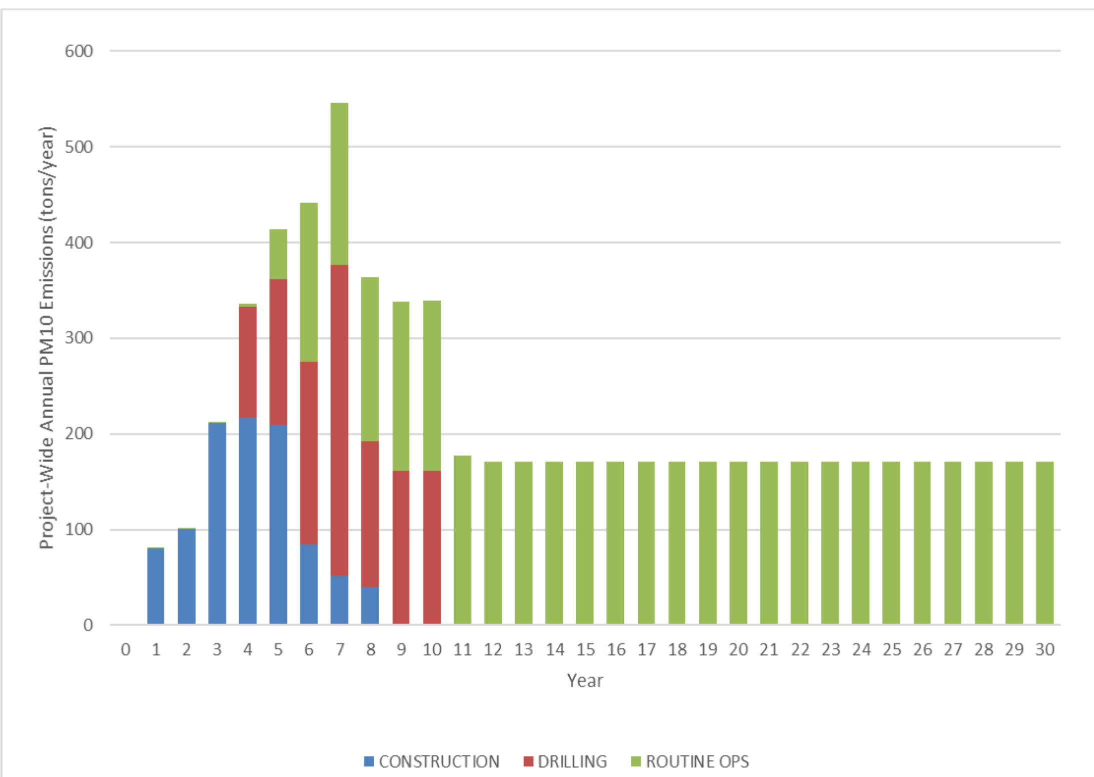


Figure 2.1-22 Alternative E (Three-Pad Alternative) Annual PM_{10} Emissions by Project Phase*

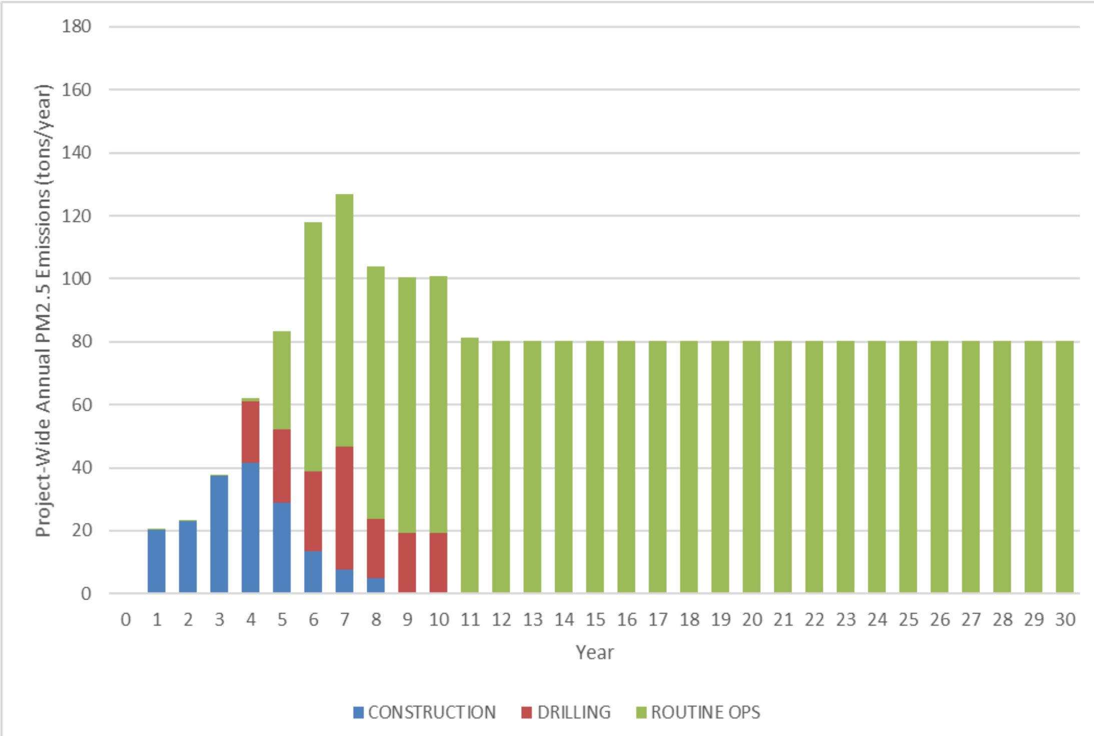


Figure 2.1-23 Alternative E (Three-Pad Alternative) Annual $PM_{2.5}$ Emissions by Project Phase*

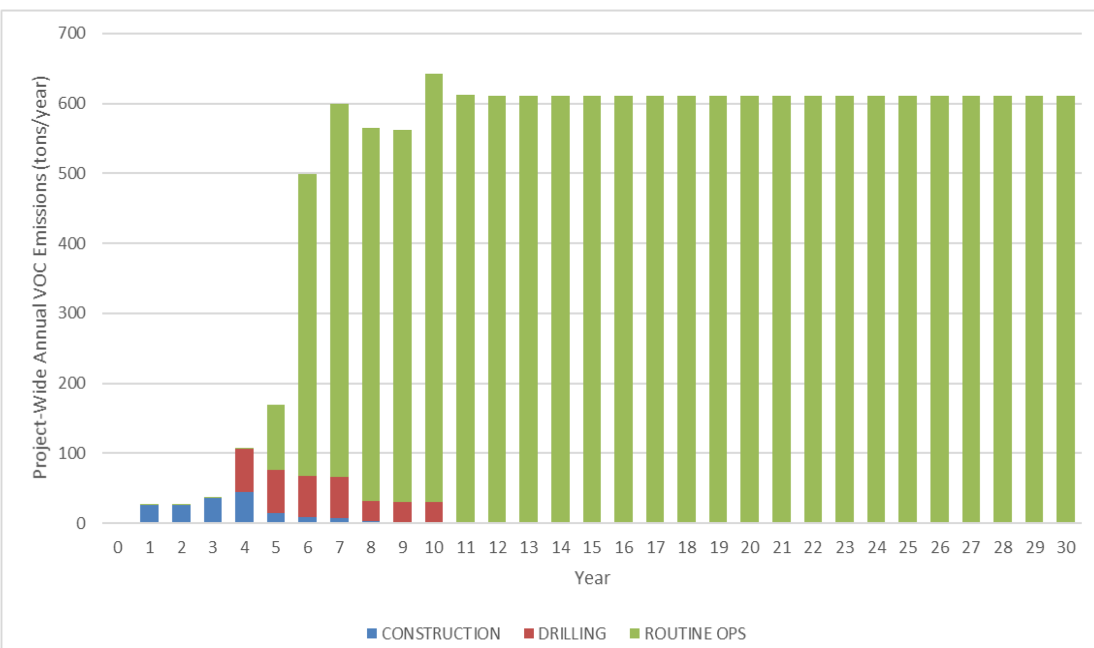


Figure 2.1-24 Alternative E (Three-Pad Alternative) Annual VOC Emissions by Project Phase

Alternative E flaring activities are consistent with the methods and input data used for Alternative B and described in Section 2.1.3, although the construction schedule for Alternative E varies slightly from Alternative B. Under Alternative E, flaring at drill sites would occur from project year 4 to 10. Typically, there would be 1 flowback event per well drilled with a duration of 3 days of flaring per flowback event. Under Alternative E, there will be 4 flowbacks per month during project years 4 to 7; from project year 8 to end of project year 10, there will be 2 flowbacks per month.

Table 2.1-26 shows maximum annual emissions under Alternative E for criteria pollutant, VOCs, HAP, and GHG emissions, which is slightly higher than Alternative B for flowback flaring at drill sites.

Table 2.1-26 Alternative E Maximum Annual Flaring Emissions

Location	Maximum Annual Emissions (tons per year [tpy])												
	Criteria Pollutants						HAP						GHGs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	n-Hexane	Formaldehyde	CO_2e
WPF	12.3	41.1	0.9	2.9	2.9	114.5	0.3	0.3	0.0	0.1	5.7	9.5	31,989
Drill sites	2.7	14.7	0.2	0.0	0.0	46.1	1.5	1.3	0.1	0.4	8.3	40.5	5,638
Total	**15.0**	**55.8**	**1.1**	**2.9**	**2.9**	**160.6**	**1.8**	**1.6**	**0.1**	**0.5**	**14.0**	**50.0**	**37,627**

2.1.7 Module Delivery Options

Sealift barges would be used to deliver processing and drill site modules near the Willow Development area under Alternatives B, C, D, and E. At the time that this inventory was developed, all three Module Delivery Options were being considered for Alternatives B, C, D, and E. Emission inventories were developed for activity associated with three Module Delivery options, Option 1, 2, and 3. Total life-of-Project emissions from the Module Delivery Options are the same under each Alternative except as follows: 1) for Alternative D, the Module Delivery Option schedule is delayed by one year, and 2) for Alternative D, Colville River Crossing (Option 3) requires increased ice road length, resulting in higher emissions for this option for Alternative D compared to Alternatives B, C, and E. Section 1.1.5 “Module Delivery Options” provides a description of Module Delivery Options. Emissions for Module Delivery Options 1 and 2 are described in more detail in Attachment D to this Air Quality Technical Support Document and Module Delivery Option 3 is described in Attachment C.

Table 2.1-27 presents total life-of-Project emissions from each Module Delivery Option. Table 2.1-28 shows activity inputs for each Module Delivery Option. Option 2 emissions are higher than Option 1 and 3 emissions primarily as a result of longer distances required for vehicular travel between the Project area and the Point Lonely module delivery area (Option 2) compared to travel between the Project area and either the Point Atigaru nearshore staging area (Option 1) or Colville River Crossing (Oliktok Dock) (Option 3). Option 3 emissions are smaller than Option 1 emissions for all pollutants (except PM_{10}) because Option 1 includes greater emissions from construction of the module delivery area at Point Atigaru compared to construction emissions at Oliktok Dock. PM_{10} emissions are higher for Option 3 because Option 3 includes more vehicle travel during the months of May to October during which road dust emissions are estimated to occur.

Table 2.1-27 Total Emissions for each Module Delivery Option

Module Delivery Option	Total Criteria Emissions (tons)						Total HAPs (tons)	Total CO_2e (thousand metric tons)
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC		
Option 1: Atigaru Point MTI	493	554	4	36	23	79	11	140
Option 2: Point Lonely MTI	1,059	1,200	6	83	50	172	22	341
Option 3 - Alt B/C/E	126	91	1	68	11	16	3	40
Option 3 - Alt D	141	95	1	68	12	17	3	43

Table 2.1-28 Activity Inputs for each Module Delivery Option

Activity	Parameter	Option 1: Atigaru Point MTI	Option 2: Point Lonely MTI	Option 3 – Alt B/C/E	Option 3 – Alt D	Unit
Ice Pads	Total Acres	59	128	30	30	acres
Ice Roads	Total Miles	111	225	80	105	miles
Gravel Mining	Total Gravel Requirement	397,000	446,000	118,700	118,700	million cubic yards (MCY)
Construction Total Traffic	Vehicle Miles Travelled (VMT)	91,154	242,621	20,996	20,996	thousand miles (kmile)
All Vessel	Total Sea Traffic	265	265	76	76	number
All Aircraft	Total Flights	680	776	86	86	number

Module Delivery Option 1 (Atigaru Point Module Transfer Island)

Table 2.1-29 presents annual emissions from Option 1 Module Delivery-related activities for Alternatives B and C and Table 2.1-30 presents annual emissions for Option 1 Module Delivery-related activities for Alternative D.

In Table 2.1-29 and Table 2.1-30 emissions drop substantially in project year 6 for Alternatives B, C, E and year 7 for Alternative D. Vehicle traffic is the largest emissions source category for all pollutants and vehicle traffic is highest during module transport. Module transport occurs in the winter months after the module has been delivered in the previous summer. The module option schedule for Alternatives B, C, and E indicate that there is no module delivered in the summer of year 5 (year 6 for Alternative D), hence little activity and emissions from module transport in the winter of year 6 (year 7 for Alternative D).

Table 2.1-29 Option 1: Proponent's Module Transfer Island Annual Emissions – Alternatives B, C, and E

Project Year [a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	1.9	1.6	0.0	0.2	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	830
2	25.2	24.0	0.4	1.7	1.0	2.8	0.0	0.0	0.0	0.0	0.0	0.4	7493
3	71.5	52.8	1.9	4.4	2.9	7.3	0.1	0.1	0.0	0.1	0.0	1.2	19236
4	74.3	77.4	0.6	5.4	3.6	12.0	0.1	0.1	0.0	0.1	0.0	1.2	23745
5	139.1	171.3	0.4	10.4	6.7	24.5	0.2	0.2	0.1	0.2	0.1	2.3	45604
6	62.7	70.4	0.2	4.6	3.0	10.6	0.1	0.1	0.0	0.1	0.0	1.1	20392
7	118.3	156.1	0.3	8.7	5.7	21.5	0.2	0.2	0.1	0.2	0.0	2.0	37294
8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
10	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
11+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Table 2.1-30 Option 1: Proponent's Module Transfer Island Annual Emissions – Alternative D (Disconnected Access)

Project Year [a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.9	1.6	0.0	0.2	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	830.4
3	25.2	24.0	0.4	1.7	1.0	2.8	0.0	0.0	0.0	0.0	0.0	0.4	7492.7
4	71.5	52.8	1.9	4.4	2.9	7.3	0.1	0.1	0.0	0.1	0.0	1.2	19235.9
5	74.3	77.4	0.6	5.4	3.6	12.0	0.1	0.1	0.0	0.1	0.0	1.2	23744.8
6	139.1	171.3	0.4	10.4	6.7	24.5	0.2	0.2	0.1	0.2	0.1	2.3	45603.7
7	62.7	70.4	0.2	4.6	3.0	10.6	0.1	0.1	0.0	0.1	0.0	1.1	20392.4
8	118.3	156.1	0.3	8.7	5.7	21.5	0.2	0.2	0.1	0.2	0.0	2.0	37294.1
9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11+	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Module Delivery Option 2 (Point Lonely Module Transfer Island)

Table 2.1-31 presents annual emissions from Option 2 Module Delivery-related activities for Alternatives B, C, and E and Table 2.1-32 presents annual emissions from Option 2 Module Delivery-related activities for Alternative D.

In Table 2.1-31 and Table 2.1-32 emissions drop substantially in project year 6 for Alternative B/C and year 7 for Alternative D. Vehicle traffic is the largest emissions source category for all pollutants and vehicle traffic is highest during module transport. Module transport occurs in the winter months after the module has been delivered in the previous summer. The module option schedule for Alternatives B, C, and E indicate that there is no module delivered in the summer of year 5 (year 6 for Alternative D), hence little activity and emissions from module transport in the winter of year 6 (year 7 for Alternative D).

Table 2.1-31 Option 2: Point Lonely Module Transfer Island Annual Emissions – Alternatives B, C, and E

Project Year[a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	3.1	3.0	0.0	0.3	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1470
2	52.9	45.7	0.5	3.9	2.1	6.4	0.1	0.1	0.0	0.1	0.0	0.8	18572
3	151.7	106.6	2.2	10.3	6.6	18.1	0.3	0.3	0.1	0.3	0.1	2.7	52506
4	145.3	164.4	0.8	11.5	7.0	24.1	0.2	0.2	0.1	0.2	0.1	2.3	51788
5	307.8	381.0	0.9	24.9	14.7	53.5	0.4	0.4	0.2	0.4	0.1	4.6	111262
6	127.6	150.8	0.4	10.0	6.1	21.8	0.2	0.2	0.1	0.2	0.1	2.1	45356
7	270.8	348.0	0.8	21.5	13.0	47.9	0.4	0.3	0.1	0.3	0.1	4.2	94699
8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
10	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
11+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Table 2.1-32 Option 2: Point Lonely Module Transfer Island Annual Emissions – Alternative D (Disconnected Access)

Project Year[a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3.1	3.0	0.0	0.3	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1469.8
3	52.9	45.7	0.5	3.9	2.1	6.4	0.1	0.1	0.0	0.1	0.0	0.8	18571.8
4	151.7	106.6	2.2	10.3	6.6	18.1	0.3	0.3	0.1	0.3	0.1	2.7	52506.0
5	145.3	164.4	0.8	11.5	7.0	24.1	0.2	0.2	0.1	0.2	0.1	2.3	51788.1
6	307.8	381.0	0.9	24.9	14.7	53.5	0.4	0.4	0.2	0.4	0.1	4.6	111261.5
7	127.6	150.8	0.4	10.0	6.1	21.8	0.2	0.2	0.1	0.2	0.1	2.1	45356.3
8	270.8	348.0	0.8	21.5	13.0	47.9	0.4	0.3	0.1	0.3	0.1	4.2	94698.8
9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11+	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Module Delivery Option 3 (Colville River Crossing)

Table 2.1-33 presents annual emissions from Option 3 Module Delivery-related activities for Alternatives B, C, E and Table 2.1-34 presents annual emissions from Option 3 Module Delivery-related activities for Alternative D.

In Table 2.1-33 and Table 2.1-34 emissions drop substantially in project year 6 for Alternative B, C, E and year 7 for Alternative D. Vehicle traffic is the largest emissions source category for all pollutants and vehicle traffic is highest during module transport. Module transport occurs in the winter months after the module has been delivered in the previous summer. The module option schedule for Alternatives B, C, and E indicate that there is no module delivered in the summer of year 5 (year 6 for Alternative D), hence little activity and emissions from module transport in the winter of year 6 (year 7 for Alternative D).

Table 2.1-33 Option 3: Colville River Crossing Annual Emissions – Alternatives B, C, and E

Project Year[a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2	1.2	3.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137
3	7.2	9.6	0.2	53.0	5.6	0.7	0.0	0.0	0.0	0.0	0.0	0.2	2154
4	18.4	11.3	0.3	4.5	1.1	2.2	0.0	0.0	0.0	0.0	0.0	0.3	6029
5	41.1	27.8	0.1	2.9	1.7	5.3	0.1	0.1	0.0	0.1	0.0	0.6	14920
6	16.7	11.1	0.1	4.4	1.0	2.1	0.0	0.0	0.0	0.0	0.0	0.3	5948
7	41.0	27.7	0.1	2.9	1.7	5.3	0.1	0.1	0.0	0.1	0.0	0.6	14874
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
11+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Table 2.1-34 Option 3: Colville River Crossing Annual Emissions – Alternative D (Disconnected Access)

Project Year[a]	Total Emissions (tpy)												
	Criteria Pollutants						HAP						GHGs
	NOx	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	EthylBen-zene	Xylene	n-Hexane	Formalde-hyde	CO_2e
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
3	1.2	3.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137
4	7.2	9.6	0.2	53.0	5.6	0.7	0.0	0.0	0.0	0.0	0.0	0.2	2154
5	20.6	11.9	0.4	4.5	1.1	2.4	0.0	0.0	0.0	0.0	0.0	0.3	6529
6	46.6	29.3	0.1	3.1	1.9	5.8	0.1	0.1	0.0	0.1	0.0	0.7	16168
7	18.9	11.7	0.1	4.4	1.1	2.3	0.0	0.0	0.0	0.0	0.0	0.3	6448
8	46.5	29.2	0.1	3.1	1.9	5.8	0.1	0.1	0.0	0.1	0.0	0.7	16123
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
11+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

2.2 Cumulative Emissions for the Willow Alternatives

Cumulative emissions for the Willow MDP were developed as part of the DEIS. Cumulative emissions include emissions for the Willow Alternatives and the Greater Willow Potential Drill Sites #1 and #2. The emissions from Greater Willow Potential Drill Sites #1 and #2 would occur as part of any Willow alternative and module delivery option. In addition to the Willow MDP cumulative emissions, emissions from Reasonably Foreseeable Future Action (RFFA) were included in the cumulative modeling analyses. The following sections describe the cumulative emissions inventory development process and the resulting emission estimates.

2.2.1 Greater Willow Potential Drill Sites #1 and #2

Cumulative emissions were estimated for the two Greater Willow Potential drill sites that would be developed after year 2035. The CPAI Environmental Effects Document (CPAI 2019) explains that the potential drill sites are part of the Willow MDP: “To support long-term planning, the Willow MDP also addresses potential future drill sites, the number and location of which depend on the results of potential future exploration activities. These potential future drill sites are addressed in the EED as reasonably foreseeable future developments for the purposes of analyzing cumulative impacts.”

The following development phases are included in the cumulative Greater Willow Potential Drill Sites #1 and #2 emissions estimates:

- Construction emissions: Annual average emissions were calculated for BT1, BT2, BT4 and BT5 by calculating the monthly average emissions over all months of construction and multiplying by 12. BT3 construction emissions were not included as it is co-located with the WPF.
- Developmental drilling emissions: Annual emissions were calculated as the total emissions from the year 2032, which was chosen as representative as only one drill rig was operational in that year.
- Non-construction emissions: Annual emissions for BT1, BT2, BT4 and BT5 were calculated as the total emissions from the year 2036, as a representative year with all routine-operation activities occurring during the year.

Table 2.2-1 below summarizes total cumulative annual average emissions from Greater Willow Potential Drill Sites #1 and #2. Emissions from activities that do not occur on the pads, such as materials and personal transportation, are not included in emissions estimates. It is anticipated that routine operation emissions for the final years of the Project shown above in Table 2.1-9 for Alternative B would continue following development of Greater Willow Potential Drill Sites #1 and #2. Routine operation emissions would be in addition to the emissions explicitly calculated for the Greater Willow Potential Drill Sites #1 and #2 (shown below in Table 2.2-1). The GWP Drill sites 1 and 2 are assumed to use the Project WPF and WOC. Peak Project production is estimated to occur in either 2029 or 2030, before the operations of the Potential Drill Sites. The production declines subsequent to peak production, so the WPF and WOC are expected to be able to accommodate additional production from GWP Drill sites 1 and 2.

Table 2.2-1 Annual Emissions from Greater Willow Potential Drill Sites #1 and #2 Combined

Pollutant		Phase		
		Construction	Developmental Drilling	Routine Operations
Criteria Pollutants (tpy)	NO_x	17.0	118.5	13.5
	CO	7.2	115.4	11.2
	SO_2	0.1	0.5	0.3
	PM_{10}	1.6	30.8	1.0
	$PM_{2.5}$	1.3	9.9	0.8
	VOC	2.3	17.7	220.1
HAP (tpy)	Benzene	0.1	0.1	0.2
	Toluene	0.1	0.1	0.6
	Ethylbenzene	0.0	0.0	5.5
	Xylene	0.1	0.0	10.8
	n-Hexane	0.0	0.0	13.6
	Formaldehyde	0.5	0.1	0.0
GHGs (metric tpy)	CO_2e	8,468	48,504	8,476

2.2.2 Reasonably Foreseeable Future Actions*

Table 2.2-2 lists the existing sources that have planned modifications, current known RFFAs, and projects that were considered but lacked sufficient information and thus were eliminated from further consideration. RFFAs were included in the cumulative near-field modeling (routine operations scenario) and cumulative far-field modeling analysis. All RFFAs located within the near-field analysis area (defined as being within approximately 31 miles of the Willow Alternative B Infrastructure Pad) were included in the near-field analysis. Several of the RFFAs located within the 4 km resolution far-field model domain (defined as being within approximately 186 miles of the Willow Alternative B Infrastructure Pad) are included in the cumulative far-field modeling if the project was not already included as part of the BOEM regional emissions database used for this Project. Table 2.2-2 also indicates those RFFAs which are analyzed qualitatively and not modeled either because they were (i) outside the modeling domain, or (ii) identified after the FEIS or (iii) they are not expected to operate during the modeling year (2025) of far-field modeling, or (iv) there is a lack of sufficient information on the source needed for modeling.

As shown in Table 2.2-2, roughly a third of the RFFAs were explicitly included in the cumulative regional modeling analysis. For those RFFAs that were not explicitly modeled, the impacts are implicitly included in the cumulative regional modeling analysis, which is discussed in Section " Cumulative 2025 No Project Scenario". The cumulative regional modeling results presented in Chapter 5 show that when RFFAs are considered in combination with the Project, air quality and AQRV conditions would be below applicable thresholds for all alternatives.

In addition to the cumulative modeling analysis, the near-field modeling analysis explicitly included GMT-1; GMT-2; Greater Willow Potential Drill Site #1; Greater Willow Potential Drill Site #2; and Alpine infrastructure upgrades, including modifications at CD-1, new gas turbine generator installation at the Alpine Central Facility, CD-4 pad expansion and a new drill site at CD-8. Near-field model results presented in Chapter 3 indicate that all cumulative air quality impacts would be below applicable thresholds for all alternatives. Projects that were not explicitly modeled in the near-field analysis due to insufficient information would also result in emissions of criteria and hazardous air pollutants that would potentially affect the ambient air concentrations of these pollutants. These projects (and others) would be required to follow applicable law and regulations, including federal and state requirement described in Appendix E.3A, and may be required to quantify project emissions and submit an air quality permit to Alaska Department of Environmental Conservation with an air quality impact assessment. Given that existing monitored ambient air concentrations and all cumulative air quality impacts modeled for this Willow MDP Project are below applicable thresholds and future projects would also be required to be below applicable thresholds, it is anticipated that additional RFFA would not adversely affect ambient air environment.

Estimates of the total criteria air pollutants, hazardous air pollutants, and greenhouse gases emissions for individual RFFAs identified since the Final EIS were estimated for those projects which data were available . Emissions from those new RFFAs identified since the FEIS are very small (1 percent or less) compared to the cumulative emissions included in the regional modeling analysis (see Table 2.3-4). Emissions estimates depend on both available information about anticipated activities and representative emission factors.

Emissions factors were developed for gravel pad construction, gravel road construction, pipeline construction, ice road construction, disposal well drilling, and oil well drilling, based on Alternative B. Production-based emission factors were developed based on peak annual emissions estimate for Alternative B divided by the project production in that year. The RFFA emissions are then estimated by multiplying the emission factors by the activities for each RFFA project, as appropriate. The following RFFAs were identified after the FEIS and are assessed below:

*Alpine Infrastructure Upgrades – Proposed expansion of the Alpine airstrip apron; expansion of gas infrastructure on the Colville Delta-1 (CD-1) pad; new disposal well at CD-1; new gas turbine generator installation at the Alpine Central Facility; Colville Delta-4 (CD-4) pad expansion (gravel and new wells); and, additional gravel pads for staging and other routine operational projects with small footprints

*Alpine Expansion – Potential to develop a new drill site (CD-8) south of Nuiqsut as part of the Narwhal discovery

*Kuparuk Projects – Potential development of Eastern Northeast West Sak (ENEWS) Project (drill site 1H)

*Peregrine Exploration – Exploration and appraisal program underway anticipated to include ice road construction, disposal well drilling, gravel pad construction

*Drill Site 3T(DS3T) Expansion – The existing 22-acre pad may be expanded by 5 acres

The emissions for the RFFA at Alpine Center Facility, Colville Delta 1, Colville Delta 4, Drill Site 3T, Drill Site 3S, and CPAI Exploration are small compared to those from Willow MDP Project Alternatives and therefore any potential air quality impacts from projects that are not explicitly modeled would not change this analysis. The Kuparuk Projects, the Peregrine Exploration and the Pikka project may also be developed in the future. These RFFAs are located more than 35 miles from the Project. Impacts from these and other RFFAs are either implicitly or explicitly included in the cumulative regional modeling analysis (see Section ”Cumulative 2025 No Project Scenario”) and air quality and AQRV conditions would be below applicable thresholds for all alternatives.

Table 2.2-2 Past, Present, and RFFA for Cumulative Assessment*

Project	Entity	Explicitly Included in Near-field Modeling	Explicitly Included in Far-Field Modeling	Notes
Greater Mooses Tooth 1 (GMT1)	ConocoPhillips Alaska, Inc.	Y	Y	Project is included in the near-field modeling analysis. Project is included in the BOEM future year far-field modeling database used in the Willow MDP EIS.
Greater Mooses Tooth 2 (GMT2)	ConocoPhillips Alaska, Inc.	Y	Y	Project is included in the near-field modeling analysis. Project was added explicitly to the far-field modeling analysis because it was not included in the BOEM future year far-field modeling database.
Deadhorse Power Plant	TDX Power	N/A	Y	This facility is outside the near-field modeling domain, but inside the far-field modeling domain and has been explicitly included.
Point Thomson Facility Expansion	ExxonMobil	N/A	Y	This facility is outside the near-field modeling domain. Project is included in the BOEM future year far-field modeling database used in the Willow MDP EIS.
Oooguruk Development	Eni (formerly Pioneer)	N/A	Y	This project is outside the near-field modeling domain, but inside the far-field modeling domain and has been explicitly included.
Mustang Pad		N/A	Y	This project is outside the near-field modeling domain, but inside the far-field modeling domain and has been explicitly included.
Pikka (formerly Nanushuk)	Santos (formerly Oil Search Alaska)	N/A	Y	This project is outside the near-field modeling domain, but inside the far-field modeling domain and has been explicitly included.
Stirrup 1	Santos (formerly Oil Search Alaska)	N	N	Near-field Project impacts are assessed qualitatively. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Drill site 3T (formerly known as Nuna DS1)	ConocoPhillips Alaska, Inc.	N/A	N	This project is outside the near-field modeling domain. It is implicitly included

Project	Entity	Explicitly Included in Near-field Modeling	Explicitly Included in Far-Field Modeling	Notes
				in the far-field analysis by using the BOEM future year growth projections.
Placer	Arctic Slope Regional Corporation	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Unnamed	ConocoPhillips Alaska, Inc.	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Peregrine	88 Energy	N/A	Y	This project is outside the near-field modeling domain. Project is included in the BOEM future year far-field modeling database used in the Willow MDP EIS.
Liberty	Hilcorp Alaska	N/A	Y	This project is outside the near-field modeling domain. Project is included in the BOEM future year far-field modeling database used in the Willow MDP EIS.
West Willow (Greater Willow 1 and Greater Willow 2)	ConocoPhillips Alaska, Inc.	Y	N	Project is included in the near-field modeling analysis. Sources are not anticipated to be operational in the selected analysis year for the cumulative far-field modeling, so these sources were not explicitly included in the far-field modeling.
Kuparuk Seawater Treatment Plant Upgrades	ConocoPhillips Alaska, Inc.	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Kuparuk Projects	ConocoPhillips Alaska, Inc.	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Alpine Infrastructure Upgrades	ConocoPhillips Alaska, Inc.	Y	N	Modifications to Alpine, CD-1, and CD-4 are included explicitly in near-field modeling. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.

Project	Entity	Explicitly Included in Near-field Modeling	Explicitly Included in Far-Field Modeling	Notes
Alpine expansion	ConocoPhillips Alaska, Inc.	Y	N	The CD-8 pad is included explicitly in near-field modeling. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Oliktok Road Upgrades	ConocoPhillips Alaska, Inc.	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
K-Pad expansion	Kuukpik Corporation	N	N	Near-field project impacts are assessed qualitatively. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
New gravel pad	Kuukpik Corporation	N	N	Near-field project impacts are assessed qualitatively. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
New gravel pad	Kuukpik Corporation	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
New gravel pads	Great Bear Pantheon LLC	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Exploration well	Great Bear Pantheon LLC	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Ongoing upgrades and maintenance to existing infrastructure	Multiple	N	N	Near-field air quality impacts are assessed qualitatively. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Alaska Stand Alone Pipeline or Alaska LNG	State of Alaska	N/A	N	This project is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.

Project	Entity	Explicitly Included in Near-field Modeling	Explicitly Included in Far-Field Modeling	Notes
Coastal Plain Oil and Gas Leasing Program	BLM	N/A	N	The Coastal Plain is outside the near-field modeling domain. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.
Legacy well cleanup	BLM	N	N	Near-field air quality impacts are assessed qualitatively. It is implicitly included in the far-field analysis by using the BOEM future year growth projections.

Table 2.2-3 Estimated Emissions for Recent RFFA*

Name of RFFA[1]	Total Criteria Emissions (tpy)						Total HAPs (tons)	Total CO_2e (thousand metric tons) AR4 100-Year GWPs	Total CO_2e (thousand metric tons) AR6 100-Year GWPs	Total CO_2e (thousand metric tons) AR6 20-Year GWPs
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC				
Alpine Central Facility Expansion	135.4	20.2	0.5	1.6	1.6	50.5	0.2	286	286	287
Colville Delta 1 (CD1) Expansion	1.9	2.7	>0.1	0.1	0.1	0.2	>0.1	0.8	0.8	0.8
Colville Delta 4 (CD4) Expansion	5.6	3.1	0.1	0.5	0.4	27.5	4.0	3.6	3.7	4.1
Colville Delta 8 (CD8) Expansion	4.4	3.7	0.2	0.5	0.3	56.8	8.0	3.3	3.4	4.4
Eastern Northeast West Sak (ENEWS)	377.4	363.3	25.9	124.3	45.2	315.7	36	444	444	453
Peregrine Exploration	80.9	28.7	0.2	8.0	3.9	9.6	3.4	26	26	26
Drill Site 3T (DS3T) Expansion	3.2	1.2	>0.1	0.2	0.2	0.5	0.2	1.9	1.9	1.9

[1] Alpine Central Facility, CD1 Expansion, CD4 Expansion, and CD8 Expansion are parts of the Alpine Infrastructure Upgrades and Alpine Expansion described in Table 3.20.3.

2.3 Emissions Inventories Prepared for Modeling

The Willow MDP emissions inventories developed for Alternatives B, C, and D as described and reported in Section 2.1 “Willow Alternatives Emissions Inventories” were used for the near-field model. The Willow MDP emissions inventories developed for Alternatives B, and C as described in the DEIS (Appendix E.3B Section 2.1) were used for the regional photochemical grid model, the reason for which is described in Section 3.3.2.3.2 of the FEIS. The development of these inventories for use in modeling are described in more detail in the following sections.

2.3.1 Near-field Emissions Inventories

The AERMOD model incorporates detailed information about the sources, emission rates over various averaging periods, emission release parameters, and effects of any structures on emission dispersion properties. Information provided as part of the emissions inventory were used to estimate peak emission rates for each modeled source over the averaging periods assessed with the AERMOD model. These averaging periods are based on AAQS and include 1-hour, 3-hour, 8-hour, 24-hour and annual periods. The variation in averaging times based on AAQS affects how the emissions from the emission inventory (described in Section 2.1 "Willow Alternatives Emissions Inventories") is prepared for near-field modeling. For example, for a hypothetical source that operates for only three hours a day, the 1-hour average and 3-hour average emissions rate for that source is calculated based on operation over the period; however, for longer averaging periods the emissions over that averaging period are averaged (i.e., total emissions over a three-hour period are divided by the modeled averaging period).

Other factors are also considered during the development of the near-field emissions inputs including the timing and location of emissions sources. For example, when it is known that emissions sources could not be active simultaneously, these sources are not modeled in the same location at the same time. More detailed information the near-field emissions inventory input preparation process is provided in Chapter 3.

The AERMOD model also requires detailed information about the emissions release parameters. Release parameters are commonly referred to as "stack parameters" even though in some cases the emissions are not emitted from a "stack". Necessary stack parameters depend on the source. Point sources require inputs such as stack height aboveground, temperature of the exhaust gas, velocity of exhaust gas, and stack diameter. Volume and area sources require information including release height, source height, length and width. Often this type of information is estimated based on the type of source and common best practices. The modeled source locations, stack parameters, and emission rates are included in Attachment A.

2.3.2 Regional Emissions Inventories

This section provides a brief overview of the regional emissions scenarios modeled for the Willow MDP EIS: the 2012 Base Year, the Cumulative No Project scenario, Cumulative Alternative B, and Cumulative Alternative C. Alternative C was selected for the far-field modeling analysis rather than Alternatives D or E because the peak emissions for Alternative C is greater than Alternative D (shown via a comparison of Table 2.1-15 and Table 2.1-20) and Alternative E (shown via a comparison of Table 2.1-15 and Table 2.1-25). The Cumulative No Project scenario has all emissions in the Cumulative Alternative B (or C) scenario except for Project emissions. Importantly, regional air quality was not remodeled using the emissions inventory developed for the Project in this Final EIS because the regional air impact assessment for the Draft EIS showed that cumulative and Project-specific impacts were below all applicable thresholds throughout the modeling domain. Additionally, Project emissions of CAPs are small relative to regional emissions (up to 6.0 % of regional emissions depending on pollutant) and changes to Project emissions between Draft EIS and Final EIS are an even smaller fraction of regional emissions (up to 4.3% depending on pollutant). For background information on the emissions, see the emissions inventories discussed in Sections

”Cumulative 2025 No Project Scenario” and ”Cumulative 2025 Alternative B (Proponent’s Project)” of this AQTSD and in Chapter 2 of the AQTSD for the Draft EIS.

The maximum NOx emissions year was selected for far-field modeling analysis based on input from the Willow MDP EIS Air Quality Technical Workgroup. For both Alternative B and C, the peak NO_X emissions year based on the emissions inventory for the Draft EIS is Project Year 5, which corresponds with calendar year 2025, so 2025 was used for the Alternative A (No Action) and C regional emissions.

Willow MDP emissions scenarios were modeled with the CAMx modeling system to estimate cumulative and Project-specific impacts to ambient air quality and AQRVs as described in Chapter 4. The SMOKE model was used to prepare and process emissions inputs into the format required by CAMx. An emissions inventory for all sources within the model domains is required for regional modeling (a map of the model domains is provided in Chapter 4). A complete emissions inventory for photochemical modeling includes point sources, area sources, nonroad and on-road mobile sources, as well as sea salt, dust, biogenic emissions, lightning-related emissions, and fire emissions. These emissions were developed for year 2012 and, are from the BOEM modeling platform (Fields Simms et al 2018, Stoeckenius et al 2017), described in Section 1.2.2.2 “Regional Modeling”. Windblown dust emissions are not included in the BOEM modeling platform (and therefore the Willow EIS) as well as other typical regional photochemical applications. Not including windblown dust emissions might ordinarily have a potential to result in an underestimate in model results; however, this is unlikely as noted below because soil (dust) concentrations are still overestimated in the model as discussed below. The BOEM modeling platform sea salt and regional unpaved road dust emissions were revised for the Willow MDP EIS due to observable overestimates noted in the BOEM study as discussed below and subsequent analyses conducted for the Willow MDP EIS (see below and Attachment B for more information).

The BOEM study (Fields Simms et al 2018) reported an overestimation of the sea salt emissions that resulted in an overestimation of particulate nitrate. Updated sea salt emissions were subsequently developed by BOEM for sensitivity analyses (Stoeckenius et al 2017). For the Willow MDP EIS the updated sea salt emissions were applied throughout all scenarios including the 2012 Base Year, model performance evaluation and future year scenarios. Estimates of the magnitude of road dust emissions were highly uncertain in the BOEM study emissions inventory due mainly to the necessary use of non-local data for estimating emissions (Fields Simms et al., 2014). As discussed in Attachment B “Willow MDP Model Performance Evaluation” Section B.2.5, it was determined that modeled ground-level dust concentrations due to the BOEM regional unpaved road dust emissions were considerably overestimated relative to monitored dust concentrations and therefore, the regional unpaved road dust emissions from the BOEM modeling platform revised downwards; the revised model performance improved considerably as a result of the correction. See Attachment B “Willow MDP Model Performance Evaluation” Section B.2.5 for more information regarding the revisions to the regional unpaved road dust emissions and the associated improvement in the model performance. For the future year analyses, three emissions inventories were developed and processed with SMOKE. The Cumulative No Project scenario emissions inventory was developed based on the BOEM modeling platform with the RFFA emissions sources updated to be consistent with the most recent available sources of information, as described in Section 2.2.2 “Reasonably Foreseeable Development”. The Cumulative Willow MDP emissions include two potential drill sites that are part of the Willow Master Development Plan, as described in Section 2.2.1 “Greater Willow Potential Drill Sites #1 and #2”. The potential future drill sites are not anticipated to begin development until after 2035. Therefore, the Greater Willow Potential Drill Sites #1 and #2 are not included in the regional cumulative emissions inventory (but modeled in the near-field cumulative analysis).

The Cumulative Alternative B Alternative emissions inventory was developed by combining the Alternative B 2025 emissions inventory with the Cumulative No Project scenario inventory. The Cumulative Alternative C Alternative emissions inventory was developed by combining the Alternative C 2025 emissions inventory with the Cumulative No Project scenario inventory.

2012 Base Year

Table 2.3-1 through 2.3-3 below shows the 2012 4 km domain Base Year emissions including the emissions for key source groups. Table 2.3-1 shows the BOEM modeling platform 4 km resolution domain emissions (Fields Simms et al 2018, Stoeckenius et al 2017) prior to sea salt and unpaved road dust modifications. Sodium (Na) emissions are provided to disclose changes to the sea salt emissions. Table 2.3-2 shows the 2012 Willow MDP Base Year emissions modeled in the far-field model which include reductions to sea salt and unpaved road dust. Table 2.3-3 shows the difference between the 2012 Willow MDP Base Year 4 km domain emissions and the BOEM 4 km domain emissions. The 2012 4 km domain Base Year emissions spatial distribution used for the far-field modeling is shown in Figure 2.3-1.

Table 2.3-1 BOEM 4 km Domain Base Year Emissions Inventory

Source Sector	BOEM 4 km Domain 2012 Base Year Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	2,221	3,598	165	34,441	3,599	818	9
North Slope Borough Baseline Oil and Gas	45,509	10,748	1,119	1,243	1,203	2,241	-
Emissions Outside North Slope Borough	25,055	550	22	13,774	11,269	127	102,407
Biogenic	1,782	25,106	-	-	-	150,967	-
Fire	482	8,829	88	392	1,207	392	-
Total 4 km Domain	**75,049**	**48,831**	**1,394**	**49,850**	**17,278**	**154,545**	**102,416**

Table 2.3-2 Willow MDP EIS 4 km Domain Base Year Emissions Inventory

Source Sector	Willow 4 km Domain 2012 Base Year Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	2,221	3,598	165	3,607	513	818	2
North Slope Borough Baseline Oil and Gas	45,509	10,748	1,119	1,243	1,203	2,241	-
Emissions Outside North Slope Borough	25,147	573	24	3,929	1,423	130	6,130
Biogenic	1,782	25,106	-	-	-	150,967	-
Fire	482	8,829	88	392	1,207	392	-
Total 4 km Domain	**75,141**	**48,854**	**1,396**	**9,171**	**4,346**	**154,548**	**6,132**

Table 2.3-3 Emission Differences between Willow and BOEM 4 km Domain Base Year Emissions

Source Sector	Willow 4 km Domain 2012 Base Year Emissions Minus BOEM 2012 Emiss. (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	0	0	0	-30,834	-3,086	0	-7
North Slope Borough Baseline Oil and Gas	0	0	0	0	0	0	-
Emissions Outside North Slope Borough	91	23	3	-9,845	-9,846	3	-96,277
Biogenic	0	0	-	-	-	0	-
Fire	0	0	0	0	0	0	-
Total 4 km Difference[a]	**91**	**23**	**3**	**-40,679**	**-12,932**	**3**	**-96,284**

[a] Small differences of less than 1 percent of the 4 km domain emissions occur due to updated species mapping used for the Willow MDP emissions processing

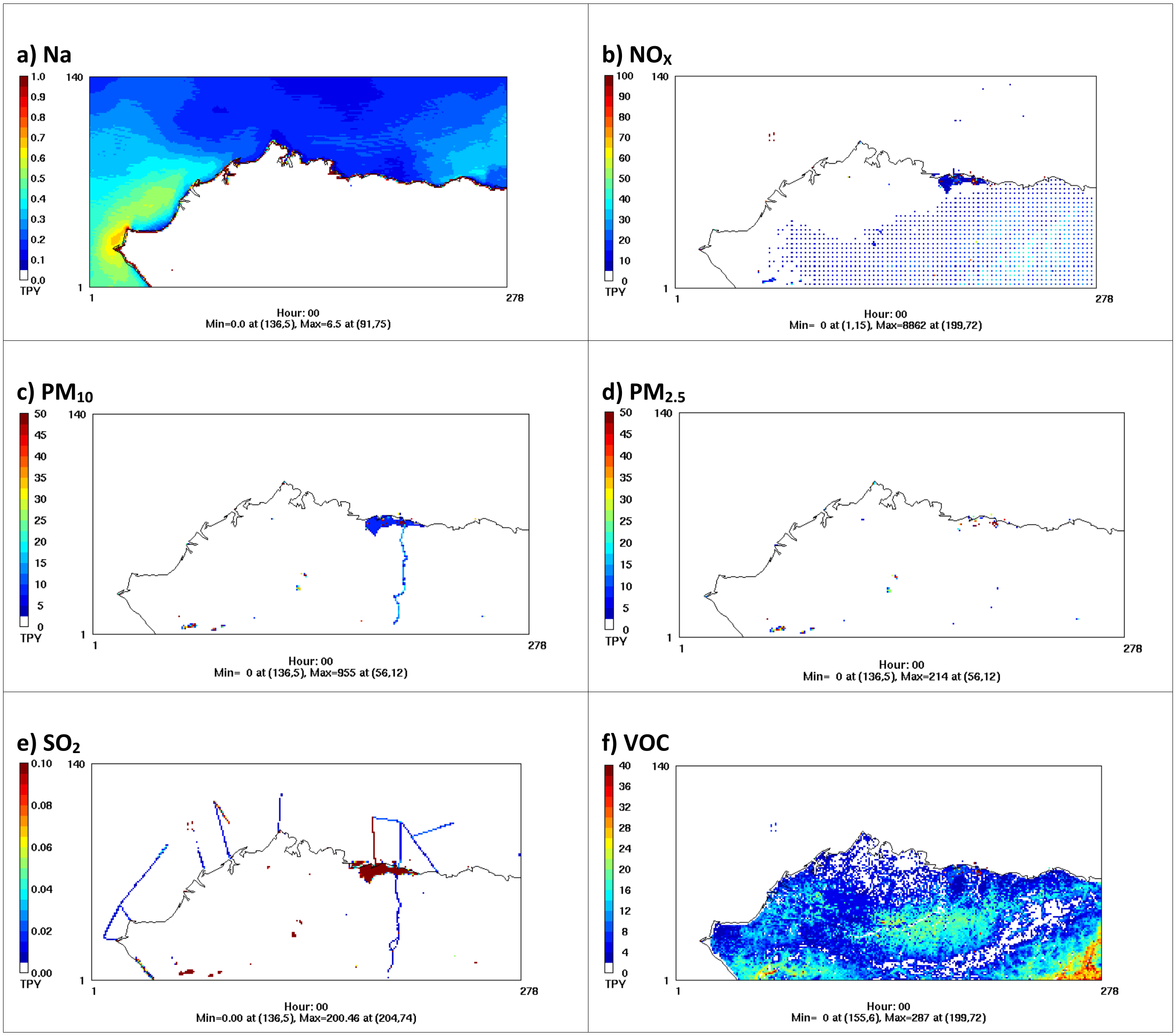


Figure 2.3-1 Willow Base Year Emissions a) Na, b) NO_X, c) PM_{10}, d) $PM_{2.5}$, e) SO_2, f) VOC

Cumulative 2025 No Project Scenario

Table 2.3-4 though Table 2.3-6 below shows the Cumulative 2025 No Project emissions including the emissions for key source groups. Table 2.3-4 shows the BOEM modeling platform 2020 4 km resolution domain emissions (Fields Simms et al 2018, Stoeckenius et al 2017) prior to sea salt and unpaved road dust modifications. Table 2.3-5 shows the Cumulative 2025 No Project emissions modeled in the far-field model which include revisions reductions to sea salt and unpaved road dust and additions of RFFA sources (described in Section 2.2.2 “Reasonably Foreseeable Future Actions”). After the FEIS, additional RFFA were identified. The complete list of RFFAs is provided in Table 2.2-2. RFFA that were not explicitly included in the cumulative regional modeling are implicitly included in the cumulative assessment by use of the BOEM 2020 Oil and Gas emissions. As shown via a comparison of the “BOEM 2020 Oil and Gas Development” and the “North Slope Borough Baseline Oil and Gas Emissions” in Table 2.3-4, the projected future year oil and gas emissions are 67 percent to 173 percent higher than the 2012 North Slope Borough oil and gas baseline, depending on the air quality pollutant. This provides a conservatively high estimate of cumulative emissions given that the U.S. Energy Information Administration reports that Alaska North Slope crude oil production declined by 15% over this same period (USEIA 2022). The modeled cumulative emissions used in the regional modeling analysis include both specific RFFA projects as listed in Table 2.2-2 and also RFFA projects that were not explicitly modeled through emissions that account for oil and gas development within the model domain. Table 2.3-6 shows the difference between the Cumulative 2025 No Project 4 km domain emissions and the BOEM modeling platform 2020 4 km domain emissions. The Cumulative 2025 No Project 4 km domain emissions spatial distribution used for the far-field modeling is shown with Alternative B in Figure 2.3-2.

Table 2.3-4 BOEM 4 km Domain 2020 Future Year Emissions Inventory

Source Sector	BOEM 4 km Domain 2020 Future Year Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	2,368	3,651	103	34,442	3,600	826	9
North Slope Borough Baseline Oil and Gas	45,627	11,942	1,130	1,260	1,220	2,302	0
BOEM 2020 Oil and Gas Development	30,751	7,829	1,955	1,860	1,433	1,769	0
Non-Oil and Gas Emissions Outside North Slope Borough	24,680	510	18	13,758	11,254	40	102,407
Biogenic	1,782	25,106	-	-	-	150,967	-
Fire	482	8,829	88	392	1,207	392	-
Total 4 km	**105,690**	**57,867**	**3,294**	**51,712**	**18,714**	**156,296**	**102,416**

Table 2.3-5 Willow 4 km Domain 2025 No Project Emissions Inventory

Source Sector	Willow 4 km Domain 2025 Future Year (No Project) Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	2,368	3,651	103	3,649	555	826	2
North Slope Borough Baseline Oil and Gas	45,627	11,942	1,130	1,260	1,220	2,302	0
BOEM 2025 Oil and Gas Development	35,757	7,829	2,509	3,041	1,708	2,612	0
Non-Oil and Gas Emissions Outside North Slope Borough	24,668	510	16	3,908	1,405	37	6,130
Biogenic	1,782	25,106	-	-	-	150,967	-
Fire	482	8,829	88	392	1,207	392	-
Total 4 km	**110,684**	**57,867**	**3,846**	**12,250**	**6,095**	**157,136**	**6,132**

Table 2.3-6 Differences between Willow 4 km Domain 2025 No Project Emissions and BOEM 4 km Domain 2020 Emissions

Source Sector	Willow 4 km Domain 2025 Future Year (No Project) Emissions-BOEM 2020 (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
North Slope Borough Baseline Emissions Excluding Oil and Gas	0	0	0	-30,793	-3,046	0	-7
North Slope Borough Baseline Oil and Gas	0	0	0	0	0	0	0
BOEM 2020 Oil and Gas Development	5,005	0	554	1,181	275	843	0
Non-Oil and Gas Emissions Outside North Slope Borough	-11	0	-1	-9,850	-9,849	-2	-96,277
Biogenic	0	0	-	-	-	0	-
Fire	0	0	0	0	0	0	-
Total 4 km Difference[a]	**4,994**	**0**	**553**	**-39,462**	**-12,620**	**841**	**-96,284**

[a] Small differences of less than 1 percent of the 4 km domain emissions occur due to updated species mapping used for the Willow MDP emissions processing

Cumulative 2025 Alternative B (Proponent's Project)

Table 2.3-7 shows the Alternative B annual emissions processed in SMOKE.[11] The emissions at the drill sites, the WPF, IP, Willow airstrip, gravel mine and horizontal directional drilling under the Colville River were modeled as point sources at the pad center. All other Project emissions such as general construction, mobile sources, pigging, and fugitive dust emissions were modeled as area sources and allocated to the Project area using a combination of linear features (i.e., roads) and all Project features. Note that the Project fugitive dust emissions of PM_{10} and $PM_{2.5}$ used in the modeling shown below for Alternative B (as well as Alternative C) were based on the emissions inventory developed for the Willow MDP Draft EIS which included a fugitive dust control (reduction) efficiency of 76% resulting from watering and a vehicle speed limit of 35 miles per hour (described in Attachment C to the Air Quality Technical Support Document, Appendix E.3B in the Willow MDP Draft EIS). The near field air dispersion modeling uses a lower dust control efficiency of 50% to estimate dust impacts within 50 km of the Project. The impacts on dust (particulate matter) concentrations due to the choice of control efficiency are expected to be minimal beyond this distance and therefore are not considered in the regional modeling. Table 2.3-8 shows the total Cumulative 2025 Alternative B emissions obtained by combining Alternative B emissions with the Cumulative 2025 No Project emissions described in Section "Cumulative 2025 No Project Scenario".

The Cumulative 2025 Alternative B 4 km domain emissions spatial distribution used for the far-field modeling is shown in Figure 2.3-2. The Willow MDP PM_{10} and SO_2 emissions can be distinguished from other cumulative emissions sources, but other criteria pollutants are not visible relative to regional sources.

[11] Note that as described in Section 2.3.2, the regional modeling was not revised for the Final EIS because the regional air impact assessment for the Draft EIS showed that cumulative and Project-specific impacts were found to be below all applicable thresholds throughout the modeling domain. Air emissions presented and described for the far-field modeling correspond with the Project emissions inventory developed for the Draft EIS.

Table 2.3-7 Willow 4 km Domain 2025 Alternative B (Proponent's Project) Emissions

Source Type	Willow 4 km Domain Alt B Project Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
Area sources	71	27	0	87	12	8	0
Point sources	811	772	54	81	79	597	0
Total Alternative B	**882**	**799**	**55**	**168**	**91**	**605**	**0**

Table 2.3-8 Cumulative 2025 Alternative B (Proponent's Project) Emissions

Emissions	Willow 4 km Domain 2025 Future Year Alt B Project Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
2025 Future Year No Project	109,427	57,809	3,845	12,237	6,087	157,135	6,132
Project – Alternative B	882	799	55	168	91	605	0
Cumulative Alternative B	**110,306**	**58,607**	**3,899**	**12,405**	**6,177**	**157,736**	**6,132**

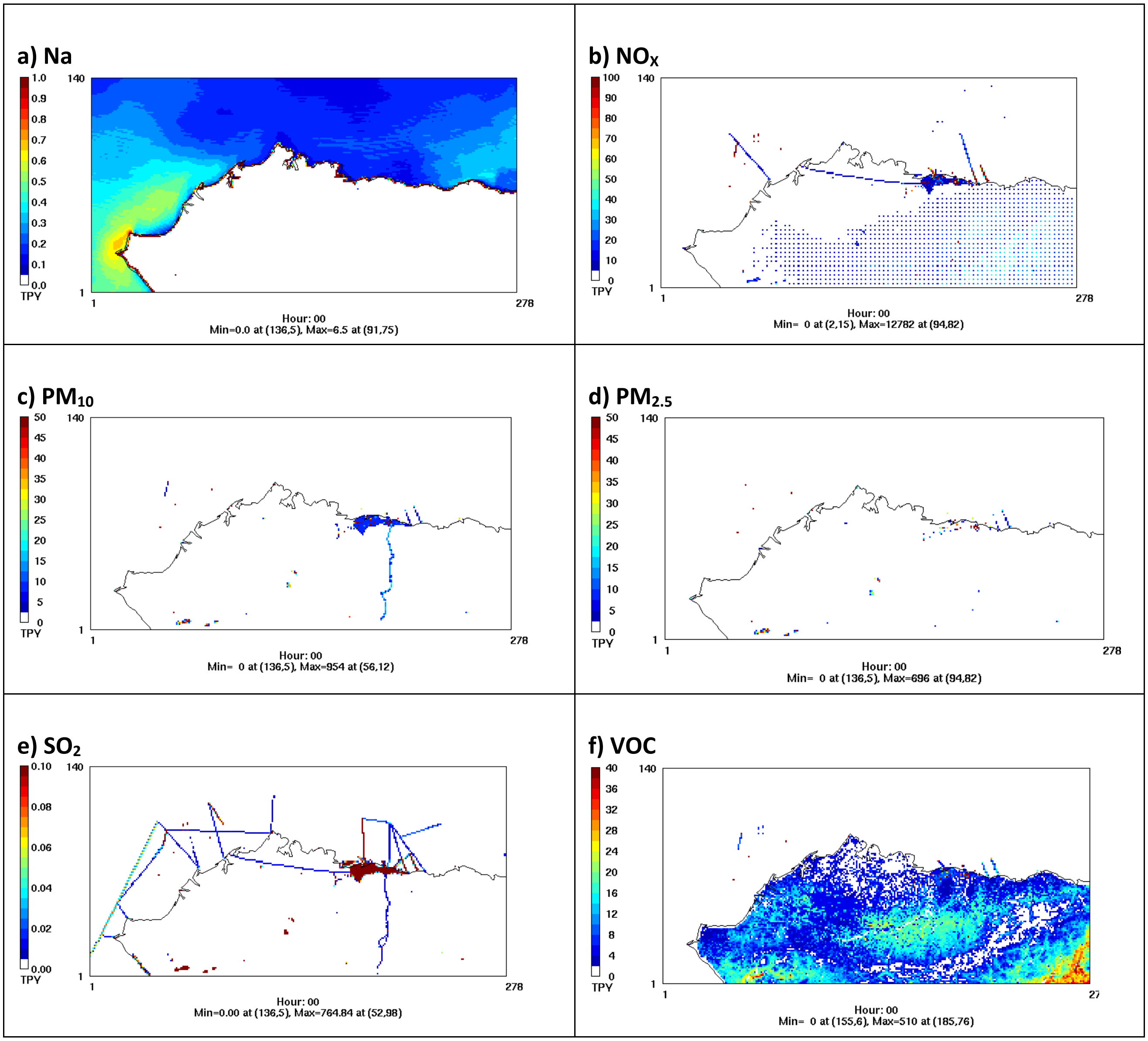


Figure 2.3-2 Willow 2025 Future Year Alternative B (Proponent's Project) Emissions a) Na, b) NO_X, c) PM_{10}, d) $PM_{2.5}$, e) SO_2, f) VOC

Cumulative 2025 Alternative C (Disconnected Infield Roads)

Table 2.3-9 shows the Alternative C annual emissions processed in SMOKE.[12] The emissions at the drill sites, the WPF, WOC North, WOC South, North Airstrip, South Airstrip, gravel mine and horizontal directional drilling under the Colville River were modeled as point sources at the center of each pad. All

[12] Note that as described in Section 2.3.2, the regional modeling was not revised for the Final EIS because the regional air impact assessment for the Draft EIS showed that cumulative and Project-specific impacts were found to be below all applicable thresholds throughout the modeling domain. Air emissions presented and described for the far-field modeling correspond with the Project emissions inventory developed for the Draft EIS.

other Project emissions such as general construction, mobile sources, pigging, and fugitive dust emissions were modeled as area sources and allocated to the Project area using a combination of linear features (i.e., roads) and all Project features. Table 2.3-10 shows the total Cumulative 2025 Alternative C emissions obtained by combining Alternative C emissions with the Cumulative 2025 No Project emissions described Section “Cumulative 2025 No Project Scenario”.

The Cumulative 2025 Alternative C 4 km domain emissions spatial distribution used for the far-field modeling is shown in Figure 2.3-3. The Willow MDP PM_{10}, $PM_{2.5}$ and SO_2 emissions can be distinguished from other cumulative emissions sources, but other criteria pollutants are not visible relative to the regional source signal.

Table 2.3-9 Willow 4 km Domain 2025 Alternative C (Disconnected Infield Roads) Emissions

Source Type	Willow 4 km Domain Alternative C Project Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
Area sources	56	19	0	67	10	5	0
Point sources	1,103	968	55	98	95	479	0
Total Alternative C	1,159	987	55	165	105	484	0

Table 2.3-10 Cumulative 2025 Alternative C (Disconnected Infield Roads) Emissions

Source Sector	Willow 4 km Domain 2025 Future Year Alt C Project Emissions (tpy)						
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Na
2025 Future Year No Project	109,427	57,809	3,845	12,237	6,087	157,135	6,132
Project - Alt C	1,159	987	55	165	105	484	0
Cumulative Alternative C	**110,586**	**58,796**	**3,899**	**12,401**	**6,192**	**157,619**	**6,132**

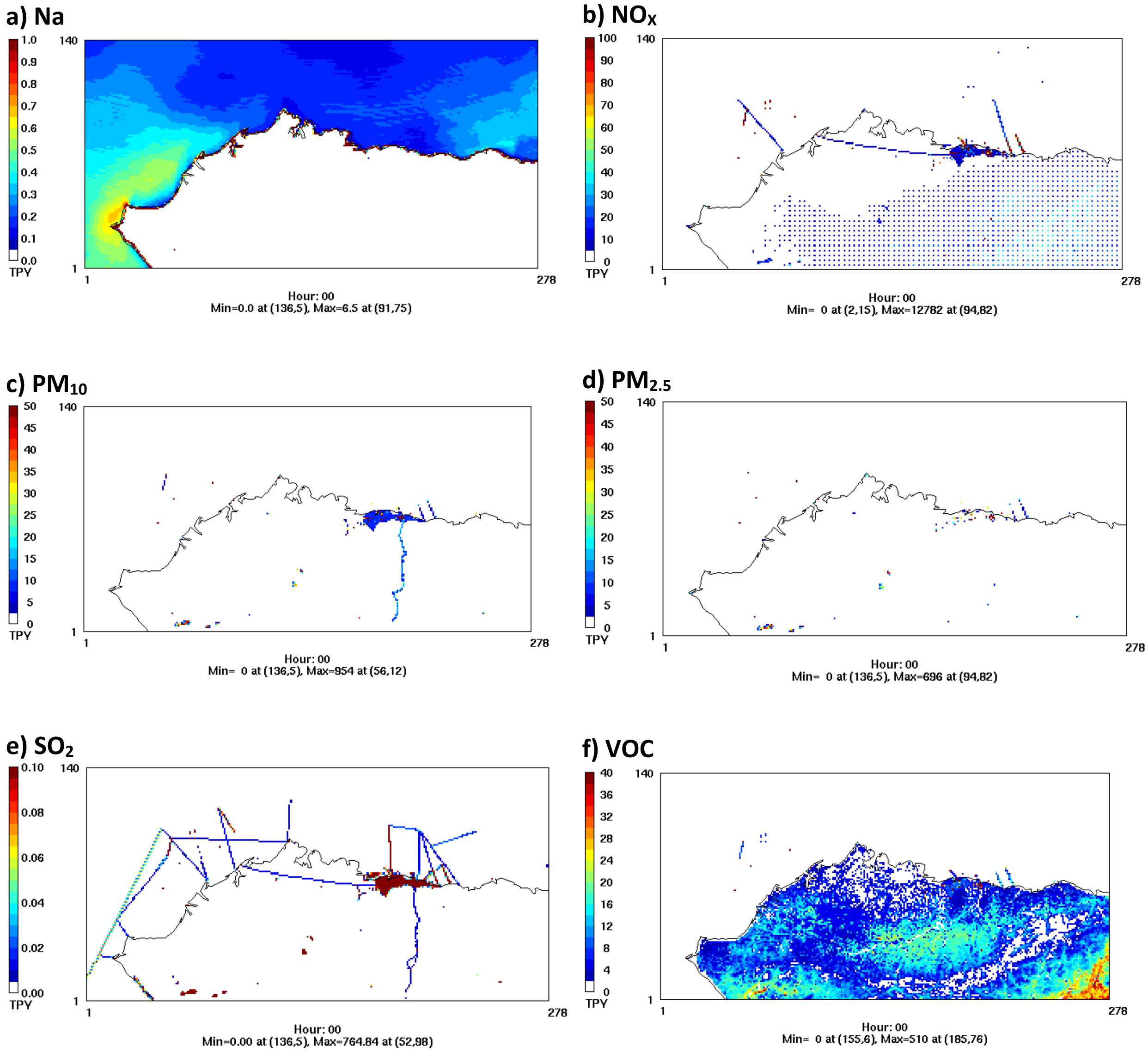


Figure 2.3-3 Willow 2025 Future Year Alternative C (Disconnected Infield Roads) Emissions a) Na, b) NO_X, c) PM_{10}, d) $PM_{2.5}$, e) SO_2, f) VOC

3.0 NEAR-FIELD MODELING ANALYSES

This chapter presents the near-field modeling approach, scenarios analyzed, development of model inputs, and model-predicted impacts.

3.1 Approach Overview and Results Summary*

The USEPA regulatory air dispersion model, AERMOD, was used to assess near-field Project impacts and cumulative impacts within 50 km of the proposed Willow MDP. As described in Section 1.2.3 "Overview of Modeling Approach and Thresholds for Comparison", AERMOD model results, which provide an estimate of air quality concentrations from the Project and RFFA sources, are added to background ambient air concentrations from existing emissions sources to calculate the total air quality concentrations. Total air quality concentrations are compared to the applicable air quality standards (both the NAAQS and AAAQS) and averaging periods shown in Table 1.2-1 to assess Project and cumulative impacts for criteria pollutants. Note that for this analysis background ambient air concentrations have been updated from the values used in the FEIS (years 2015-2017) to the most recent 3-year period available (2018-2020).

In addition to assessing impacts on criteria pollutants, the hazardous air pollutants benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde are assessed with the AERMOD model. Model results are compared to non-cancer acute and chronic pollutant specific threshold levels shown in

and Table 1.2-4, respectively. Chronic cancer risk is calculated for the analyzed HAPs that have published cancer risk factors and risk from the Project is compared to a one-in-one million risk threshold.

Scenarios were developed to characterize potential peak localized impacts from the Project for various pollutants or spatial locations. The near-field modeling scenarios were selected to capture high impacts with careful consideration of peak emissions, spatial and temporal emissions variations, and in consultation with air quality specialists at key cooperating agencies. Based on the anticipated emissions activities, source types, and development schedule, five near-field scenarios are analyzed for each alternative:

1. Construction
2. Bear Tooth (BT)1 Pre-drilling
3. BT1 and BT2 Pre-drilling
4. Development Drilling
5. Routine Operations

The Construction scenario models the maximum annual construction emissions for each alternative and assesses impacts from key activities expected to occur during the construction phase, including gravel mining and horizontal directional drilling to install pipelines under the Coleville River. The Pre-drill scenario assesses impacts associated with concurrent diesel-fired drilling and hydraulic fracturing activities before electricity is available for electric drill rigs to operate. The Pre-drill BT1 scenario assesses two diesel-fired drill rigs, hydraulic fracturing units, portable flares, and supporting ancillary equipment at BT1. The Pre-drill BT1 and BT2 scenario assesses a single diesel-fired drill rig, hydraulic fracturing units, portable flare and ancillary equipment operating concurrently at BT1 and BT2. Once the Willow

Processing Facility is operational and is generating electric power, diesel-fired drilling activities would no longer occur and electric drill rigs and hydraulic fracturing units would be used. Impacts associated with concurrent operation of two electric drill rigs, hydraulic fracturing units, drill site facilities installation, as well as operation of the WPF (including flaring) and all other routine operations are assessed as part of the Development Drilling scenario. The Development Drilling scenario analyzes concurrent drilling, facility construction, and operations for the peak emissions year for each alternative. The Routine Operations scenario assesses impacts from Project operational emissions (including flaring) after temporary and transient activities associated with construction and drilling are complete.

The impacts associated with Module Delivery Options are also assessed. Peak year emissions for Option 1 (Atigaru Point Module Transfer Island) occur in year 2025 and 2026 (depending on Alternative) and are lower than peak year emissions for Option 2 (Point Lonely Module Transfer Island). Impacts for Option 1 Atigaru Point are expected to be lower than impacts for Option 2; therefore, Option 1 is not assessed quantitatively.

The near-field impact assessment method, data, and results are detailed for each alternative and scenario in the following sections. As described in Section 1.2.2.1 Action Alternatives B, C and D were modeled in the near-field modeling analysis for the Final EIS and Alternative E was modeled in the near-field analysis for the Final SEIS. The modeling approach, configuration, and results for Alternative E are detailed in Attachment H. Table 3.1-1 shows a summary of the modeled Willow MDP impacts on air quality and hazardous air pollutants for all alternatives and scenarios analyzed. Impacts on air quality and HAPs are below all applicable standards and thresholds for all alternatives and scenarios.

Table 3.1-1 Summary of Near-field Air Quality and HAPs Impacts*

Alternative	Development Scenario	Criteria Air Pollutants	HAPs
Alternative A (No Action)	Not Applicable	No impacts to criteria air pollutants. Pollutant concentrations would be similar to existing background levels.	No impacts to HAPs. Pollutant concentrations would be similar to current levels.
Alternative B (Proponent's Project)	Construction	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 Pre-Drill	Impacts would be below all ambient air quality standards. Impacts would be identical to Alternative D.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 and BT2 Pre-Drill	Impacts would be below all ambient air quality standards. Impacts would be identical to Alternative D.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	Development Drilling	Impacts would be below all ambient air quality standards.	HAPs emissions from Development Drilling are comparable to Routine Operations. Since the HAPs impacts were well below thresholds for Routine Operations, HAPs were not directly assessed for this scenario.
	Routine Operations	Impacts would be below all ambient air quality standards.	*Non-carcinogenic:* All analyzed HAPs would be below respective Reference

Alternative	Development Scenario	Criteria Air Pollutants	HAPs
			Exposure Levels (RELs) and Reference Concentrations (RfCs). *Carcinogenic:* Cancer risks for individual HAPs as well as total cancer risk across all pollutants were modeled to be less than a 1-in-1 million risk for all carcinogenic HAPs analyzed.
Alternative C (Disconnected Infield Roads)	Construction	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 Pre-Drill	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 and BT2 Pre-Drill	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	Development Drilling	Impacts would be below all ambient air quality standards.	HAPs emissions from these activities are comparable to Routine Operations. Since the HAPs impacts were well below thresholds for Routine Operations, HAPs were not directly assessed for this scenario.
	Routine Operations	Impacts would be below all ambient air quality standards.	*Non-carcinogenic:* All analyzed HAPs would be below respective RELs and RfCs. *Carcinogenic:* Cancer risks for individual HAPs as well as total cancer risk across all pollutants were modeled to be less than a 1-in-1 million risk for all carcinogenic HAPs analyzed.
Alternative D (Disconnected Access)	Construction	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 Pre-Drill	Impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	BT1 and BT2 Pre-Drill	Impacts would be below all ambient air quality standards. Impacts would be identical to Alternative B.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations.
	Development Drilling	Impacts would be below all ambient air quality standards.	HAPs emissions from these activities are comparable to Routine Operations. Since the HAPs impacts were well below thresholds for

Alternative	Development Scenario	Criteria Air Pollutants	HAPs
			Routine Operations, HAPs were not directly assessed for this scenario.
	Routine Operations	Impacts would be below all ambient air quality standards.	*Non-carcinogenic:* All analyzed HAPs would be below respective RELs and RfCs. *Carcinogenic:* Cancer risks for individual HAPs as well as total cancer risk across all pollutants were modeled to be less than a 1-in-1 million risk for all carcinogenic HAPs analyzed.
Alternative E	Construction	Impacts would be below all AAQS.	HAPs impacts were not directly assessed with the model because HAPs emissions from these activities would be substantially lower than the routine operations development scenario.
	BT1 Pre-Drill	Impacts would be below all AAQS.	HAPs impacts were not directly assessed with the model because HAPs emissions from these activities would be substantially lower than the routine operations development scenario.
	BT1 and BT2 Pre-Drill	Impacts would be below all AAQS.	HAPs impacts were not directly assessed with the model because HAPs emissions from these activities would be substantially lower than the routine operations development scenario.
	Development Drilling	Impacts would be below all AAQS.	HAPs impacts were not directly assessed with the model because HAPs emissions from these activities would be substantially lower than the routine operations development scenario.
	Routine Operations	Impacts would be below all AAQS.	Non-carcinogenic: All analyzed HAPs would be below RELs and RfCs. Carcinogenic: Cancer risks for individual HAPs and total cancer risk across all pollutants were modeled and results were less than a 1-in-1-million risk for all carcinogenic HAPs analyzed.
Module Delivery	Option 1: Atigaru Point MTI	Onshore impacts are not directly assessed. Impacts are anticipated to be lower than Option 2: Point Lonely MTI and below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from MTI activities would be lower than Routine Operations under Alternatives B, C, and D.

Alternative	Development Scenario	Criteria Air Pollutants	HAPs
	Option 2: Point Lonely MTI	Onshore impacts would be below all ambient air quality standards and higher than Option 1: Atigaru Point MTI.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations under Alternatives B, C, and D.
	Option 3: Colville River Crossing	Onshore impacts would be below all ambient air quality standards.	HAPs impacts were not directly assessed with a model because HAPs emissions from these activities would be lower than Routine Operations under Alternatives B, C, and D.

3.2 Modeling Approach*

This section describes the dispersion model, inputs and settings used to analyze impacts from Alternatives B, C, and D. The dispersion model, inputs and settings used to analyze impacts from Alternative E are detailed in Attachment H. Model inputs and settings used to analyze impacts from Module Delivery Option 2 and Option 3 are presented in Section 3.7 and 3.8, respectively.

3.2.1 Dispersion Model*

The most recent version of AERMOD available at the time of the modeling was version 19191, which was the version used for the near-field analysis. The latest version of AERMOD (v22112) was not available when the assessment of Alternatives B, C, and D was conducted. The changes made to AERMOD version 22112 as documented by EPA (2022a) are expected to have negligible effect on model-predicted Project impacts given the modeled Project sources and model settings.

3.2.2 Applicable Air Quality Standards and Hazardous Air Pollutant Thresholds

Modeling results were compared to applicable NAAQS and AAAQS, collectively referred to as AAQS (shown in Table 1.2-1). AAQS represent the total concentrations of a given pollutant allowed to protect public health. Table 1.2-1 does not include AAQS for lead and ammonia because the Project is not anticipated to emit lead or ammonia and hence these pollutants are not issues of concern. Pollutants analyzed are based on the form of the AAQS, PSD Class II increments or HAPs thresholds as shown in Table 1.2-1 though Table 1.2-5. Near-field modeled Project impacts due to the action alternatives are compared to PSD increments at only the Nuiqsut receptor location.

AERMOD was used to assess the near-field impacts for the following criteria pollutants and averaging periods:

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

The 1-hour NO_2, 1-hour SO_2, and 24-hour $PM_{2.5}$ standards are based on three-year average concentrations. For these standards, yearly maximum impacts were estimated for each of the five years of meteorological data and the top three values were averaged to calculate a value for comparison to the applicable AAQS.

While the regional modeling analysis conducted with CAMx includes estimates of all emissions sources including naturally occurring emissions, the near-field modeling analysis conducted with AERMOD evaluates only anthropogenic emissions sources within 50 km of the Willow MDP. The AERMOD model is configured to assess Willow MDP activities for various alternatives in combination with existing emissions sources. For routine activities anticipated to extend into the future for typical operations, the modeling analysis included emissions from all RFFAs within the modeling domain in addition to Willow MDP sources. RFFA emission sources are described in Section 2.2 "Cumulative Emissions for the Willow Alternatives".

To estimate total ambient air quality conditions with AERMOD, modeled impacts are added to representative background concentrations. The background concentrations representative of the Project area are discussed in Section 3.2.6 "Ambient Background Data". Ozone impacts and secondary $PM_{2.5}$ ($PM_{2.5}$ formed in the atmosphere from chemical reactions) impacts are assessed with the CAMx model. These pollutants are not assessed using the AERMOD model because the model does not include the necessary chemical reactions to estimate concentrations of pollutants not directly emitted from sources. In order to estimate the contribution of secondary $PM_{2.5}$ to near-field impacts, results from the regional CAMx model were used. The secondary $PM_{2.5}$ concentrations from CAMx were derived by removing chemical species that are primary emissions sources. The secondary $PM_{2.5}$ calculated here is the total $PM_{2.5}$ without the contributions of primary organic aerosol, fine crustal particulate matter, fine other primary particulate matter with a diameter less than 2.5 microns and primary elemental carbon. This methodology likely provides an over-estimate of secondary $PM_{2.5}$ since some species included as completely secondary $PM_{2.5}$, like sulfate, can be emitted directly as primary $PM_{2.5}$.

The estimated secondary $PM_{2.5}$ concentrations resulting from Project alternative emissions were derived from the CAMx regional modeling described in Chapter 4 of this Technical Support Document (TSD) for the far field modeling. For Alternative B and Alternative C scenarios, the maximum 24-hour $PM_{2.5}$ daily average and the annual average $PM_{2.5}$ concentrations were calculated for each CAMx grid cell in area that surrounds the Project which is consistent with the modeling domain where near-field impacts are assessed (see Figure 3.2-1 for the study area). The maximum 24-hour and annual values from each alternative were selected. The maximum 24-hour 98^{th} percentile value over all the grid cells over 365 days is 0.47902 $\mu g/m^3$. This value is used to estimate the maximum potential secondary 24-hour $PM_{2.5}$ impact in the near-field modeling domain of the Willow MDP. For annual average concentrations the value of 0.04831 $\mu g/m^3$ is the maximum annual average secondary $PM_{2.5}$ impact in the near-field modeling domain of the Willow MDP. These values are added to all near-field AERMOD modeled PM_{10} and $PM_{2.5}$ concentrations presented for all Alternatives below.

Note that the CAMx performance analysis indicated that $PM_{2.5}$ concentrations were biased low overall, and therefore the secondary $PM_{2.5}$ impacts, although low, could potentially be higher than predicted based on the findings from the performance analysis.

Emissions for benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde are modeled for a 1-hour average to compare to the acute reference exposure limits (REL) shown in

, 8-hour average to compare to the Acute Exposure Guideline Levels (AEGLs) shown in

, and an annual average period to compare to the non-cancer RfC shown in Table 1.2-4 and chronic carcinogenic exposure to compare to the one-in-one million risk threshold. No ambient air background levels were added to the HAP model results. Based on analysis of the HAP emissions inventory, HAP emissions from construction and drilling activities are lower than operations. Therefore, impacts to HAPs are only assessed for the Routine Operations scenario for all Alternatives.

3.2.3 Meteorological Data*

Meteorological data for the AERMOD modeling system were prepared using the AERMET meteorological processor applied to representative surface and regional upper air observations. USEPA modeling guidance recommends either five years of National Weather Service (NWS) hourly surface observations or at least one year of onsite/site-specific meteorological observations. As such, five years (2013 -2017) of available meteorological data from the Nuiqsut monitoring station, and upper data from Utqiaġvik, Alaska were processed with AERMET and were used for the near-field modeling analysis. More recent meteorological data from the period 2016-2020 were compared to the 2013-2017 meteorological data used for modeling and the datasets are nearly identical. More information about these datasets are presented below.

The meteorological observation dataset collected at the CPAI Nuiqsut monitoring site were the only source of hourly surface data for the AERMOD simulations. These data meet USEPA modeling guidance for calendar quarter 90 percent data recovery for wind speed and direction, solar radiation, and differential temperature measurements. The surface data from the Nuiqsut monitoring station and upper data from Utqiaġvik were processed with AERMET into AERMOD surface and profile data formats using AERMET default options and surface parameters data as described in the Willow MDP Protocol (Ramboll 2018)..

The Nuiqsut site shown in Figure 3.2-1 is located at the northern edge of the City of Nuiqsut approximately 41 km (26 miles) east northeast of the Willow Bear Tooth (BT)3 pad. The Nuiqsut data were collected in a physical setting geographically similar to the proposed Willow MDP Drill Pads and in the absence of intervening terrain are considered to be representative of surface meteorological conditions in the Project area. The Utqiaġvik station location used for the upper air data is also shown in Figure 3.2-1. The Nuiqsut surface data and Utqiaġvik upper air data were also used for the dispersion modeling analyses supporting the GMT1 and GMT2 projects approved by ADEC.

The Nuiqsut site collects hourly horizontal wind speed, wind direction, vertical wind speed, temperature, differential temperature (between 2 meters and 10 meters in height and on an hourly basis), and solar radiation data (on an hourly basis). The wind observations are measured at about 10 m above the surface. In addition, turbulence parameters are also calculated at the site. The supplemental data include the standard deviation of the vertical wind speed (sigma-w) and standard deviation of horizontal wind direction (sigma-theta). The instrumentation, quality assurance (QA), and quality control (QC) procedures meet the requirements of USEPA guidance for PSD regulatory modeling (SLR, 2016) and are performed according to an ADEC-approved Quality Assurance Project Plan (QAPP) (SLR, 2012).

Figure 3.2-2 below shows a wind rose constructed from the Nuiqsut site surface observations. The winds at Nuiqsut show the characteristic east-northeast to west-southwest bimodal pattern commonly observed on the North Slope. The average wind speed during 2013-2017 was 5 meters per second (m/s) and calm winds were infrequent, occurring for less than 1 percent of hours during the five-year period.

Figure 3.2-2 shown below presents a wind rose constructed from the Nuiqsut site surface observations for a more recent five-year period (2016-2020). As indicated in this figure the winds at Nuiqsut for this more recent five-year period (2016-2020) show the same east-northeast to west-southwest bimodal pattern as the 2013-2017 dataset. The average wind speed and percentage of calm winds for the two datasets are nearly identical.

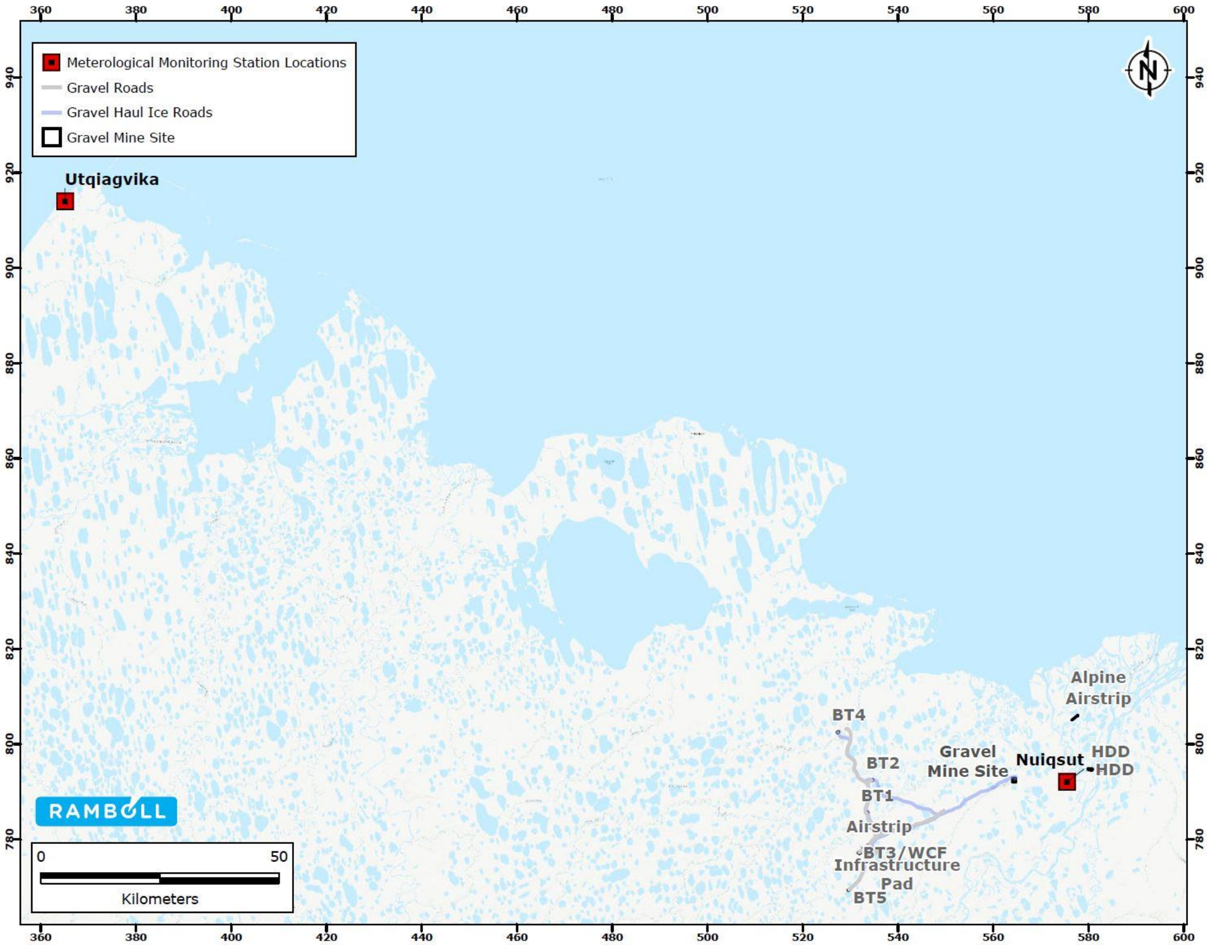


Figure 3.2-1 Meteorological Monitoring Stations used for AERMET

3.2.4 Building Downwash

Downwash effects from buildings and structures were included for the Development Drilling and Routine Operations scenarios for all Alternatives (see Sections 3.3.1 “Alternative B - Overview of Scenarios”, 3.4.1 “Alternative C – Overview of Scenarios”, and 3.5.1 “Alternative D – Overview of

Scenarios" for a description of model scenarios for all action alternatives). The BPIP-PRIME results were then included in the AERMOD modeling for Development Drilling and Routine Operation scenarios.

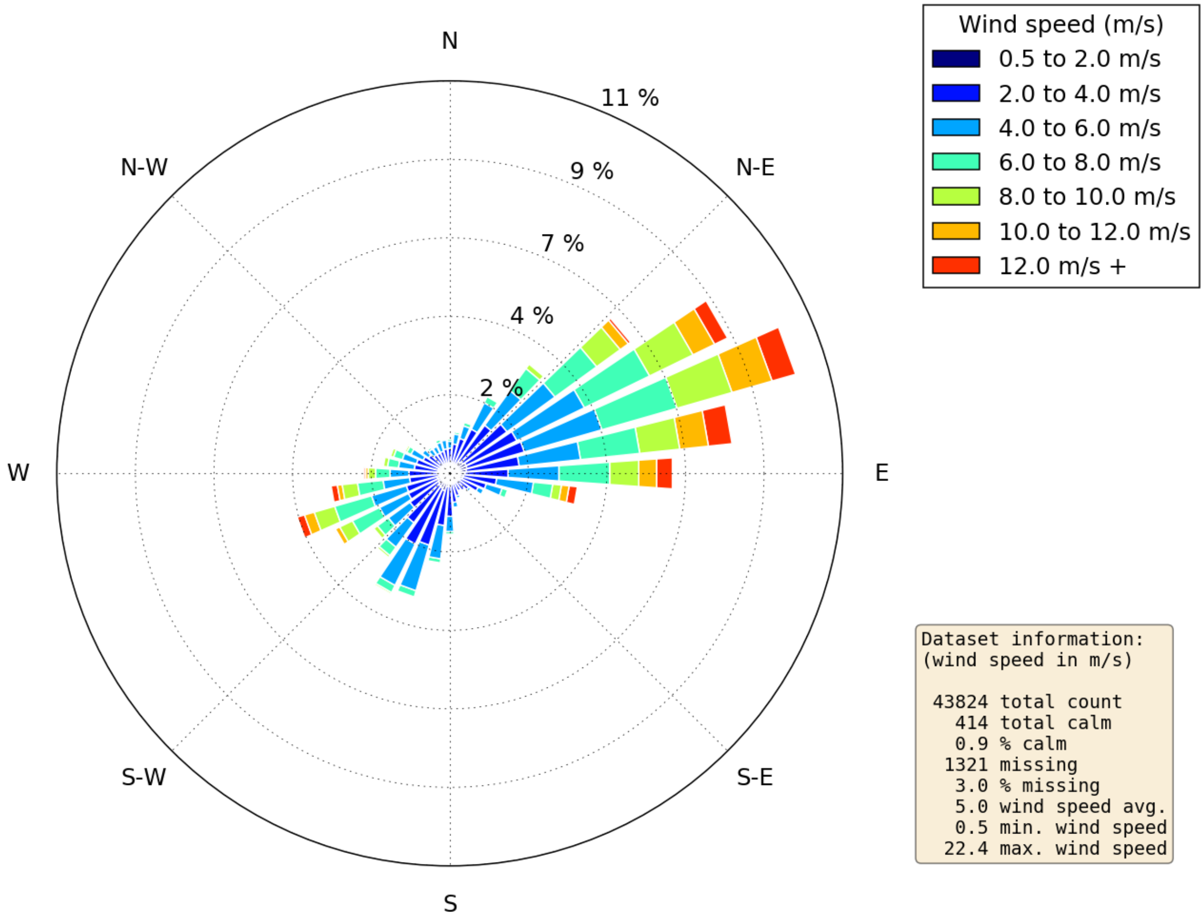


Figure 3.2-2 Nuiqsut Air Monitoring Station 2013-2017 Wind Rose

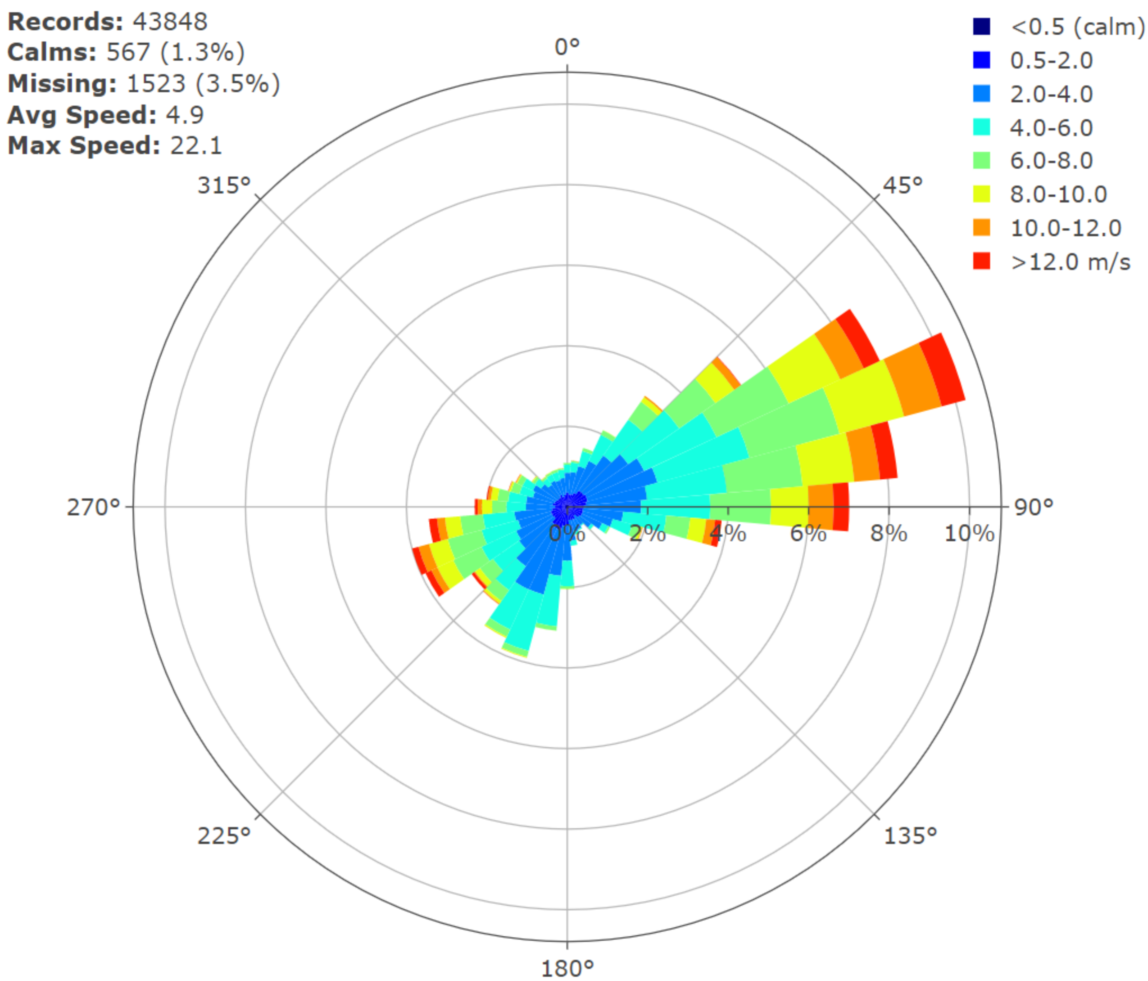


Figure 3.2-3 Nuiqsut Air Monitoring Station 2016-2020 Wind Rose *

3.2.5 Model Options

AERMOD model options were set to their regulatory default values, unless otherwise noted below in additional subsections of this chapter related to meteorological data processing and NO_2 modeling.

Urban vs Rural

None of the area in the vicinity of the Project is classified as urban; therefore, the urban option (URBOPT) keyword was not used in AERMOD.

Adjusted U-star

Due to the use of turbulence parameters collected at Nuiqsut meteorological station, adjusted u-star option is not used.

*NO_2 Modeling Approach**

For modeling NO_2, the Ozone Limiting Method (OLM) is used to estimate the NO_x to NO_2 conversion. The hourly ozone data measured at Nuiqsut shown in Figure 3.2-4 are used for 2013-2017, the same calendar years as the meteorological data presented in Section 3.2.3 “Meteorological Data”. More recent ozone concentrations from 2016-2020 were comparable to measured concentrations during the 2013-2017 period. Current ozone concentrations are comparable to the values used in the modeling analysis. The in-stack ratios are shown for the various types of equipment in Table 3.2-1 below and an equilibrium ratio of 0.9 was used for all sources. Unless noted, the ratios were derived from data contained in a spreadsheet available from ADEC with approved in-stack ratio values (ADEC, 2013). Data were averaged over all loads available for similar equipment to what would be used in the Project. The USEPA also has an in-stack ratio database (USEPA, n.d.); however, most of the data contained in this database for the emission sources in Table 3.2-1 were from the ADEC spreadsheet. In the absence of any available data, the USEPA default value of 0.5 was used (USEPA, 2011).

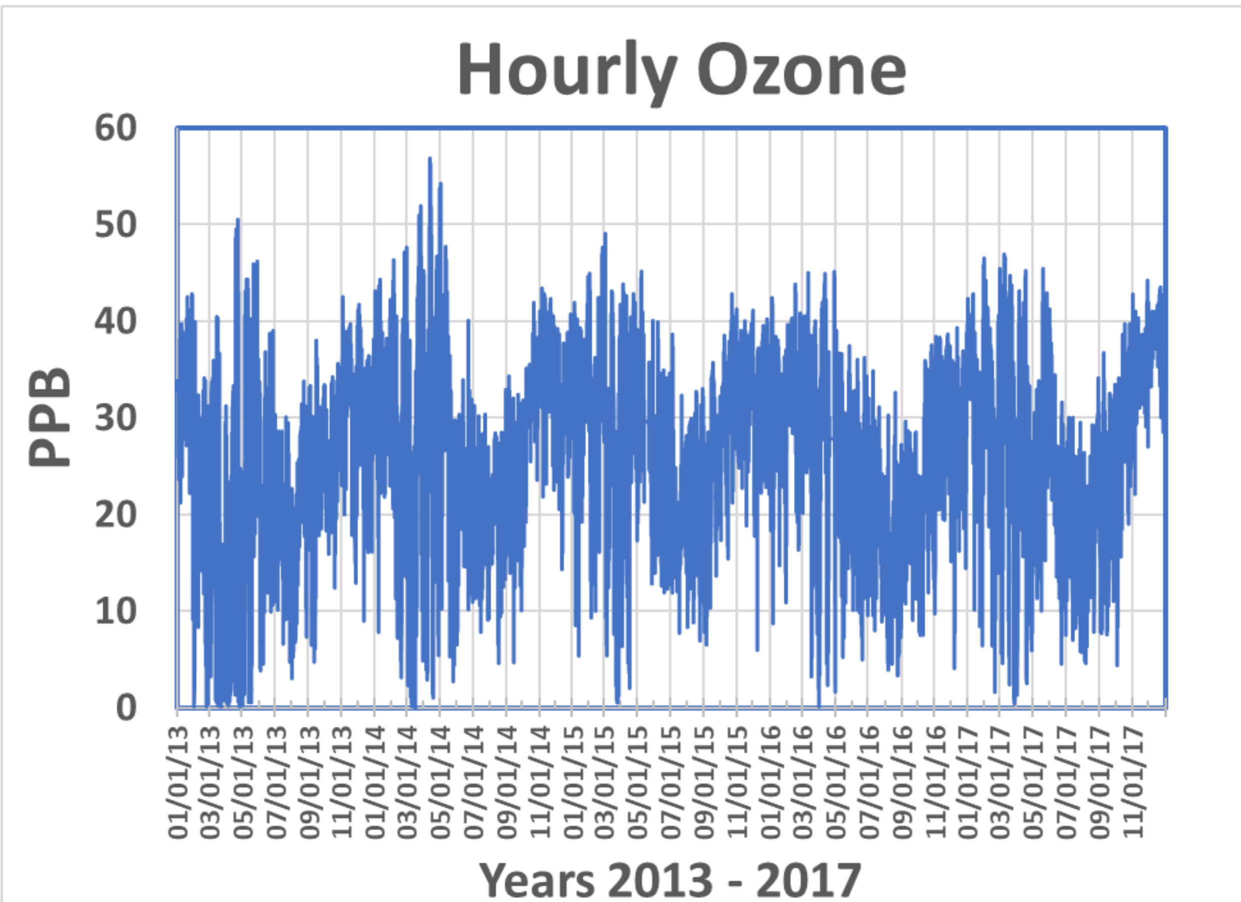


Figure 3.2-4 Hourly ozone data at Nuiqsut monitoring station in years between 2013 to 2017.

Table 3.2-1 In-Stack NO_2/NOx Ratios for use with OLM.

Type of Emission Source	NO2/NOx Ratio	Source of Data for Ratio
Diesel Engines	0.1	Average rounded to the nearest tenth of data from Trident Akutan, Tok Power Generation Station, Dutch Harbor Power Plant, Dillingham Power Plant, Peter Pan Seafoods, and DU-JBER Services engines (ADEC, 2013)
Diesel fueled heaters and boiler	0.05	Ambient Demonstration for the North Slope Portable Oil and Gas Operation Simulation report (AECOM, 2017)
Flares	0.5	USEPA default value (USEPA, 2011)
Natural gas heaters	0.05	Data for natural gas-fired heaters and boilers from EPA and ADEC NO-to-NO2 instack ratio database (ADEC, 2013; EPA, n.d.)
Diesel tailpipe from nonroad equipment	0.2	GMT1 and GMT2 value
Diesel tailpipe from on-road vehicles	0.15	GMT1 and GMT2 value
Natural-gas-fired turbines	0.3	In-stack ratio used for natural-gas fired turbines in Nanushuk EIS AQIA (SLR, 2017a)
Cumulative Sources	Variable	Were based on the values contained in this table and the predominant source at each facility

3.2.6 Ambient Background Data*

The ambient air monitoring stations closest to the proposed Project are the Nuiqsut Monitoring Station, a station at the CD1 Facility, and a station at the CD5 Pad. As discussed in the Willow MDP Protocol (Ramboll 2018), the Nuiqsut Monitoring Station is representative of ambient air background concentrations anticipated for the Project. The Nuiqsut Monitoring Station is located at the north end of Nuiqsut approximately 400 meters northwest of the Nuiqsut Power Plant and approximately 41 km (26 miles) east northeast of the Willow BT3 pad. The monitoring program, which began in 1999, is being conducted primarily to address community concerns in Nuiqsut. The Nuiqsut Monitoring Station also collects wind direction and speed, among other meteorological data as discussed in Section 3.2.3 “Meteorological Data”. Based on the wind roses (Figure 3.2-2 and Figure 3.23) from data collected at the Nuiqsut Monitoring Station, the wind predominately blows from the east northeast and east directions (SLR, 2016, 2017b, 2018, 2019, 2020, 2021).

Background concentrations at the Nuiqsut Monitoring Station are calculated using approaches defined in Kleinfelder, 2017, and are discussed below. Data for CO, NO_x, nitric oxide (NO), NO_2, SO_2, O_3, particulate matter less than $PM_{2.5}$, and PM_{10} are provided.

Many of the NAAQS are based on a three-year average and thus three years of background data are needed to calculate values used in the near-field impact analysis. Three years of Nuiqsut Monitoring Station data were used to calculate background data and hourly ozone data was processed for OLM modeling (see Section 3.2.5.3 “NO_2 Modeling Approach”). The background data have been updated from the analysis performed for the project FEIS (years 2015-2017) to the most recent 3-year period (2018-2020). Table 3.2-2 shows the values from 2018 – 2020 along with the final background value and the form of the data value chosen. The values in Table 3.2-2 are referenced directly from the Annual Data Reports (ADRs) (SLR, 2019, 2020, 2021) except for SO_2, NO_2 and PM_{10}.

SO_2 1-hour values were referenced directly from the ADRs; however, the 3-hour, 24-hour and annual background values used to calculate total air quality impacts were derived from hourly data, rather than use the valued directly from the ADRs because the ADRs did not contain adequate significant digits.

NO_2 and PM_{10} concentrations have been revised as described below. Consistent with USEPA guidance, a constant background value representative of each pollutant and averaging time was added to the model results except for 1-hour NO_2 and 24-hour PM_{10}. For 1-hour background NO_2 values, a seasonally-varying hourly concentration is determined based on 2018-2020 monitoring data following USEPA's March 1, 2011 Memorandum "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" (EPA, 2011) for modeling assessments of 1-hour NO_2 impacts. For this analysis the 3rd highest hourly values were determined for each season and averaged for each hour of day and season over the 3-year period. Table 3.2-3 shows the 3rd highest NO_2 value for each hour of each day within each of the seasons for 2018, 2019, and 2020, and a three-year average for each hour of each season. Season 1 is December, January, and February; Season 2 is March, April, and May; Season 3 is June, July, and August; and Season 4 is September, October, and November in Table 3.2-3. Since NO_2 3rd highest values are determined for each year and are dependent on the number of days with valid data for each season, we show the percentage of valid observations of hourly NO_2 by hour and season in Table 3.2-4. To ensure that outliers and inaccurate data are excluded, only sufficiently valid observations were averaged. Since all hours, all seasons, and all years had at least 70 percent valid observations, all values were included in the three-year averages shown in Table 3.2-4.

Table 3.2-2 Ambient Background Concentrations at Nuiqsut

Pollutant	Average Time	2018	2019	2020	Final Value	Data Value
CO	1-hour[a]	1 ppm/ 1144.5 μg/m³	1 ppm/ 1,144.5 μg/m³	9 ppm/ 10,300.5 μg/m³	9 ppm/ 10,300.5 μg/m³	Maximum second high value from three years of data
	8-hour[a]	1 ppm/ 1,144.5 μg/m³	1 ppm/ 1,144.5 μg/m³	3 ppm/ 3,433.5 μg/m³	3 ppm/ 3,433.5 μg/m³	Maximum second high value from three years of data
NO_2	1-hour	-	-	-	-	See Table 3.2-3 for the 3-year average seasonally-varying hourly background concentrations
	Annual	2 ppb / 3.8μg/m³	2 ppb/ 3.8μg/m³	2 ppb/ 3.8μg/m³	2 ppb/ 3.8μg/m³	Maximum value from three years of data
SO_2	1-hour	2.6 ppb / 6.8μg/m³	3.5 ppb/ 9.2μg/m³	4.2 ppb/ 11.0μg/m³	3.4 ppb/ 9.0μg/m³	99th percentile of daily 1-hr maximum averaged over three years
	3-hour	2.6 ppb / 6.7μg/m³	3.5 ppb/ 9.1μg/m³	3.8 ppb/ 10.0μg/m³	3.8 ppb/ 10.0μg/m³	Maximum second high value from three years of data
	24-hour	2.5 ppb/ 6.5μg/m³	3.3 ppb/ 8.7μg/m³	3.6 ppb/ 9.3μg/m³	3.6 ppb/ 9.3μg/m³	Maximum second high value from three years of data
	Annual	0.7 ppb/ 1.8μg/m³	0.3 ppb/ 0.8μg/m³	0.0 ppb/ 0.0μg/m³	0.7 ppb/ 1.8μg/m³	Maximum value from three years of data
PM_{10}	24-hour	-	-	-	-	See Table 3.2-66 for the 3-year average monthly background concentrations
$PM_{2.5}$	24-hour	8 μg/m³	7 μg/m³	6 μg/m³	7.0 μg/m³	98th percentile averaged over three years
	Annual	1.9 μg/m³	1.7 μg/m³	1.2 μg/m³	1.6 μg/m³	Annual mean averaged over three years

Data from SLR 2019, SLR 2020, and SLR 2021. Values from reports that are presented in units of ppb are also provided in units of μg/m³ for consistency with values and units used in the modeling analyses.
[a] 1-hour and 8-hour CO values are reported as the same value based on precision in the report.

The PM_{10} data collected at Nuiqsut during 2018 through 2020 were analyzed to determine a background level representative of the Project area. Previous analyses (AECOM 2013), and (Kleinfelder and Ramboll Environ 2017b) have shown that the elevated PM_{10} values at the Nuiqsut Monitoring Station are due to the monitoring station's proximity to the exposed silt banks of the Nigliq Channel. Figure 3.2-5 illustrates the proximity of the Nuiqsut Monitoring Station to these silt banks. In general, the highest PM_{10} values occur on days with strong winds from the east between 60° and 100° (from the Nigliq Channel). High wind events that entrain silt from the Nigliq Channel lead to elevated concentrations of PM_{10} that are not reasonably controllable or preventable and are a natural event. As recommended in EPA's "Guideline on Air Quality Models" (USEPA 2017) modeling results should use representative PM_{10} background concentrations with natural exceptional events removed. Therefore, the PM_{10} data from the Nuiqsut Monitoring Station coupled with wind speed and direction data were analyzed in detail to determine a more representative background for the Project area. Previous projects including GMT1 (AECOM 2013), GMT2 SEIS (Kleinfelder and Ramboll Environ 2017b), excluded unrepresentative hourly and daily PM_{10} values from background concentrations for days with high winds and with the wind direction between 60° and 100°. For this Project a similar analysis was performed to determine if there were high wind events during the 2018 – 2020 period that caused unrepresentative hourly and daily PM_{10} measurements. Table 3.2-5 shows the days that were excluded along with the daily average wind speed and wind direction, and the PM_{10} concentration measured on that day. Also indicated in Table 3.2-5 is the number of hours in the day where the winds were between 60° and 100° (from the Nigliq Channel). Table 3.2-6 shows the highest first high PM_{10} background values by month used for monthly background concentrations.

Consistent with 40 CFR Part 50 Appendix K, the average of the highest first high PM_{10} (H1H) background values for each month are rounded to the nearest 1 $\mu g/m^3$, and then rounded to the nearest 10 $\mu g/m^3$ for the purposes of determining exceedances (40 CFR Part 50 Appendix K 4.2(b)), the monthly background values in the Average PM_{10} H1H Background Value are rounded to nearest ten $\mu g/m^3$. These monthly values, provided in Table 3.2-6 , were added to AERMOD modeled 24-hour PM_{10} impacts from Project and cumulative sources.

For the use of OLM for NO_2 modeling, raw ozone data from the Nuiqsut Monitoring Station ADR reports (SLR, 2015, 2016, 2017) were used. More recent ozone concentrations from 2016-2020 were comparable to measured concentrations during the 2013-2017 period. Current ozone concentrations are comparable to the values used in the modeling analysis. For days and hours when ozone values are missing due to missing data, calibration, or sampling, the average ozone value from that month was used to fill in the missing hours.

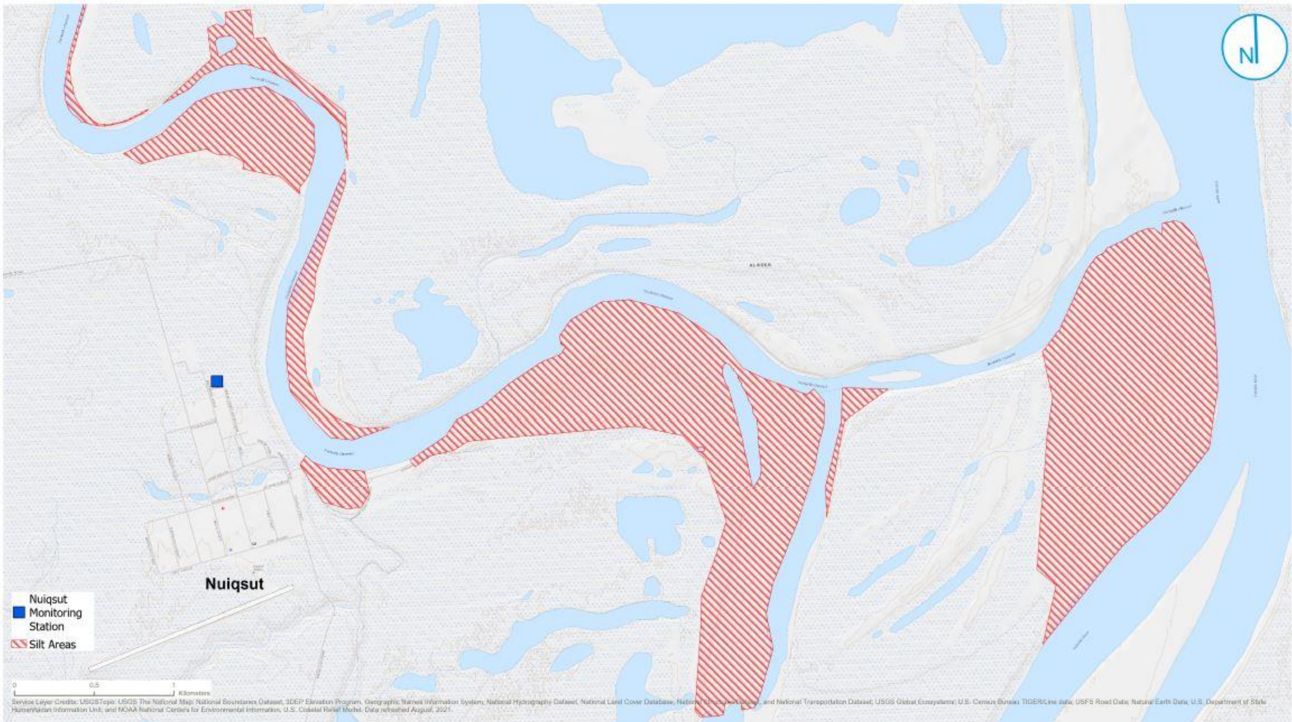


Figure 3.22-5 Proximity of Nuiqsut Monitoring Station to the Nigliq (Nechelik) Channel (potential Sources of Particulate Matter are Shaded in Red).

Table 3.2-3 3rd Highest Hourly NO_2 Values by Hour and Season (ppb)*

3-Year Average	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Season 1	15.87	18.20	16.27	12.00	17.33	15.20	17.30	17.57	17.13	17.47	14.97	16.17	17.13	19.43	19.37	19.23	23.13	20.27	16.20	16.23	17.43	14.07	16.87	16.80
Season 2	13.33	10.33	11.80	11.20	15.13	14.53	10.30	7.67	9.73	9.53	7.30	6.73	6.53	6.37	5.77	6.57	7.17	8.40	10.30	8.30	9.00	12.23	11.93	12.93
Season 3	6.33	6.67	8.57	6.97	6.17	5.93	5.67	5.07	5.37	4.60	4.47	3.63	4.30	3.57	4.10	3.77	3.73	4.17	5.00	6.00	7.20	6.70	7.90	6.90
Season 4	5.10	5.40	4.40	4.10	4.23	5.17	5.43	5.47	4.87	5.17	5.97	4.83	4.43	5.30	6.23	7.03	6.13	6.27	6.70	4.93	6.77	4.63	4.20	4.60
2018	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	16.30	16.10	16.00	10.50	13.60	16.50	12.40	14.90	14.30	22.70	14.10	13.80	16.70	16.50	13.40	16.50	14.80	13.80	13.50	16.30	16.30	14.40	13.40	16.20
Season 2	9.10	10.70	10.40	8.10	11.30	8.90	9.70	6.10	6.30	4.30	4.70	5.60	4.80	4.30	4.40	5.70	5.80	4.60	7.90	5.30	6.00	8.50	8.70	6.60
Season 3	5.50	6.30	8.70	7.00	5.10	5.30	4.40	4.80	4.30	4.10	3.70	3.50	4.30	3.00	3.20	3.00	3.00	3.20	2.80	3.70	4.30	5.80	5.30	3.60
Season 4	4.30	4.10	2.20	2.40	2.90	5.70	5.70	4.50	5.40	5.80	8.40	5.20	4.70	5.20	7.10	8.60	8.30	7.40	7.10	6.80	7.00	6.70	6.10	5.40
2019	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	18.90	19.70	13.50	11.70	18.70	14.90	21.50	21.00	19.80	12.30	15.70	16.90	20.00	13.80	14.40	18.20	27.90	20.60	19.60	15.10	19.20	13.10	20.10	20.10
Season 2	15.40	6.50	8.30	12.10	14.70	12.20	9.30	8.10	13.50	13.40	9.60	6.40	7.90	6.00	5.50	5.60	4.40	7.80	7.30	6.50	9.50	9.10	9.20	12.70
Season 3	7.60	6.60	6.50	9.50	7.40	6.20	6.20	5.60	5.30	4.60	4.40	4.10	5.20	4.50	5.70	4.10	3.90	4.10	6.50	5.90	8.10	8.60	10.40	8.20
Season 4	5.60	5.60	6.70	5.00	5.30	4.60	4.60	4.80	4.50	5.00	5.40	5.20	4.10	5.40	7.70	8.40	6.10	7.20	8.70	5.40	9.60	3.40	3.50	4.60
2020	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	12.40	18.80	19.30	13.80	19.70	14.20	18.00	16.80	17.30	17.40	15.10	17.80	14.70	28.00	30.30	23.00	26.70	26.40	15.50	17.30	16.80	14.70	17.10	14.10
Season 2	15.50	13.80	16.70	13.40	19.40	22.50	11.90	8.80	9.40	10.90	7.60	8.20	6.90	8.80	7.40	8.40	11.30	12.80	15.70	13.10	11.50	19.10	17.90	19.50
Season 3	5.90	7.10	10.50	4.40	6.00	6.30	6.40	4.80	6.50	5.10	5.30	3.30	3.40	3.20	3.40	4.20	4.30	5.20	5.70	8.40	9.20	5.70	8.00	8.90
Season 4	5.40	6.50	4.30	4.90	4.50	5.20	6.00	7.10	4.70	4.70	4.10	4.10	4.50	5.30	3.90	4.10	4.00	4.20	4.30	2.60	3.70	3.80	3.00	3.80

Table 3.2-4 Valid Observations of Hourly NO_2 by Hour and Season*

Year/Season	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour
2018	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	100%	100%	100%	87%	99%	98%	98%	98%	98%	97%	98%	97%	97%	96%	96%	97%	96%	98%	98%	100%	100%	100%	100%	100%
Season 2	100%	100%	100%	88%	100%	99%	100%	100%	99%	99%	97%	96%	99%	99%	98%	95%	96%	99%	99%	100%	100%	100%	100%	100%
Season 3	82%	82%	82%	70%	79%	80%	80%	82%	82%	82%	82%	82%	80%	80%	79%	80%	78%	80%	82%	82%	83%	83%	83%	83%
Season 4	100%	99%	99%	86%	100%	99%	98%	98%	98%	98%	98%	99%	99%	98%	98%	98%	96%	97%	99%	99%	99%	100%	100%	100%

Year/Season	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour	Hour
2019	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	99%	99%	99%	84%	98%	93%	92%	97%	97%	94%	93%	98%	99%	98%	98%	98%	98%	97%	97%	97%	98%	98%	97%	99%
Season 2	100%	100%	100%	86%	100%	99%	99%	99%	99%	99%	98%	98%	97%	96%	98%	97%	97%	98%	97%	98%	100%	100%	100%	100%
Season 3	84%	84%	84%	73%	84%	84%	84%	84%	83%	78%	78%	79%	84%	83%	80%	84%	84%	84%	83%	80%	80%	83%	84%	84%
Season 4	97%	97%	97%	86%	98%	97%	98%	98%	98%	98%	97%	90%	92%	93%	93%	93%	93%	95%	97%	96%	96%	97%	97%	97%
2020	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Season 1	97%	99%	98%	78%	99%	99%	98%	98%	99%	99%	97%	99%	98%	96%	96%	99%	98%	99%	98%	98%	98%	98%	97%	98%
Season 2	100%	100%	100%	91%	100%	100%	100%	100%	100%	100%	99%	99%	98%	100%	99%	99%	96%	97%	99%	98%	99%	98%	98%	99%
Season 3	96%	96%	95%	83%	95%	96%	93%	93%	93%	95%	93%	92%	92%	93%	91%	93%	95%	93%	95%	96%	95%	95%	95%	96%
Season 4	88%	88%	88%	70%	86%	86%	87%	86%	86%	86%	86%	86%	86%	87%	87%	87%	87%	88%	89%	89%	87%	88%	88%	88%

Table 3.2-5 Days and Meteorology Removed from PM_{10} Background Analysis*

Date	24-hour PM_{10} Concentration (µg/m³)	Average Daily Wind Speed (m/s)	Average Daily Wind Direction (degrees)	Number of Hours Wind Direction is Within 60-100 degrees
October 3, 2018	137.2	8.9	88.2	24
October 4, 2018	142.2	9.5	86.7	24
May 17, 2019	79.7	11.9	86.3	24
July 2, 2019	126.0	5.2	127.7	4
October 18, 2019	70.8	10.5	97.0	23
October 27, 2019	196.0	7.5	89.0	23
June 27, 2020	107.3	5.8	92.6	14

Table 3.2-6 Highest First High PM_{10} Background Values by Month*

Month	2018 PM_{10} H1H Background Value (µg/m³)	2019 PM_{10} H1H Background Value (µg/m³)	2020 PM_{10} H1H Background Value (µg/m³)	Average PM_{10} H1H Background Value (µg/m³)	Average PM_{10} H1H Background Value to nearest ten (µg/m³)
January	17.3	8.8	6.2	10.8	10
February	15.0	7.8	6.6	9.8	10
March	8.2	15.4	12.5	12.0	10
April	53.4	69.1	12,8	45.1	50
May	41.4	43.0	41.4	41.9	40
June	48.6	24.3	59.1	44.0	40
July	16.1	38.8	31.5	28.8	30
August	22.8	12.5	28.8	21.4	20
September	23.1	37.8	8.8	23.2	20
October	34.7	27.6	35.0	32.4	30
November	13.7	17.3	5.3	12.1	10
December	18.6	12.3	15.0	15.3	20

3.2.7 Receptors

An ambient air boundary and receptor grid was developed to assess near-field impacts for each modeling scenario. Each scenario required different ambient air boundaries and receptors based on the actives occurring with each scenario. In particular, the access to pads during construction activities uses ice roads in a different location than the gravel road that is used once the pads are constructed and operational. In general, the approach for developing ambient boundaries for Willow MDP are:

- Drill sites and other pads (Willow Processing Facility (WPF), Willow Operations Centers (WOC), airstrip) use the edge of the gravel pad.
- The mine uses the mine edge in combination with the surrounding ice pads.
- Roads use 1-plume width from either side of the center line of the road, following the approach for GMT2 (Kleinfelder and Ramboll Environ, 2017b).

Receptors were placed around the ambient air boundaries using the following spacing:

- 10 meter spacing along the ambient air boundary
- 25 meter spacing from the ambient air boundary to 100 meters
- 100 meter spacing from 100m to 1km
- 250 meter spacing from 1 km to 2 km
- 500 meter spacing from 2 km to 5 km
- 1,000 meter spacing from 5 km to 50 km

All receptors were in the UTM NAD83 Zone 5N coordinate system.

Receptors along the access road section were placed at the spacing noted above; however, receptors were at a minimum distance of one volume source width from the road volume sources due to model instabilities when the receptors are placed too close to volume sources. It should be noted that while roads exist throughout the development, road emissions were evaluated within 100 meters of the pads where proximity to other sources would have the maximum impact.

To capture cumulative source impacts that may interact with the Willow MDP impacts, the receptors with a grid spacing of 1,000 meters extended up to 50km from the center of the Project area. Because the intent was not to specifically analyze individual non-Willow source impacts, but rather any interaction of the cumulative sources with Willow MDP impacts, the coarse grid receptors were not placed closer than 200 meters to any cumulative source. An additional discrete modeling receptor was placed at Nuiqsut to characterize impacts to sensitive receptors for both criteria pollutant impacts and the six selected HAPs.

The area surrounding the proposed Willow MDP drill sites and infrastructure pads (including WPF) is generally flat on a local scale, with the terrain sloping downward generally to the north. There are not any prominent elevation features surrounding the proposed Willow MDP. The proposed WOC would be at the highest elevation when compared to the cumulative sources and the town of Nuiqsut with the greatest elevation difference being roughly 26 m between the proposed WOC and the lowest cumulative source, which would be approximately 35 km away. Because of the relatively small elevation difference over this large distance, flat terrain was assumed for all receptors and cumulative source elevations.

All emissions sources have a base elevation value established based on the location of the gravel pad or road and the estimated gravel thickness of that pad or road as documented in the Willow MDP Environmental Effect Document (CPAI 2019).

3.3 Alternative B (Proponent's Project)

This section describes the selection of scenarios designed to characterize the potential impacts anticipated under Alternative B, the modeled receptors, source types, emissions, and resulting impacts.

3.3.1 Overview of Scenarios

Based on Alternative B emissions activities, source types, and development phases, five scenarios are analyzed:

1. Construction
2. Pre-drilling activities at Bear Tooth (BT)1
3. Pre-drilling activities at BT1 and BT2
4. Development drilling
5. Routine Operations

All scenarios include emissions of criteria pollutants, HAPs and GHGs. As shown in Section 2.1 "Willow Alternatives Emissions Inventories", HAPs from construction and drilling activities are substantially lower than routine operations. Therefore, HAP impacts are explicitly modeled for Routine Operations only and HAP impacts from all other scenarios would be lower than Routine Operations.

Modeled sources include point source emissions, area sources, and volume sources. Equipment modeled as point sources include stationary sources, such as engines, heaters and flares, as well as large portable equipment and nonroad engines. Groupings of similar low-level equipment were generally aggregated as area sources. Fugitive dust and mobile sources tailpipe emissions were modeled as volume sources. For example, the gravel access road was modeled as a series of volume sources to represent dust or tailpipe emissions from vehicle traffic. Point source stack parameters were provided by CPAI for most stationary sources, including flares. For those sources without stack parameter information, stack parameters are selected to be consistent with stack parameters used for modeling GMT2 or other public information. For area and volume sources release heights, initial vertical dimensions, and initial horizontal dimensions were based on the equipment as well as Table 3-2 from the AERMOD User's Guide (USEPA, 2019).

Based on AERMOD/ISCST guidance for modeling (USEPA 2019), road segment volume source dimensions are based on the road width and placed along the road segments at calculated spacing intervals. Therefore, volume source dimensions and spacing are calculated as follows:

- For gravel haul roads 24 feet (7.32 m) wide, volume sources are spaced 14.63 meters (48 feet) apart, use a sigma-y of 6.80 m (14.63/2.15) and exclude receptors along 15 meters on each side of the road. For gravel haul roads 32 feet (9.75 m) wide volume sources are spaced 19.51 meters (64 feet) apart, use a sigma-y of 9.07 m (19.51/2.15), and exclude receptors along 20 meters on each side of the road.

- For the gravel haul ice roads 50 feet (15.24 m) wide, volume sources are spaced 30.48 meters apart, use a sigma-y of 14.18 m (30.48/2.15) and exclude receptors within 30 meters on each side of the road.
- For the module delivery ice roads 60 feet (18.29 m) wide, volume sources are spaced 36.58 meters apart, use a sigma-y of 17.01 m (36.58/2.15) and exclude receptors within 35 meters on each side of the road.

See Attachment A for detailed information about the sources included in each scenario. All sources modeled for each scenario are shown in figures in Attachment A depicting the layout of the sources relative to ambient air boundaries, structures, roads, and other Project features. In addition, Attachment A includes detailed tables that provide a description of each modeled source, source emissions rates for all modeled pollutants and averaging periods, in-stack NO_2-to-NOx ratio, modeled location, and stack parameters.

Construction

The construction of Willow MDP is on a ten-year schedule beginning late in Year 0 and completing in Year 9. This ten-year period will include construction of five drill sites, processing facility, Willow Operations Center, airstrip, gravel access roads, pipelines, communications facilities, living quarters and other infrastructure to support long-term operations. In addition, construction and cooperation of temporary facilities including a gravel mine, seasonal ice roads, single-season and multi-season ice pads, and temporary camp facilities for worker housing to support construction activities are proposed in the Willow MDP. Two mine sites within the Tiŋmiaqsiuġvik Area (located about 20 miles from the Willow Operations Center) are proposed to supply the gravel needed to construct the Willow Development. The gravel mines would be accessed seasonally via ice road and the mine pit would be opened during winter construction seasons to support construction of the drill sites, the WPF, Willow Operations Center, MTI, airstrip, and associated roads.

As shown in Section 2.1 “Willow Alternatives Emissions Inventories”, the annual criteria pollutant emissions totals during construction phases are expected to peak during Year 4 when emissions activities occur during construction of WPF, Willow Operation Center, BT1 drill site, BT2 drill site, BT3 drill site along with installation of major pipeline and roads/bridges. Therefore, emissions activities occurring in Year 4 are modeled for the Alternative B construction scenario. In Year 4, BT4 and BT5 are not yet under construction so those drill sites are not included in the construction scenario. Although Alternative B could be authorized with either Module Delivery Option, emissions activities involving module delivery requiring trucking trips through Project areas are independent of the module delivery Option selected and are thus included as part of the construction scenario.

BT1 Pre-drill

Willow MDP is proposing to construct 251 wells at the five proposed drill sites (BT1 – BT5). It is estimated that it will take approximately 15-30 days to drill each well and drill all wells consecutively beginning in Year 4 at the BT1 drill site. While drilling operations are anticipated to be conducted predominantly with drill rigs operating on highline supplied electrical power, highline power would not be available during BT1 construction and initial drilling until the WPF is fully operational. Therefore, two diesel-fired drill rigs, hydraulic fracturing units, and associated ancillary support equipment two drill rigs will operate at BT1 until highline power is available. In addition, until the infrastructure is in place to handle gas from flowbacks, any gas will be routed to a portable flare located at the drill site. Drilling activities may include emissions from the operation of the drill rig engine, rig boiler, and associated drilling equipment. Drilling and hydraulic fracturing activities could occur at a single drill site concurrently. Hydraulic fracturing activities includes emissions from hydraulic fracturing units, including hydraulic fracturing performed to increase fluid movement from the rock into the well bore, and vehicle emissions.

BT1 and BT2 Pre-drill

BT1 and BT2 Pre-drill scenario is similar to BT1 Pre-drill scenario with the exception that a single diesel-fired drill rig and hydraulic fracturing equipment operate at both BT1 and BT2 pads concurrently.

Development Drilling

Starting in Year 6 drilling and hydraulic fracturing equipment would operate on highline power. The Development Drilling scenario is designed to assess potential peak short-term and annual air quality impacts from drilling and hydraulic fracturing operations occurring at the same time as localized construction and operational activities throughout the rest of the Project area. This modeling scenario is based on electric drill rigs and hydraulic fracturing units operating concurrently at BT2 and BT3 as these well sites are in closest proximity to each other spatially and are likely to be drilled concurrently based on the drilling schedule in the Environmental Evaluation Document (Revision No. 3): Willow Master Development Plan (CPAI 2019). Modeled activities would be similar to the Routine Operation scenario with the addition of drilling activities conducted with electric drill rigs and hydraulic fracturing units at BT2 and BT3 and construction activities occurring at BT2 and BT3. Portable flares would be used at BT2 and BT3 to handle gas from flowbacks, and low pressure and high pressure flares would be operational at the WPF. Since drilling would be complete by 2029 in Alternative B, impacts from Development Drilling would not occur after Year 9.

Routine operation and production of wells

Routine operation and production emissions include well pad production equipment; product storage, transfer, and transport; product processing and disposal facilities; as well as vehicle traffic for routine inspection and maintenance. Low pressure and high pressure flares would be operational at the WPF. These types of activities are associated with the planned production and processing of oil, gas, and produced water. The annual criteria pollutant emissions for production and operations will steadily increase and reach the highest starting in Year 2030 as shown in Section 2.1 “Willow Alternatives Emissions Inventories”. During production operations, produced water and oil from wells would be stored in tanks on processing facilities. The Routine Operation scenario also explicitly models emissions from other projects anticipated to be developed within the near-field of the Willow MDP Project as shown in Table 2.2-2 to assess expected cumulative long-term impacts.

3.3.2 Construction

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

The ambient air boundaries and receptors (consistent with Section 3.2.7 “Receptors”) are shown in in Attachment E.

Emissions Calculations

Emission rates for all modeled sources are provided in Attachment A. Emission rates used in the model were based on maximum hourly or average annual emissions depending on the ambient air threshold for the pollutant of interest. For example, 1-hour NO_2 was modeled using maximum hourly potential emissions as calculated in the approved emissions inventory. Most emission sources were assumed to operate 24 hours per day, 7 days per week, and 52 weeks per year unless the emissions inventory includes information indicating a shorter period of operation. Fugitive dust emissions are estimated for months from May through October, consistent with the months for which fugitive dust emissions were estimated in the BOEM Arctic modeling study (Fields Simms et al 2018, Stoeckenius et al 2017). Fugitive dust may also occur in other months, especially during dry snowless conditions and from dry and frozen roads. Thus, fugitive dust emissions outside May through October may affect air concentrations of particulate matter, but likely to a smaller extent than fugitive dust emitted during May through October when there is much less (or no) snow cover. Likewise, some operations would only be expected to occur during daytime hours. Appropriate adjustments to the gram (g) per second emission rates were made for sources that do not operate continuously. Emission rates for activities that operate exclusively during specific periods were “turned on” and “turned off” to match the expected seasonality as appropriate. Annual emissions for sources that do not occur year-round were “annualized” to the period that the model is turned on. For example, if a source in the model is turned on for 4,380 hours per year, the source’s annual emissions will be converted to gram per second by using 4,380 hours per year.

In general, for nonroad equipment operating during construction a category specific utilization factor was applied to approximate the fraction of the nonroad equipment that would be operating simultaneously at a given time. The utilization factor accounts for the fact that not all the equipment operates simultaneously within the same hour. The factor is derived using average operating hours of equipment spread over a 24 hours period. The factor is calculated as the fleet-wide average of fractional hours of operation per day and applied hourly emissions. This utilization factor is not applied to all nonroad sources that are treated as point sources including heaters, off-highway-trucks (B-70s), air compressors, generator sets, pumps, and bore/drill rigs unless explicitly stated below.

<u>BT1 Facilities Installation, Pipeline Installation, and Vertical Support Member Construction Nonroad Equipment</u> – Individual hourly emission and annual rates are calculated using the general approach outlined above and by applying its respective nonroad utilization factor to hourly emissions. A category-wide emission rate is then calculated for hourly and annual emissions by summing emission rates of all nonroad equipment not treated explicitly as point sources across its respective category.

<u>BT2 and BT3 Pad Construction Nonroad Equipment</u> – Hourly and annual emission rates are initially calculated using the general approach outlined above. Monthly emission factors are then applied to annual emission rates to allocate emissions to each month of the year based on based on the level of pad construction activity occurring during that month. For all sources not treated explicitly as point sources a utilization factor is applied to hourly emission rates. A category-wide emission rate is then calculated for hourly and annual emissions by summing these individual nonroad equipment emission rates in its respective category.

<u>Gravel Mining Nonroad Equipment</u> - Individual hourly emission and annual rates are calculated using the general approach outlined above and by applying the respective nonroad utilization factor to hourly emissions. A category-wide emission rate is then calculated for hourly and annual emissions by summing

emission rates of all nonroad equipment not treated explicitly as point sources across its respective category. These hourly and annual emission rates are then split into nine (9) equivalent volume sources.

Ice Road Construction Nonroad Equipment – Individual hourly and annual emissions rates are calculated using the general approach outlined above. The equipment needed by Willow is scaled up or down from equipment needed by GMT1 based on the ratio of annual ice road needed to be constructed annually in Willow vs ice road constructed in GMT1 based on ice road mileage needed in Willow. Thus, a Willow/GMT1 annual activity scaling factor based on the ice road constructed annually to ice road constructed in GMT1 is applied to account for fluctuations in annual activity. For all sources not treated explicitly as point sources a utilization factor is applied to hourly emission rates. A category-wide emission rate is then calculated for hourly and annual emissions by summing these individual nonroad equipment emission rates in its respective category. These nonroad emissions are then scaled based on the ratio of total length of the ice road within the modeling domain to the total ice road length constructed in 2024 and split into four (4) equivalent volume sources.

Single Season Ice Pad Construction Nonroad Equipment – Individual hourly and annual emissions rates are calculated using the general approach outlined above. A Willow/GMT1 annual activity scaling factor based on the ice pad constructed annually to ice pad constructed in GMT1 is then applied to account for the fluctuations in annual activity. For all sources not treated explicitly as point sources a utilization factor is applied to hourly emission rates. A category-wide emission rate is then calculated for hourly and annual emissions by summing these individual nonroad equipment emission rates in its respective category. These nonroad emissions are then placed on six different locations within the ice pad scaled based on the ratio of total acreage of the ice pad within the modeling domain to the total ice pad acreage constructed in 2024 and split into the. The locations are broken down as follows:

- Housing Construction Equipment at the mine – 1 equivalent volume sources
- Organic Stockpile at the mine – 44 volume sources
- Inorganic Stockpile at the mine – 44 equivalent volume sources
- Ice Pad Perimeter at the mine – 44 equivalent volume sources
- HDD Pad #1 – 1 volume source
- HDD Pad #2 – 1 volume sources

Multi-Season Ice Pad Construction Nonroad Equipment – Individual hourly and annual emissions rates are calculated using the general approach outlined above. A Willow/GMT1 annual activity scaling factor based on the ice pad constructed annually to ice pad constructed in GMT1 is then applied to account for the fluctuations in annual activity. For all sources not treated explicitly as point sources a utilization factor is applied to hourly emission rates. A category-wide emission rate is then calculated for hourly and annual emissions by summing these individual nonroad equipment emission rates in its respective category. All sources associated with multi-season ice pad construction are conservatively assumed to operate at the mine site, WOC, and GMT2 multi-season ice pads.

Willow and Alpine Airstrip Aircraft Activity – Hourly and annual emission rates are calculated by extracting takeoff and landing emission factors for each aircraft type. Emission factors for each aircraft type are then multiplied by the number of flights for each aircraft type in the model year, 2024. Since each flight constitutes one takeoff and one landing the takeoff and landing emission rates are summed across their respective aircraft type. The total aircraft emission rates are then calculated by summing across the aircraft types and converted to g/s. The total emission rates are split into three separate areas, based on release height, and divided by the respective airstrip area.

Blasting Emissions – Hourly emission rates are calculated using the emission rate extracted from the emissions inventory. Emission rates in lbs/day are divided by the number of hours in a day and converted to g/s to get hourly emission rates. Annual emission rates are then calculated using the same method as the general approach outlined above using weeks of operation instead of hours of operation. Short-term blasting is modeled using hourly emission rates while long-term blasting is modeled using annual emission rates.

Willow Operations Center Temporary Power Generation Turbine – Hourly and annual emission rates are calculated using the general approach outlined above. Monthly emission factors are applied to hourly and annual emission rates to account for fluctuations in emission rates. Monthly fluctuations in emission rates are caused by variations in ambient temperatures affecting the air density which affects fuel capacity into the turbine at full load.

Willow Operations Center and WPF Facilities Installation Nonroad Equipment – Individual hourly emission and annual rates are calculated using the general approach outlined above and by applying its respective nonroad utilization factor to hourly emissions. A category-wide emission rate is then calculated for hourly and annual emissions by summing emission rates of all nonroad equipment not treated explicitly as point sources across its respective category. Monthly emission factors are then applied to annual emission rates to allocate emissions to each month of the year based on based on the level of facilities installation activity occurring during that month.

Mobile Tailpipe Emissions – Hourly and annual emission rates are calculated by extracting the running and idling emission factors for each vehicle type. Running emission factors are then multiplied by annual mileage travelled for each vehicle type to get the total running emissions per year. Idling emission factors are multiplied by the total idling hours per year to get total idling emissions per year. Emissions are then converted into g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their "respective modeling area" by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. The "respective modeling area" here and below refers to the pad or drill site activity with which the emissions are associated in the modeling. Running and idling emission rates are summed across all vehicle types for their respective modeling area and split in the following manner:

- BT1-3 – 4 equivalent volume sources
- Willow Operations Center – 4 equivalent volume sources
- WPF – 4 equivalent volumes sources
- Gravel Mine – 4 equivalent volume sources

Mobile Equipment Fugitive Dust – Hourly and annul emission rates are calculated by extracting the fugitive dust emission factors for each vehicle type. Fugitive dust emission factors are then multiplied by annual vehicle miles travelled to get total fugitive dust emissions per year and converted to g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. Fugitive dust emission rates are summed across all vehicle types for their respective modeling area and split in the same manner as their tailpipe equivalent.

Gravel Road Construction, Pipeline Installation, Vertical Member Support Construction, and Fiber Optics Installation Nonroad Equipment – Individual hourly emission and annual rates are calculated using the general approach outlined above. and by applying its respective nonroad utilization factor to hourly emissions. A category-wide emission rate is then calculated for hourly and annual emissions by summing emission rates of all nonroad equipment not treated explicitly as point sources across its respective category. These hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the segment road length within the modeling domain to the total road length constructed in 2024. Hourly and annual emissions rates are then split into four equivalent volume sources. Gravel road construction is assumed to be occurring at BT2 and BT3.

Bridge Installation Nonroad Equipment - Individual hourly emission and annual rates are calculated using the general approach outlined above. and by applying its respective nonroad utilization factor to hourly emissions. A category-wide emission rate is then calculated for hourly and annual emissions by summing emission rates of all nonroad equipment not treated explicitly as point sources across its respective category. Hourly and annual emission rates for all sources associated with bridge installation are then divided by the number of bridges based on the assumption only one bridge is being installed at any moment.

Willow Operations Center Snowmelters and Portable Heaters – Hourly and annual emissions are calculated using the general approach outlined above. Emissions are then summed and treated as a single volume source.

Off-Highway Trucks (B-70s) – Individual hourly emission and annual rates are calculated using the general approach outlined above. Emission rates are then scaled down to a per unit basis. Two B-70 trucks are then placed on BT2, BT3, the gravel mine, and the gravel road split into 4 equivalent volume sources for the pads and 9 equivalent volume sources for the mine. The B-70s along the gravel road are scaled based on the ratio road length in the modeling domain to total road length constructed in Year 4 and split into 4 equivalent volume sources along the gravel road segment along BT2 and the road segment along BT3.

Criteria Pollutant Impacts

Table 3.3-1 shows the modeled impacts to air quality everywhere in the model domain and Table 3.3-2 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods.

Table 3.3-1 Construction Activity AAQS Impacts – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m^3)	Background Concentration (µg/m^3)	Total Concentration (µg/m^3)	NAAQS (µg/m^3)	AAAQS (µg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	526.4	10,300.5	10,826.9	40,000	40,000	27%	27%
	8-Hour	390.0	3,433.5	3,823.5	10,000	10,000	38%	38%
NO_2	1-Hour	111.4	22.4	133.8	188	188	71%	71%
	Annual	17.0	3.8	20.8	100	100	21%	21%
SO_2	1-Hour	3.6	9.0	12.6	196	196	6%	6%
	3-Hour	5.2	10.0	15.2	1,300	1,300	1%	1%
	24-Hour	1.2	9.3	10.6	--	365	--	3%
	Annual	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	61.9	30.0	91.9	150	150	61%	61%
$PM_{2.5}$	24-Hour	11.6	7.0	18.6	35	35	53%	53%
	Annual	2.6	1.6	4.2	12	12	35%	35%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m^3 - 24-hour and 0.05 µg/m^3 - annual) from CAMx modeling.

Table 3.3-2 Construction Activity AAQS Impacts at Nuiqsut – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m^3)	Background Concentration (µg/m^3)	Total Concentration (µg/m^3)	NAAQS (µg/m^3)	AAAQS (µg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	45.1	10,300.5	10,345.7	40,000	40,000	26%	26%
	8-Hour	15.2	3,433.5	3,448.7	10,000	10,000	34%	34%
NO_2	1-Hour	31.4	18.0	49.4	188	188	26%	26%
	Annual	0.4	3.8	4.2	100	100	4%	4%
SO_2	1-Hour	0.7	9.0	9.7	196	196	5%	5%
	3-Hour	0.5	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.1	9.3	9.4	--	365	--	3%
	Annual	0.002	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.0	50.0	51.0	150	150	34%	34%
$PM_{2.5}$	24-Hour	0.75	7.0	7.7	35	35	22%	22%
	Annual	0.074	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;

SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m^3 - 24-hour and 0.05 μg/m^3 - annual) from CAMx modeling.

3.3.3 BT1 Pre-Drill

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emission rates for all modeled sources are provided in Attachment A.

Mobile Tailpipe Emissions - Hourly and annual emission rates are calculated by extracting the running emission factors. Running emission factors are then multiplied by annual mileage travelled for each vehicle type to get the total running emissions per year. Emissions are then converted into g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. Running emission rates are summed across all vehicle types for their respective modeling area and split into nine (9) equal volume sources at its respective modeling domain.

Mobile Equipment Fugitive Dust – Hourly and annul emission rates are calculated by extracting the fugitive dust emission factors for each vehicle type. Fugitive dust emission factors are then multiplied annual vehicle miles travelled to get total fugitive dust emissions per year and converted to g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. Mobile fugitive dust emissions are then split into volume sources equivalent to mobile tailpipe.

Snowmelters and Portable Heaters – Hourly and annual emissions are calculated using the general approach outlined above. Emissions are then summed and treated as a single volume source. Monthly emission factors are then applied. No operation is assumed during summer months (June-August).

Drill Rigs and Drilling Support Equipment – Hourly and annual emissions are calculated using the general approach outlined above and two drill rigs are active at BT1 during Pre-Drill.

Hydraulic Fracturing Engines – Hourly emission rates are calculated by extracting from the emission inventory. Hourly emission rates are then halved under the assumption fracturing engines will operate at 50% load for sixteen hours instead of 100% load for eight hours for 120 days per year. Annual emission rates are then calculated by smearing hourly emissions over the entire year based on a sixteen hour work day. Hourly emission factors are then applied to annual emissions to allocated emissions during operational hours (5 am – 9 pm). Hourly emission factors are calculated in consideration of two concurrent drill rigs active at BT1 during Pre-Drill.

Well Flowback and Flaring – Hourly and annual emissions are calculated using the general approach outlined above and two drill rigs are active at BT1 during Pre-Drill.

Criteria Pollutant Impacts

Table 3.3-3 shows the modeled impacts to air quality everywhere in the model domain and Table 3.3-4 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from drill site flaring are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.3-3 and Table 3.3-4 is minimal.

Table 3.3-3 BT1 Pre-Drill Activity AAQS Impacts – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	AAAQS ($\mu g/m^3$)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,483.3	10,300.5	11,783.8	40,000	40,000	29%	29%
	8-Hour	1,103.9	3,433.5	4,537.4	10,000	10,000	45%	45%
NO_2	1-Hour	64.3	26.7	91.0	188	188	48%	48%
	Annual	10.8	3.8	14.6	100	100	15%	15%
SO_2	1-Hour	4.2	9.0	13.1	196	196	7%	7%
	3-Hour	3.6	10.0	13.6	1,300	1,300	1%	1%
	24-Hour	2.0	9.3	11.4	--	365	--	3%
	Annual	0.2	1.8	2.0	--	80	--	3%
PM_{10}	24-Hour	16.7	20.0	36.7	150	150	24%	24%
$PM_{2.5}$	24-Hour	10.0	7.0	17.0	35	35	49%	49%
	Annual	2.0	1.6	3.6	12	12	30%	30%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 $\mu g/m^3$ - 24-hour and 0.05 $\mu g/m^3$ - annual) from CAMx modeling.

Table 3.3-4 BT1 Pre-Drill Activity AAQS Impacts at Nuiqsut – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	26.1	10,300.5	10,326.6	40,000	40,000	26%	26%
	8-Hour	3.4	3,433.5	3,436.9	10,000	10,000	34%	34%
NO_2	1-Hour	3.3	27.9	31.2	188	188	17%	17%
	Annual	0.02	3.8	3.8	100	100	4%	4%
SO_2	1-Hour	0.07	9.0	9.1	196	196	5%	5%
	3-Hour	0.04	10.0	10.1	1,300	1,300	1%	1%
	24-Hour	0.006	9.3	9.3	--	365	--	3%
	Annual	1.4E-04	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	0.51	10	11	150	150	7%	7%
$PM_{2.5}$	24-Hour	0.49	7.0	7.5	35	35	21%	21%
	Annual	0.05	1.6	1.6	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

3.3.4 BT1 and BT2 Pre-Drill

Pre-drilling at BT1 and BT2 pads is similar to the pre-drilling activities planned for BT1.

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emission rates for all modeled sources are provided in Attachment A.

Mobile Tailpipe Emissions - Hourly and annual emission rates are calculated by extracting the running emission factors. Running emission factors are then multiplied by annual mileage travelled for each vehicle type to get the total running emissions per year. Emissions are then converted into g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. Running emission rates are summed across all vehicle types for their respective modeling area and split into nine (9) equal volume sources at BT1 and six (6) at BT2.

Mobile Equipment Fugitive Dust – Hourly and annul emission rates are calculated by extracting the fugitive dust emission factors for each vehicle type. Fugitive dust emission factors are then multiplied annual vehicle miles travelled to get total fugitive dust emissions per year and converted to g/s by assuming operation through all hours of the operating months. Hourly and annual emission rates are then scaled within their respective modeling area by applying the ratio of the one-way trip mileage within in the modeling domain to the total mileage per one-way trip. Mobile fugitive dust emissions are then split into volume sources equivalent to mobile tailpipe.

Snowmelters and Portable Heaters – Hourly and annual emissions are calculated using the general approach outlined above. Emissions are then summed and treated as a single volume source. Monthly emission factors are then applied. No operation is assumed during summer months (June-August).

Hydraulic Fracturing Engines – Hourly emission rates are calculated by extracting from the emission inventory. Hourly emission rates are then halved under the assumption fracturing engines will operate at 50% load for sixteen hours instead of 100% load for eight hours for 120 days per year. Annual emission rates are then calculated by smearing hourly emissions over the entire year based on a sixteen-hour day. Hourly emission factors are then applied to annual emissions to allocated emissions during operational hours (5 am – 9 pm).

Criteria Pollutant Impacts

Table 3.3-5 shows the modeled impacts to air quality everywhere in the model domain and Table 3.3-6 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from flaring are included in the modeling analysis and the contribution from drill site flare emissions to the maximum concentrations shown in Table 3.3-5 and Table 3.3-6 is minimal.

Table 3.3-5 BT1 and BT2 Pre-Drill Activity AAQS Impacts – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	833.2	10,300.5	11,133.8	40,000	40,000	28%	28%
	8-Hour	641.0	3,433.5	4,074.5	10,000	10,000	41%	41%
NO_2	1-Hour	55.8	26.6	82.4	188	188	44%	44%
	Annual	6.7	3.8	10.4	100	100	10%	10%
SO_2	1-Hour	3.1	9.0	12.1	196	196	6%	6%
	3-Hour	2.8	10.0	12.8	1,300	1,300	1%	1%
	24-Hour	1.3	9.3	10.6	--	365	--	3%
	Annual	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	17.1	40.0	57.1	150	150	38%	38%
$PM_{2.5}$	24-Hour	7.5	7.0	14.5	35	35	41%	41%
	Annual	0.9	1.6	2.5	12	12	21%	21%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:

NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m^3 - 24-hour and 0.05 μg/m^3 - annual) from CAMx modeling.

Table 3.3-6 BT1 and BT2 Pre-Drill Activity AAQS Impacts at Nuiqsut – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m^3)	Background Concentration (μg/m^3)	Total Concentration (μg/m^3)	NAAQS (μg/m^3)	AAAQS (μg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	17.7	10,300.5	10,318.2	40,000	40,000	26%	26%
	8-Hour	3.7	3,433.5	3,437.2	10,000	10,000	34%	34%
NO_2	1-Hour	2.4	18.9	21.4	188	188	11%	11%
	Annual	0.02	3.8	3.8	100	100	4%	4%
SO_2	1-Hour	0.05	9.0	9.0	196	196	5%	5%
	3-Hour	0.03	10.0	10.1	1,300	1,300	1%	1%
	24-Hour	0.006	9.3	9.3	--	365	--	3%
	Annual	0.0001	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	0.50	10.0	10.5	150	150	7%	7%
$PM_{2.5}$	24-Hour	0.49	7.0	7.5	35	35	21%	21%
	Annual	0.05	1.6	1.6	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m^3 - 24-hour and 0.05 μg/m^3 - annual) from CAMx modeling.

3.3.5 Development Drilling

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emission rates for all modeled sources are provided in Attachment A. The emissions development methods for Development Drilling drill rigs and hydraulic fracturing activities follows an approach identical to that described for BT1 Pre-Drilling in Section 3.3.3.2 "Emissions Calculations". The underlying emission rates are different from the BT1 Pre-Drilling (as shown via a comparison of emission rates provided in Attachment A); however, the methodology is identical.

Hydraulic Fracturing Engines – Hourly and annual emissions for hydraulic fracturing engines are zero due to highline power being used rather than diesel engines.

Similarly, the emissions development methods for the operational activities included in Development Drilling are identical to Routine Operations in Section 3.3.6.2 "Emissions Calculations". Construction emissions from facility installation activities at BT2 and BT3 are also included in this scenario. Sources associated with facility installation activities included heaters, shop heaters, generator sets, non-road equipment, B-70s, and fugitive dust at BT2 and BT3.

Criteria Pollutant Impacts

Table 3.3-7 shows the modeled impacts to air quality everywhere in the model domain and Table 3.3-8 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from drill site flaring and routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.3-7 and Table 3.3-8 is minimal.

Table 3.3-7 Development Drilling Activity AAQS Impacts– Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m^3)	Background Concentration (μg/m^3)	Total Concentration (μg/m^3)	NAAQS (μg/m^3)	AAAQS (μg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,389.5	10,300.5	11,690.0	40,000	40,000	29%	29%
	8-Hour	921.7	3,433.5	4,355.2	10,000	10,000	44%	44%
NO_2	1-Hour	138.5	20.4	158.9	188	188	85%	85%
	Annual	24.9	3.8	28.7	100	100	29%	29%
SO_2	1-Hour	17.9	9.0	26.9	196	196	14%	14%
	3-Hour	16.6	10.0	26.6	1,300	1,300	2%	2%
	24-Hour	10.2	9.3	19.5	--	365	--	5%
	Annual	0.8	1.8	2.7	--	80	--	3%
PM_{10}	24-Hour	65.7	30.0	95.7	150	150	64%	64%
$PM_{2.5}$	24-Hour	22.6	7.0	29.6	35	35	85%	85%
	Annual	4.2	1.6	5.8	12	12	49%	49%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m^3 - 24-hour and 0.05 μg/m^3 - annual) from CAMx modeling.

Table 3.3-8 Development Drilling Activity AAQS Impacts at Nuiqsut – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	30.4	10,300.5	10,330.9	40,000	40,000	26%	26%
	8-Hour	9.4	3,433.5	3,442.9	10,000	10,000	34%	34%
NO_2	1-Hour	19.0	24.7	43.7	188	188	23%	23%
	Annual	0.18	3.8	3.9	100	100	4%	4%
SO_2	1-Hour	0.86	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.008	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.4	50.0	51.4	150	150	34%	34%
$PM_{2.5}$	24-Hour	0.63	7.0	7.6	35	35	22%	22%
	Annual	0.07	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

3.3.6 <u>Routine Operations</u>

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emission Calculations

Emission rates for all modeled sources are provided in Attachment A.

<u>Gravel Pad Routine Operations Non-Mobile Support Equipment</u> – Individual emission rates are extracted from the emissions inventory and converted to g/s. A category-wide emission rate is then calculated by summing the individual nonroad equipment hourly emission rates in its respective category. A category-wide annual emission rate is then quantified using the hourly emission rate and assuming equipment operates continuously across all hours of operating months. Emissions are allocated within each modeling domain by dividing hourly and annual emission rates by the acreage of the modeling domain.

<u>Gravel Pad Well Intervention Non-Mobile Support Equipment</u> – see *Gravel Pad Routine Operations Non-Mobile Support*, above, for calculation method. A minor difference relative to the Gravel Pad Routine

Operations Non-Mobile Support is that total engine emissions are not included in summation and treated as separate point sources.

WOC Internal Combustion Equipment, Nonroad Engines – *see Gravel Pad Routine Operations Non-Mobile Support for calculation method.* Equipment defined as internal combustion equipment includes pumps, light plants, snowmelter boilers, and other engines.

WOC Portable External Combustion Equipment – *see Gravel Pad Routine Operations Non-Mobile Support for calculation method.* Equipment defined as portable external combustion equipment includes heaters, heater engine fans, and snowmelter engines.

WOC Stationary External Combustion Equipment – *see Gravel Pad Routine Operations Non-Mobile Support for calculation method.* Equipment defined as stationary external combustion equipment include non-portable natural gas heaters.

Mobile Tailpipe Emissions – See mobile tailpipe emissions in section 3.3.3.2. Additional emission volumes sources are added to WOC and adjacent airstrip road.

Mobile Equipment Fugitive Dust - See mobile equipment fugitive dust in section 3.3.3.2. Additional emission volumes sources are added to WOC and adjacent airstrip road.

WPF Injection and Power Generation Turbines - Hourly and annual emission rates are initially calculated using the general approach outlined above. Extracted emissions rates are taken as an annual average so monthly emission factors are applied to hourly and annual emission rates to account for fluctuations in emission rates. Monthly fluctuations in emission rates are caused by variations in ambient temperatures affecting the air density which affects fuel capacity into the turbine at full load.

WPF Internal Combustion Equipment, Small Nonroad Engines - Individual emission rates are extracted from the emissions inventory and converted to g/s. Equipment defined as small nonroad engines include pumps, compressors, light plants, pressure washers, and other engines under 140 horsepower. A category-wide emission rate is then calculated by summing the individual nonroad equipment hourly emission rates in its respective category. A category-wide annual emission rate is then quantified using the hourly emission rate and assuming equipment operates continuously across all hours of operating months. Emissions are split into seven equal area sources and divided by the acreage of the modeling domain.

WPF Portable External Combustion Equipment – See *WPF Internal Combustion Equipment, Small Nonroad Engines* for calculation method. Equipment defined as portable external combustion equipment includes heaters, heater engine fans, and aircraft de-icers.

WPF Stationary External Combustion Equipment – *See WPF Internal Combustion Equipment, Small Nonroad Engines* for calculation method. Equipment defined as stationary external combustion equipment include non-portable natural gas heaters.

WPF Low Pressure and High Pressure Flaring – Hourly and annual emissions are calculated for normal (pilot/purge/assist) operation 8760 hours per year and for upset (maximum flow) operation 10 hours per year.

Willow Airstrip Aircraft Activity – Hourly and annual emission rates are calculated by extracting takeoff and landing emission factors for each aircraft type. Emission factors for each aircraft type are then multiplied by the number of flights for each aircraft type in the Year 13. Since each flight constitutes one takeoff and one landing, the takeoff and landing emission rates are summed across their respective aircraft type. Total aircraft emission rates are then calculated by summing across the aircraft types and converted to g/s. The total emission rates are split into three separate areas, based on release height, and divided by the respective airstrip area.

Structure Locations and Building Downwash

See Attachment A for figures depicting the structure locations relative to emissions sources.

Criteria Pollutant Impacts

Table 3.3-9 shows the modeled impacts to air quality everywhere in the domain (the analysis area) while Table 3.3-10 shows the modeled impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods.

Table 3.3-11 provides the modeled impacts at Nuiqsut for comparison to PSD Class II increments. Impacts at Nuiqsut are below applicable PSD increments for all pollutants and averaging times. It is important to note that a PSD increment assessment is the jurisdiction of ADEC and the proposed analysis differs from a formal increment consumption assessment in several important ways. See Section 1.2.3.2 for more information. With regards to the $PM_{2.5}$ analysis shown here and for the other alternatives, the secondary $PM_{2.5}$ concentration from CAMx (see footnote of Table 3.3-10) was added to the AERMOD primary $PM_{2.5}$ modeled concentration prior to comparison with the AAQS. Thus, the $PM_{2.5}$ concentration would be affected by potential biases in the secondary nitrate and sulfate. Also note that impacts from routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.3-9, Table 3.3-10 and Table 3.3-11 is minimal.

Table 3.3-9 Routine Operations AAQS Impacts – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,389.5	10,300.5	11,690.0	40,000	40,000	29%	29%
	8-Hour	921.7	3,433.5	4,355.2	10,000	10,000	44%	44%
NO_2	1-Hour	138.5	20.4	158.9	188	188	85%	85%
	Annual	24.9	3.8	28.6	100	100	29%	29%
SO_2	1-Hour	17.9	9.0	26.9	196	196	14%	14%
	3-Hour	16.6	10.0	26.6	1,300	1,300	2%	2%
	24-Hour	10.2	9.3	19.5	--	365	--	5%
	Annual	0.8	1.8	2.7	--	80	--	3%
PM_{10}	24-Hour	65.6	30.0	95.6	150	150	64%	64%

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
$PM_{2.5}$	24-Hour	22.6	7.0	29.6	35	35	85%	85%
	Annual	4.2	1.6	5.8	12	12	49%	49%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

Table 3.3-10 Routine Operations AAQS Impacts at Nuiqsut – Alternative B (Proponent's Project)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	29.7	10,300.5	10,330.2	40,000	40,000	26%	26%
	8-Hour	9.6	3,433.5	3,443.1	10,000	10,000	34%	34%
NO_2	1-Hour	18.9	24.7	43.6	188	188	23%	23%
	Annual	0.16	3.8	3.9	100	100	4%	4%
SO_2	1-Hour	0.86	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.01	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.42	50.0	51.4	150	150	34%	34%
$PM_{2.5}$	24-Hour	0.63	7.0	7.6	35	35	22%	22%
	Annual	0.06	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

Table 3.3-11 Routine Operation Activity PSD Increment Impacts at Nuiqsut – Alternative B (Proponent's Project)

Pollutant	Average Time [a]	Modeled Concentration[b] (μg/m³)	Class II PSD Increment (μg/m³)

NO_2	Annual	0.16	25
SO_2	3-hour	0.51	512
	24-hour	0.14	91
	Annual	0.01	20
PM_{10}	24-hour	1.49	30
	Annual	0.11	17
$PM_{2.5}$	24-hour	0.81	9
	Annual	0.06	4

Notes:
[a] For comparison to annual PSD increments, the maximum annual arithmetic mean value from any of 5-years of modeled impacts were used. For comparison to short-term (3- and 24-hour) PSD increments, the maximum 2nd high value from any of 5-years of modeled.
[b] PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m^3 - 24-hour and 0.05 µg/m^3 - annual) from CAMx modeling.

*HAPs Impacts**

For comparison to RELs and RfCs, toxic modeling was conducted and evaluated for the 6 HAPs shown in

Table 3.3-12. The evaluations against the RELs and RfCs were done using the HAP emission rates documented in Attachment A. Cancer risk was evaluated for the Nuiqsut community using the procedures discussed in Chapter 1. As shown in Table 3.3-10, the concentrations of all HAPs everywhere in the analysis area are well below their respective RELs on an hourly period, and RfCs on an annual period. As shown in Table 3.3-13, the estimated cancer risk due to the Project is much less than the threshold of one in one million (1.0e-06) at Nuiqsut. Note that the HAPs considered for this analysis only include those most commonly emitted from oil and gas development (benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde) and that the Total HAPs reported in Table 3.3-13 are the sum of only a subset of HAPs. Also note that impacts from flaring during routine operations are included in the maximum HAP impacts in the analysis area (Table 3.3-12) and in the estimated cancer risk at Nuiqsut (Table 3.3-13) and the contribution from flare emissions to the maximum HAP concentrations shown is minimal.

Table 3.3.3 in the main body of the Supplemental DEIS presents HAPs concentrations measured at Nuiqsut monitoring station starting in 2014 through March 2021. As shown in Table 3.3.3, measured HAPs concentrations are well below Acute REL and AEGLs. HAP measurements at Nuiqsut frequently have been below the measurement detection limit which indicates that HAP concentrations in ambient air are typically low. Note that some of health thresholds used for this assessment have become more stringent.

Table 3.3-12 Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts – Alternative B (Proponent's Project)

Pollutant	Max 1-hour in analysis area (µg/m^3)	Acute REL (µg/m^3)	Max 8-hour in analysis area (µg/m^3)	AEGLs (µg/m^3)	Max Annual in analysis area (µg/m^3)	RfC (µg/m^3)
Benzene	8.8	27.0	6.0	29,000.0	0.2	30.0
Ethylbenzene	230.7	140,000.0	155.4	140,000.0	5.0	260.0

Formaldehyde	1.4	55.0	0.8	1,100.0	0.0	9.8
n-hexane	562.9	10,000,000.0	379.1	10,000,000.0	12.1	700.0
Toluene	25.7	5,000.0	17.3	250,000.0	0.6	5,000.0
Xylene	454.5	22,000.0	306.2	560,000.0	9.8	100.0

Notes:
[1] No REL available for these air toxics. Values shown are Acute Exposure Guideline Levels for mild effects (AELG-1) (ethyl benzene) and moderate effects (AEGL-2) (n-hexane).

Table 3.3-13 Routine Operation Activity Carcinogenic HAPs Impacts – Alternative B)

Pollutant	Max Annual (µg/m^3)	Cancer Unit Risk Factor thresholds (1/(µg/m^3))	Exposure Adjustment Factor	Cancer Risks
Benzene	9.70E-04	7.80E-06	4.30E-01	3.25E-09
Ethylbenzene	3.97E-03	2.50E-06		4.27E-09
Formaldehyde	3.70E-04	1.30E-05		2.07E-09
			Total Cancer Risk:	9.6.E-09

3.4 Alternative C (Disconnected Infield Roads)

This section describes the selection of scenarios designed to characterize the potential impacts anticipated under Alternative C, the modeled receptors, source types, emissions, and resulting impacts.

3.4.1 Overview of Scenarios

Based on Alternative C emissions activities, source types, and development phases, five scenarios are analyzed:

1. Construction
2. Pre-drilling activities at BT1
3. Pre-drilling activities at BT1 and BT2
4. Development drilling
5. Routine Operations

As in the case of Alternative B, all scenarios consider emission of criteria pollutants, HAPs and GHGs. As shown in Section 2.1 “Willow Alternatives Emissions Inventories”, HAPs from construction and drilling activities are substantially lower than routine operations. Therefore, HAP impacts are explicitly modeled for Routine Operations and HAP impacts from all other scenarios would be lower than Routine Operations.

Modeled sources include point source emissions, area sources, and volume sources. Equipment modeled as point sources include stationary sources, such as engines and heaters, as well as large portable equipment and nonroad engines. Groupings of similar low-level equipment were generally aggregated as area sources. Fugitive dust and mobile sources tailpipe emissions were modeled as volume sources. For example, the gravel access road was modeled as a series of volume sources to represent dust or tailpipe emissions from vehicle traffic. Point source stack parameters were provided by CPAI for most stationary sources, for those sources without stack parameter information, stack parameters are selected to be consistent with stack parameters used for modeling GMT2 or other public information. For area and volume sources release heights, initial vertical dimensions, and initial horizontal dimensions were based on the equipment as well as Table 3-2 from the AERMOD User's Guide (USEPA, 2019).

See Attachment A for detailed information about the sources included in each scenario. All sources modeled for each scenario are shown in figures in Attachment A depicting the layout of the sources relative to ambient air boundaries, structures, roads, and other Project features. In addition, Attachment A includes detailed tables that provide a description of each modeled source, source emissions rates for all modeled pollutants and averaging periods, in-stack NO_2-to-NOx ratio, modeled location, and stack parameters.

Construction

The construction of Willow MDP is similar to Alternative B except that due to the disconnected access of the northern portion of the Project area from the southern portion Alternative C includes construction of additional operational facilities, including a WOC North and WOC South (which consists of the same functions as the WOC in Alternatives B and D), and a northern airstrip in addition to the southern airstrip included in Alternatives B and D.

BT1 Pre-drilling

Alternative C BT1 pre-drilling phase is identical to Alternative B with the exception of the number of mobile tailpipe and mobile fugitive dust volume sources due to change in modeled road length along BT1.

BT1 and BT2 Pre-drilling

Alternative C BT1 and BT2 pre-drilling phase identical to Alternative B BT1 and BT2 Pre-drill with the exception that BT2 has a larger pad size for Alternative C than Alternative B, so the impacts for Alternative C BT1 and BT2 Pre-Drill are explicitly modeled. This scenario is similar to BT1 Pre-drilling with the exception that the drill rig and hydraulic fracturing equipment are active at both BT1 and BT2 pads.
Development Drilling

The development drilling under Alternative C would consist of drilling on highline power at BT2 and BT3 and would be identical to development drilling for Alternative B except for the drill sites and infrastructure differences.

Routine operation and production of wells

Routine operations under Alternative C would be similar to the types of sources modeled in Alternative B except that due to the disconnected infield access, additional facilities operate, including WOC North and WOC South (which has the same functions as the WOC in Alternatives B and D), and a northern airstrip in addition to the southern airstrip included in Alternatives B and D. Just like Alternative B, in order to assess expected cumulative long-term impacts, the Alternative C Routine Operation scenario explicitly modeled emissions from other projects anticipated to be developed within the near-field of the Willow MDP Project, as shown in Table 2.2-2.

3.4.2 Construction

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions calculations were identical to Alternative B Construction except for the 1) exclusion of BT2 pad construction; 2) relocation of sources from WOC to WOC North and WOC South; 3) select sources from Alternative B Routine Operations that did not operate during construction, would operate during construction for Alternative C; and 4) there would be increased road lengths due to road alignments along the pads. Specifically,

1. BT3 Pad Construction Nonroad Equipment is included in the Alternative C Construction scenario while BT1 and BT2 Pad Construction Nonroad Equipment is not because for Alternative C, BT3 Pad Construction occurs during the model year, 2024, and BT1 Pad Construction occurs during 2023 and BT2 Pad Construction occurs during 2025. Emissions calculations for BT3 Pad Construction Nonroad Equipment are identical to those described for BT3 Pad Construction Nonroad Equipment in Section 3.3.2.2 ”Emissions Calculations”.
2. Alternative C involves the construction of WOC North and WOC South rather than one WOC. Sources located at the WOC in Alternative B, including sources related to facilities installation nonroad equipment, power generation, pipeline installation, vertical member support construction, drill rigs, drilling non-mobile support equipment, aircraft activity, mobile tailpipe emissions, ice road construction, mobile equipment fugitive dust, and wind erosion fugitive dust, are re-located to WOC North and WOC South. Emissions calculation methods are identical to those described in section 3.3.2.2 except emissions for wind erosion fugitive dust at WOC South are scaled by the respective pad sizes at WOC North and WOC South to obtain emissions for wind erosion fugitive dust at WOC North. Additionally, sources related to fiber optics installation are located at the WPF for Alternative B Construction. For Alternative C, these sources occur at WOC North and WOC South rather than the WPF. The emissions associated with fiber optics installation are split in half and then allocated to WOC North and WOC South because the total emissions remain the same despite the installation occurring at two different locations. Additionally, sources associated with disposal well drilling at the WOC North including drill rigs engines, boilers, heaters, and drilling nonmobile support equipment were added and emissions rates were calculated using the general approach.
3. Certain sources only included in Routine Operations for Alternative B, including WOC internal Combustion Equipment - Nonroad Engines, WOC Portable External Combustion Equipment, WOC Stationary External Combustion Equipment, and two incinerators, are included in the Alternative C Construction scenario. Description of emission calculations for these sources is in Section 3.3.6.2 “Emission Calculations”.
4. For Alternative B Construction, Pipeline Installation, Vertical Member Support Construction, Fiber Optics Installation, and WPF Mobile Equipment are split into various volume sources. For Alternative C, these sources are split into differing equivalent volume sources due to the change

in the road lengths and alignment relative to the gravel pads. See figures of sources in Attachment A for a visual depiction.

Description of emissions calculations for all other sources is included in Section 3.3.2.2 “Emission Calculations”.

Criteria Pollutant Impacts

Table 3.4-1 shows the modeled impacts to air quality everywhere in the model domain and Table 3.4-2 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods everywhere in the model domain and, in particular, at Nuiqsut.

Table 3.4-1 Construction Activity AAQS Impacts – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	643.2	10,300.5	10,943.8	40,000	40,000	27%	27%
	8-Hour	488.1	3,433.5	3,921.6	10,000	10,000	39%	39%
NO_2	1-Hour	136.0	13.4	149.4	188	188	79%	79%
	Annual	35.4	3.8	39.1	100	100	39%	39%
SO_2	1-Hour	4.3	9.0	13.3	196	196	7%	7%
	3-Hour	5.2	10.0	15.2	1,300	1,300	1%	1%
	24-Hour	1.3	9.3	10.6	--	365	--	3%
	Annual	0.2	1.8	2.1	--	80	--	3%
PM_{10}	24-Hour	90.4	20.0	110.4	150	150	74%	74%
$PM_{2.5}$	24-Hour	16.7	7.0	23.7	35	35	68%	68%
	Annual	5.4	1.6	7.0	12	12	59%	59%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-2 Construction Activity AAQS Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	45.1	10,300.5	10,345.6	40,000	40,000	26%	26%
	8-Hour	15.1	3,433.5	3,448.6	10,000	10000	34%	34%
NO_2	1-Hour	31.9	22.0	54.0	188	188	29%	29%
	Annual	0.49	3.8	4.2	100	100	4%	4%
SO_2	1-Hour	0.83	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.12	9.3	9.4	--	365	--	3%
	Annual	0.003	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.0	50.0	51.0	150	150	34%	34%
$PM_{2.5}$	24-Hour	0.75	7.0	7.8	35	35	22%	22%
	Annual	0.07	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

3.4.3 BT1 Pre-Drill

Alternative C BT1 pre-drilling phase is similar to Alternative B

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions calculations procedures were identical to Alternative B. See Attachment A for the emissions rates.

Criteria Pollutant Impacts

Table 3.4-3 shows the modeled impacts to air quality everywhere in the model domain and Table 3.4-4 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from flaring are included in the modeling analysis and the contribution from drill site flare emissions to the maximum concentrations shown in Table 3.4-3 and Table 3.4-4 is minimal.

Table 3.4-3 BT1 Pre-Drill Activity AAQS Impacts – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,471.5	10,300.5	11,772.0	40,000	40,000	29%	29%
	8-Hour	1,128.2	3,433.5	4,561.7	10,000	10,000	46%	46%
NO_2	1-Hour	65.7	23.9	89.6	188	188	48%	48%
	Annual	12.7	3.8	16.5	100	100	16%	16%
SO_2	1-Hour	4.2	9.0	13.2	196	196	7%	7%
	3-Hour	4.1	10.0	14.2	1,300	1,300	1%	1%
	24-Hour	2.2	9.3	11.5	--	365	--	3%
	Annual	0.2	1.8	2.1	--	80	--	3%
PM_{10}	24-Hour	18.0	10.0	28.0	150	150	19%	19%
$PM_{2.5}$	24-Hour	11.4	7.0	18.4	35	35	53%	53%
	Annual	2.3	1.6	3.9	12	12	32%	32%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-4 BT1 Pre-Drill Activity AAQS Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	26.1	10,300.5	10,326.6	40,000	40,000	26%	26%
	8-Hour	3.4	3,433.5	3,436.9	10,000	10,000	34%	34%
NO_2	1-Hour	3.3	27.9	31.2	188	188	17%	17%
	Annual	0.02	3.8	3.8	100	100	4%	4%
SO_2	1-Hour	0.07	9.0	9.1	196	196	5%	5%
	3-Hour	0.04	10.0	10.1	1,300	1,300	1%	1%
	24-Hour	0.006	9.3	9.3	--	365	--	3%
	Annual	0.0001	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	0.51	10.0	10.5	150	150	7%	7%
$PM_{2.5}$	24-Hour	0.49	7.0	7.5	35	35	21%	21%
	Annual	0.05	1.6	1.6	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

3.4.4 BT1 and BT2 Pre-Drill

Alternative C BT1 and BT2 pre-drilling phase is similar to Alternative B.

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions calculations procedures were identical to Alternative B. See Attachment A for emissions rates.

Criteria Pollutant Impacts

Table 3.4-5 shows the modeled impacts to air quality everywhere in the model domain and Table 3.4-6 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from flaring are included in the modeling analysis and the contribution from drill site flare emissions to the maximum concentrations shown in Table 3.4-5 and Table 3.4-6 is minimal.

Table 3.4-5 BT1 and BT2 Pre-Drill Activity AAQS Impacts – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	826.4	10,300.5	11,126.9	40,000	40,000	28%	28%
	8-Hour	635.7	3,433.5	4,069.2	10,000	10,000	41%	41%
NO_2	1-Hour	57.6	15.6	73.2	188	188	39%	39%
	Annual	12.6	3.8	16.3	100	100	16%	16%
SO_2	1-Hour	4.2	9.0	13.1	196	196	7%	7%
	3-Hour	4.1	10.0	14.1	1,300	1,300	1%	1%
	24-Hour	1.8	9.3	11.1	--	365	--	3%
	Annual	0.2	1.8	2.0	--	80	--	3%
PM_{10}	24-Hour	17.9	10.0	27.9	150	150	19%	19%
$PM_{2.5}$	24-Hour	11.4	7.0	18.4	35	35	53%	53%
	Annual	2.3	1.6	3.9	12	12	32%	32%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-6 BT1 and BT2 Pre-Drill Activity AAQS Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	21.8	10,300.5	10,322.3	40,000	40,000	26%	26%
	8-Hour	3.4	3,433.5	3,436.9	10,000	10,000	34%	34%
NO_2	1-Hour	3.0	22.4	0,025.3	188	188	13%	13%
	Annual	0.02	3.8	3.8	100	100	4%	4%
SO_2	1-Hour	0.05	9.0	9.0	196	196	5%	5%
	3-Hour	0.03	10.0	10.1	1,300	1,300	1%	1%
	24-Hour	0.006	9.3	9.3	--	365	--	3%
	Annual	1.4E-04	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	0.51	10.0	10.5	150	150	7%	7%
$PM_{2.5}$	24-Hour	0.49	7.0	7.5	35	35	21%	21%
	Annual	0.05	1.6	1.6	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

3.4.5 Development Drilling

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions calculations procedures were identical to Alternative B. See Attachment A for emissions rates.

Criteria Pollutant Impacts

Table 3.4-7 shows the modeled impacts to air quality everywhere in the model domain and Table 3.4-8 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from drill site flaring and routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.4-7 and Table 3.4-8 is minimal.

Table 3.4-7 Developmental Drilling Activity AAQS Impacts – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1308.0	10,300.5	11,608.5	40,000	40,000	29%	29%
	8-Hour	930.9	3,433.5	4,364.4	10,000	10,000	44%	44%
NO_2	1-Hour	147.6	25.1	172.7	188	188	92%	92%
	Annual	24.1	3.8	27.8	100	100	28%	28%
SO_2	1-Hour	19.3	9.0	28.2	196	196	14%	14%
	3-Hour	16.9	10.0	26.9	1,300	1,300	2%	2%
	24-Hour	10.4	9.3	19.8	--	365	--	5%
	Annual	0.9	1.8	2.8	--	80	--	3%
PM_{10}	24-Hour	91.4	30.0	121.4	150	150	81%	81%
$PM_{2.5}$	24-Hour	19.0	7.0	26.0	35	35	74%	74%
	Annual	5.0	1.6	6.6	12	12	55%	55%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-8 Development Drilling Activity AAQS Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m^3)	Background Concentration (µg/m^3)	Total Concentration (µg/m^3)	NAAQS (µg/m^3)	AAAQS (µg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	36	10,300.5	10,336.4	40,000	40,000	26%	26%
	8-Hour	12.6	3,433.5	3,446.1	10,000	10,000	34%	34%
NO_2	1-Hour	19.9	19.5	39.3	188	188	21%	21%
	Annual	0.19	3.8	4.0	100	100	4%	4%
SO_2	1-Hour	0.86	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.008	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.5	10.0	11.5	150	150	8%	8%
$PM_{2.5}$	24-Hour	0.65	7.0	7.6	35	35	22%	22%
	Annual	0.07	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m^3 - 24-hour and 0.05 µg/m^3 - annual) from CAMx modeling.

3.4.6 Routine Operations

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions calculations were identical to Alternative B Construction except for 1) relocation of sources from WOC to WOC North and WOC South, and 2) increased road lengths due to road alignments along the pads. Specifically,

1. Alternative C involves operations at WOC North and WOC South rather than at one Operating Center. Sources located at the WOC in Alternative B, including sources related to gravel pad routine operations nonroad equipment, power generation, aircraft activity, mobile tailpipe emissions, mobile equipment fugitive dust, and wind erosion fugitive dust, are re-located to WOC North and WOC South. Emissions calculation methods are identical to those described in Section 3.3.2.2 "Emissions Calculations" except emissions for wind erosion fugitive dust at WOC South are scaled by the respective pad sizes at WOC North and WOC South to obtain emissions for wind erosion fugitive dust at WOC North.

2. For Alternative C, mobile tailpipe emissions and mobile fugitive dust emissions at WPF, WOC North, and WOC South are split into a number of equivalent volume sources differing from Alternative B due to increased road segment associated with the road alignment along gravel pads. See Attachment A for a visual depiction.

Description of emissions calculations for all other sources is included in Section 3.3.2.2 "Emissions Calculations".

Structure Locations and Building Downwash

See Attachment A for figures depicting the structure locations relative to emissions sources.

Criteria Pollutant Impacts

Table 3.4-9 shows the modeled impacts to air quality everywhere in the model domain. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. All pollutants are below the applicable AAQS. Table 3.4-10 shows the modeled impacts at Nuiqsut for comparisons to applicable AAQS and Table 3.4-11 provides the impacts at Nuiqsut for comparison to applicable PSD Class II increments. Impacts at Nuiqsut are below AAQS and PSD increments for all pollutants and averaging times. It is important to note that a PSD increment assessment is the jurisdiction of ADEC and the proposed analysis differs from a formal increment consumption assessment in several important ways. See Section 1.2.3.2 for more information. Also note that impacts from routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.4-9, Table 3.4-10 and Table 3.4-11 is minimal.

Table 3.4-9 Routine Operation AAQS Impacts – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,308.0	10,300.5	11,608.5	40,000	40,000	29%	29%
	8-Hour	930.9	3,433.5	4,364.4	10,000	10,000	44%	44%
NO_2	1-Hour	147.6	25.1	172.7	188	188	92%	92%
	Annual	24.0	3.8	27.8	100	100	28%	28%
SO_2	1-Hour	19.2	9.0	28.2	196	196	14%	14%
	3-Hour	16.9	10.0	26.9	1,300	1,300	2%	2%
	24-Hour	10.4	9.3	19.8	--	365	--	5%
	Annual	0.9	1.8	2.8	--	80	--	3%
PM_{10}	24-Hour	77.8	40.0	117.8	150	150	79%	79%
$PM_{2.5}$	24-Hour	19.0	7.0	26.0	35	35	74%	74%
	Annual	5.0	1.6	6.6	12	12	55%	55%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-10 Routine Operations AAQS Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	33.6	10,300.5	10,334.1	40,000	40,000	26%	26%
	8-Hour	11.4	3,433.5	3,444.9	10,000	10,000	34%	34%
NO_2	1-Hour	19.9	19.5	39.3	188	188	21%	21%
	Annual	0.17	3.8	3.9	100	100	4%	4%
SO_2	1-Hour	0.86	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.01	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.45	10.0	11.5	150	150	8%	8%
$PM_{2.5}$	24-Hour	0.64	7.0	7.6	35	35	22%	22%
	Annual	0.07	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.4-11 Routine Operation Activity PSD Increment Impacts at Nuiqsut – Alternative C (Disconnected Infield Roads)

Pollutant	Average Time [a]	Modeled Concentration[b] (µg/m³)	Class II PSD Increment (µg/m³)
NO_2	Annual	0.17	25
SO_2	3-hour	0.51	512
	24-hour	0.14	91
	Annual	0.01	20
PM_{10}	24-hour	1.56	30
	Annual	0.11	17
$PM_{2.5}$	24-hour	0.88	9
	Annual	0.07	4

Notes:
[a] For comparison to annual PSD increments, the maximum annual arithmetic mean value from any of 5-years of modeled impacts were used. For comparison to short-term (3- and 24-hour) PSD increments, the maximum 2nd high value from any of 5-years of modeled.
[b] PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

*HAPs Impacts**

For comparison to RELs and RfCs, toxic modeling was conducted and evaluated for the six HAPs shown in Table 3.4-12. The evaluations against the RELs and RfCs were done using the HAP emission rates documented in Attachment A. Cancer risk was evaluated for the Nuiqsut community using the procedures discussed in Chapter 1. As shown in Table 3.4-12, the concentrations of all HAPs are well below their respective RELs on an hourly period, and RfCs on an annual period. As shown in Table 3.4-13, the estimated cancer risk is much less than the threshold of one in one million (1.0E-06) at Nuiqsut. Note that the HAPs considered for this analysis only include those most commonly emitted from oil and gas development (benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde) and that the Total HAPs reported in Table 3.4-13 are the sum of only a subset of HAPs. Also note that impacts from flaring during routine operations are included in the maximum HAP impacts in the analysis area (Table 3.4-12) and in the estimated cancer risk at Nuiqsut (Table 3.4-13) and the contribution from flare emissions to the maximum HAP concentrations shown is minimal.

Table 3.3.3 in the main body of the Supplemental DEIS presents HAPs concentrations measured at Nuiqsut monitoring station starting in 2014 through March 2021. As shown in Table 3.3.3, measured HAPs concentrations are well below Acute REL and AEGLs. HAP measurements at Nuiqsut frequently have been below the measurement detection limit which indicates that HAP concentrations in ambient air are typically low. Note that some of health thresholds used for this assessment have become more stringent.

Table 3.4-12 Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts – Alternative C (Disconnected Infield Roads)

Pollutant	Max 1-hour in analysis area (µg/m³)	Acute REL (µg/m³)	Max 8-hour in analysis area (µg/m³)	AEGLs (µg/m³)	Max Annual in analysis area (µg/m³)	RfC (µg/m³)
Benzene	8.7	27.0	5.9	29,000.0	0.2	30.0
Ethylbenzene	226.8	140,000.0	152.5	140,000.0	4.8	260.0
Formaldehyde	1.4	55.0	0.8	1,100.0	0.0	9.8
n-hexane	553.3	10,000,000.0	372.0	10,000,000.0	11.6	700.0
Toluene	25.3	5,000.0	17.0	250,000.0	0.5	5,000.0
Xylene	446.8	22,000.0	300.4	560,000.0	9.4	100.0

Notes:
[1] No REL available for these air toxics. Values shown are Acute Exposure Guideline Levels for mild effects (AELG-1) (ethyl benzene) and moderate effects (AEGL-2) (n-hexane).

Table 3.4-13 Routine Operation Activity Carcinogenic HAPs Impacts – Alternative C (Disconnected Infield Roads)

Pollutant	Max Annual (µg/m³)	Cancer Unit Risk Factor thresholds (1/(µg/m³))	Exposure Adjustment Factor	Cancer Risks
Benzene	1.03E-03	7.80E-06	4.30E-01	3.45E-09
Ethylbenzene	3.97E-03	2.50E-06		4.27E-09
Formaldehyde	3.80E-04	1.30E-05		2.12E-09
			Total Cancer Risk:	9.8.E-09

3.5 Alternative D (Disconnected Access)

This section describes the scenarios designed to characterize the potential impacts anticipated under Alternative D, the modeled receptors and source types, emissions, and resulting impacts.

3.5.1 Overview of Scenarios

Based on Alternative D emissions activities, source types, and development phases, five scenarios are analyzed:

1. Construction
2. Pre-drilling activities at BT1
3. Pre-drilling activities at BT1 and BT2
4. Development drilling
5. Routine Operations

All scenarios consider emission of criteria pollutants, HAPs and GHGs. As shown in Section 2.1 “Willow Alternatives Emissions Inventories”, HAPs from construction and drilling activities are substantially lower than routine operations. Therefore, HAP impacts are explicitly modeled for Routine Operations only; HAP impacts from all other scenarios would be lower than Routine Operations.

Modeled sources include point source emissions, area sources, and volume sources. Equipment modeled as point sources include stationary sources, such as engines and heaters, as well as large portable equipment and nonroad engines. Groupings of similar low-level equipment were generally aggregated as area sources. Fugitive dust and mobile sources tailpipe emissions were modeled as volume sources. For example, the gravel access road was modeled as a series of volume sources to represent dust or tailpipe emissions from vehicle traffic. Point source stack parameters were provided by CPAI for most stationary sources, for those sources without stack parameter information, stack parameters are selected to be consistent with stack parameters used for modeling GMT2 or other public information. For area and volume sources release heights, initial vertical dimensions, and initial horizontal dimensions were based on the equipment as well as Table 3-2 from the AERMOD User’s Guide (USEPA, 2019).

See Attachment A for detailed information about the sources included in each scenario. All sources modeled for each scenario are shown in figures in Attachment A depicting the layout of the sources relative to ambient air boundaries, structures, roads, and other Project features. In addition, Attachment A includes detailed tables that provide a description of each modeled source, source emissions rates for all modeled pollutants and averaging periods, in-stack NO_2-to-NOx ratio, modeled location, and stack parameters.

Construction

The construction of Willow MDP is similar to Alternative B except that due to the disconnected access the Alternative D construction phase takes longer to complete.

BT1 Pre-drilling

Alternative D BT1 pre-drilling phase is identical to Alternative B and so is not re-evaluated further. See Section 3.3.3 “BT1 Pre-Drill” for more information about BT1 Pre-drilling.

BT1 and BT2 Pre-drilling

Alternative D BT1 and BT2 pre-drilling phase is identical to Alternative B BT1 and BT2 pre-drilling and so is not re-evaluated further. See Section 3.3.4 “BT1 and BT2 Pre-Drill” for more information about BT1 and BT2 Pre-drilling.

Development Drilling

The development drilling under Alternative D is identical to Alternative B except that the WPF is located further to the west and collocated with BT3. The WPF/BT3 and WOC pad boundary is larger under Alternative D to provide additional storage capacity necessary without access to the rest of the North Slope.

*Routine operation and production of wells**

Routine operations under Alternative D would be identical to Alternative B except that due to the disconnected access to the rest of the North Slope it takes longer to construct the Project area and as a result production from BT2 through BT5 comes on-line later and the overall Project lifetime is extended to 2052. In addition, the WPF is located further to the west and collocated with BT3. The WPF/BT3 and WOC pad boundaries are larger under Alternative D to provide additional storage capacity necessary without access to the rest of the North Slope. Just like Alternative B, in order to assess expected cumulative long-term impacts, the Alternative D Routine Operation scenario explicitly modeled emissions from other projects anticipated to be developed within the near-field of the Willow MDP Project, as shown in Table 2.2-2.

3.5.2 Construction

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions development methods are identical to those presented for Alternative B Construction (see Section 3.3.2.2 “Emissions Calculations” for details) except that 1) BT1 facilities, pipeline, and VSM installation is not occurring in year 2024; and 2) WPF facilities installation and associated mobile source emissions are not occurring in year 2024. These activities would start in 2025 under Alternative D.

Criteria Pollutant Impacts

Table 3.5-1 shows the modeled impacts to air quality everywhere in the model domain and Table 3.5-2 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods everywhere in the model domain and, in particular, at Nuiqsut.

Table 3.5-1 Construction Activity AAQS Impacts – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	AAAQS ($\mu g/m^3$)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	528.1	10,300.5	10,828.6	40,000	40,000	27%	27%
	8-Hour	390.1	3,433.5	3,823.6	10,000	10,000	38%	38%
NO_2	1-Hour	111.5	22.4	133.9	188	188	71%	71%
	Annual	15.6	3.8	19.4	100	100	19%	19%
SO_2	1-Hour	3.6	9.0	12.6	196	196	6%	6%
	3-Hour	5.2	10.0	15.2	1,300	1,300	1%	1%
	24-Hour	1.2	9.3	10.6	--	365	--	3%
	Annual	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	102.8	30.0	132.8	150	150	89%	89%
$PM_{2.5}$	24-Hour	9.2	7.0	16.2	35	35	46%	46%
	Annual	2.4	1.6	4.0	12	12	34%	34%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 $\mu g/m^3$ - 24-hour and 0.05 $\mu g/m^3$ - annual) from CAMx modeling.

Table 3.5-2 Construction Activity AAQS Impacts at Nuiqsut – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m^3)	Background Concentration (μg/m^3)	Total Concentration (μg/m^3)	NAAQS (μg/m^3)	AAAQS (μg/m^3)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	45.2	10,300.5	10,345.8	40,000	40,000	26%	26%
	8-Hour	15.2	3,433.5	3,448.7	10,000	10,000	34%	34%
NO_2	1-Hour	31.4	18.0	49.4	188	188	26%	26%
	Annual	0.40	3.8	4.2	100	100	4%	4%
SO_2	1-Hour	0.73	9.0	9.7	196	196	5%	5%
	3-Hour	0.46	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.09	9.3	9.4	--	365	--	3%
	Annual	0.001	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	0.99	50.0	51.0	150	150	34%	34%
$PM_{2.5}$	24-Hour	0.75	7.0	7.8	35	35	22%	22%
	Annual	0.07	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m^3 - 24-hour and 0.05 μg/m^3 - annual) from CAMx modeling.

3.5.3 BT1 Pre-Drill

Alternative D BT1 pre-drilling phase is identical to Alternative B and so modeled impacts are anticipated to be identical to impacts presented in Table 3.3-3 and Table 3.3-4.

3.5.4 BT1 and BT2 Pre-Drill

Alternative D BT1 and BT2 pre-drilling phase is identical to Alternative B and so modeled impacts are anticipated to be identical to impacts presented in Table 3.3-5 and Table 3.3-6.

3.5.5 Development Drilling

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions development methods are identical to those presented for Alternative B Development Drilling, with the only difference being the changes to the WPF/BT3 and WOC pad layout and source locations. See Section 3.3.5.2 "Emissions Calculations" for details regarding the emissions preparation approach and Attachment A for visual depictions of the source layout and locations.

Criteria Pollutant Impacts

Table 3.5-3 shows the modeled impacts to air quality everywhere in the model domain and Table 3.5-4 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods. Note that impacts from drill site flaring and routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.5-3 and Table 3.5-4 is minimal.

Table 3.5-3 Developmental Drilling Activity AAQS Impacts – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,535.5	10,300.5	11,836.0	40,000	40,000	30%	30%
	8-Hour	599.7	3,433.5	4,033.2	10,000	10,000	40%	40%
NO_2	1-Hour	150.7	25.0	175.7	188	188	93%	93%
	Annual	23.6	3.8	27.4	100	100	27%	27%
SO_2	1-Hour	18.0	9.0	27.0	196	196	14%	14%
	3-Hour	15.6	10.0	25.7	1,300	1,300	2%	2%
	24-Hour	12.2	9.3	21.5	--	365	--	6%
	Annual	0.9	1.8	2.7	--	80	--	3%
PM_{10}	24-Hour	66.2	30.0	96.2	150	150	64%	64%
$PM_{2.5}$	24-Hour	21.1	7.0	28.1	35	35	80%	80%
	Annual	5.1	1.6	6.7	12	12	56%	56%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

Table 3.5-4 Development Drilling Activity AAQS Impacts at Nuiqsut – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	30	10,300.5	10,331.0	40,000	40,000	26%	26%
	8-Hour	8.9	3,433.5	3,442.4	10,000	10,000	34%	34%
NO_2	1-Hour	15.5	16.6	32.0	188	188	17%	17%
	Annual	0.17	3.8	3.9	100	100	4%	4%

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
SO_2	1-Hour	0.87	9.0	9.8	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.008	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.40	10.0	11.4	150	150	8%	8%
$PM_{2.5}$	24-Hour	0.62	7.0	7.6	35	35	22%	22%
	Annual	0.06	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

3.5.6 <u>Routine Operations</u>

Receptors and Source Configurations

See Attachment A for detailed information regarding the modeled sources, emission rates, locations, and in-stack NO_2-to-NOx ratios.

See Attachment E for the ambient air boundaries and receptors.

Emissions Calculations

Emissions development methods are identical to those presented for Alternative B Routine Operations, with the only difference being the change to the WPF/BT3 and WOC pad layout and source locations. See Section 3.3.6.2 “Emission Calculations” for details regarding the emissions preparation approach and Attachment A for visual depictions of the source layout and locations.

Structure Locations and Building Downwash

See Attachment A for figures depicting the structure locations relative to emissions sources.

Criteria Pollutant Impacts

Table 3.5-5 shows the modeled impacts to air quality everywhere in the model domain and Table 3.5-6 shows the model impacts at Nuiqsut. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS and PSD increments for all criteria pollutants and averaging periods. Table 3.5-7 provides the modeled impacts at Nuiqsut for comparison to PSD Class II increments. Impacts at Nuiqsut are below applicable PSD increments for all pollutants and averaging times. It is important to note that a PSD increment assessment is the jurisdiction of ADEC and the proposed analysis differs from a formal increment consumption assessment in several important ways. See Section 1.2.3.2 for more information. Also note that impacts from routine operations flaring at the WPF are included in the modeling analysis and the contribution from flare emissions to the maximum concentrations shown in Table 3.5-5, Table 3.5-6 and Table 3.5-7 is minimal.

Table 3.5-5 Routine Operations Activity AAQS Impacts – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,535.5	10,300.5	11,836.0	40,000	40,000	30%	30%
	8-Hour	566.0	3,433.5	3,999.5	10,000	10,000	40%	40%
NO_2	1-Hour	143.6	25	168	188	188	89%	89%
	Annual	22.1	3.8	26	100	100	26%	26%
SO_2	1-Hour	17.9	9.0	27	196	196	14%	14%
	3-Hour	15.1	10.0	25	1,300	1,300	2%	2%
	24-Hour	11.8	9.3	21	--	365	--	6%
	Annual	0.8	1.8	2.6	--	80	--	3%
PM_{10}	24-Hour	63.9	20	84	150	150	56%	56%
$PM_{2.5}$	24-Hour	18.5	7.0	26	35	35	73%	73%
	Annual	3.9	1.6	5.5	12	12	46%	46%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.5-6 Routine Operations AAQS Impacts at Nuiqsut – Alternative D (Disconnected Access)*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	29.7	10,300.5	10,330.2	40,000	40,000	26%	26%
	8-Hour	7.7	3,433.5	3,441.2	10,000	10,000	34%	34%
NO_2	1-Hour	14.4	25.8	40.3	188	188	21%	21%
	Annual	0.15	3.8	3.9	100	100	4%	4%
SO_2	1-Hour	0.91	9.0	9.9	196	196	5%	5%
	3-Hour	0.51	10.0	10.5	1,300	1,300	1%	1%
	24-Hour	0.14	9.3	9.5	--	365	--	3%
	Annual	0.01	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	1.38	11.4	12.8	150	150	9%	9%
$PM_{2.5}$	24-Hour	0.62	7.0	7.6	35	35	22%	22%
	Annual	0.06	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of the following:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

Table 3.5-7 Routine Operation Activity PSD Increment Impacts at Nuiqsut – Alternative D (Disconnected Access)

Pollutant	Average Time [a]	Modeled Concentration[b] (µg/m³)	Class II PSD Increment (µg/m³)
NO_2	Annual	0.15	25
SO_2	3-hour	0.51	512
	24-hour	0.14	91
	Annual	0.01	20
PM_{10}	24-hour	1.42	30
	Annual	0.10	17
$PM_{2.5}$	24-hour	0.73	9
	Annual	0.06	4

Notes:
[a] For comparison to annual PSD increments, the maximum annual arithmetic mean value from any of 5-years of modeled impacts were used. For comparison to short-term (3- and 24-hour) PSD increments, the maximum 2nd high value from any of 5-years of modeled.
[b] PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

*HAPs Impacts**

For comparison to RELs and RfCs, toxic modeling was conducted and evaluated for the six HAPs shown in Table 3.5-8. The evaluations against the RELs and RfCs were done using the HAP emission rates documented in Attachment A. Cancer risk was evaluated for the Nuiqsut community using the procedures discussed in Chapter 1. As shown in Table 3.5-8, the concentrations of all HAPs are well below their respective RELs on an hourly period, and RfCs on an annual period. As shown in Table 3.5-9, the cancer risk is much less than the threshold of one in one million (1.0E-06) at Nuiqsut. Note that the HAPs considered for this analysis only include those most commonly emitted from oil and gas development (benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde) and that the Total HAPs reported in Table 3.3-9 are the sum of only a subset of HAPs. Also note that impacts from flaring during routine operations are included in the maximum HAP impacts in the analysis area (Table 3.5-8) and in the estimated cancer risk at Nuiqsut (Table 3.5-9) and the contribution from flare emissions to the maximum HAP concentrations shown is minimal.

Table 3.3.3 in the main body of the Supplemental DEIS presents HAPs concentrations measured at Nuiqsut monitoring station starting in 2014 through March 2021. As shown in Table 3.3.3, measured HAPs concentrations are well below Acute REL and AEGLs. HAP measurements at Nuiqsut frequently have been below the measurement detection limit which indicates that HAP concentrations in ambient air are typically low. Note that some of health thresholds used for this assessment have become more stringent.

Table 3.5-8 Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts – Alternative D (Disconnected Access)

Pollutant	Max 1-hour in analysis area (µg/m^3)	Acute REL (µg/m^3)	Max 8-hour in analysis area (µg/m^3)	AEGLs (µg/m^3)	Max Annual in analysis area (µg/m^3)	RfC (µg/m^3)
Benzene	8.8	27.0	5.9	29,000.0	0.2	30.0
Ethylbenzene	232.3	140,000.0	155.4	140,000.0	5.0	260.0
Formaldehyde	1.4	55.0	0.8	1,100.0	0.0	9.8
n-hexane	566.7	10,000,000.0	379.1	10,000,000.0	12.1	700.0
Toluene	25.9	5,000.0	17.3	250,000.0	0.6	5,000.0
Xylene	457.7	22,000.0	306.2	560,000.0	9.8	100.0

Notes:
1 No REL available for these air toxics. Values shown are Acute Exposure Guideline Levels for mild effects (AELG-1) (ethyl benzene) and moderate effects (AEGL-2) (n-hexane).

Table 3.5-9 Routine Operation Activity Carcinogenic HAPs Impacts – Alternative D (Disconnected Access)

Pollutant	Max Annual (µg/m^3)	Cancer Unit Risk Factor thresholds (1/(µg/m^3))	Exposure Adjustment Factor	Cancer Risks
Benzene	1.00E-03	7.80E-06	4.30E-01	3.35E-09
Ethylbenzene	3.96E-03	2.50E-06		4.26E-09

Pollutant	Max Annual (µg/m³)	Cancer Unit Risk Factor thresholds (1/(µg/m³))	Exposure Adjustment Factor	Cancer Risks
Formaldehyde	3.70E-04	1.30E-05		2.07E-09
			Total Cancer Risk:	9.7.E-09

3.6 Alternative E (Three-Pad Alternative)*

The near-field modeling approach, configuration, and results for Alternative E are detailed in Attachment H. Source locations and modeled emission rates are provided in Attachment I.

3.7 Module Delivery Option 2

Sections 3.6 and 3.7 describe the analysis of scenarios designed to characterize the potential impacts anticipated from transport of process and drill site modules to the North Slope via sealift barges. These sections also describe the modeled receptors, source types, emissions, and resulting impacts.

3.7.1 Overview of Scenario

Three options are analyzed for delivery of modules to the North Slope, any of which may be authorized with any of the action alternatives presented in the previous sections of this chapter:

1. Option 1 (Atigaru Point Module Transfer Island) – not modeled due to emissions being lower than Option 2 as explained below
2. Option 2 (Point Lonely Module Transfer Island)
3. Option 3 (Colville River Crossing) – modeling described in Section 3.8

In this section, Option 1 and Option 2 will be discussed and presented, while Option 3 is further described in Section 3.8.

As described in earlier sections, sealift barges would be used to deliver processing and drill site modules to the North Slope as part of the module delivery options. Module Delivery Option 1 and Option 2 would deliver modules to an MTI west of the Colville River, either at Atigaru Point or Point Lonely, and use ice roads to reach the Willow Development (See Figure 3.7-1 below).

The emissions for Module Delivery Options are shown in Section 2.1 “Willow Alternatives Emissions Inventories” (Table 2.1-29 and Table 2.1-31) for Option 1 (Atigaru Point Module Transfer Island) and Option 2 (Point Lonely Module Transfer Island). Peak year emissions for Option 1 (Atigaru Point Module Transfer Island) occur in year 2025 and 2026 (depending on Alternative) and are lower than peak year emissions for Option 2 (Point Lonely Module Transfer Island). As such, the Point Lonely option (MTI Option 2) was selected for a conservatively high quantitative analysis of potential air quality impacts.

This section provides a summary of the near-field modeling analysis that was performed to estimate the potential air quality impacts that could result from the construction and operation of a module transfer island (MTI). The AERMOD (version 18081) dispersion model was used to estimate criteria pollutant

(CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$) impacts from the construction and operation of the Point Lonely MTI. Version 18081 was the latest version of AERMOD available when the modeling was conducted. The change of model version would not change the impact analysis conclusions for the Point Lonely MTI. The meteorological data, model options, modeled receptors and source types and emissions utilized, and resulting impacts are described below.

As shown below, modeled impacts for Option 2 (Point Lonely) diminish with distance from the MTI and are negligible 25 km away. Modeled criteria air pollutant impacts are lower than the NAAQS and AAAQS. Impacts for HAPs were not directly modeled for Module Delivery Options because HAPs emissions (and hence impacts) from these activities would be substantially lower than the Routine Operations scenario in all action alternatives.

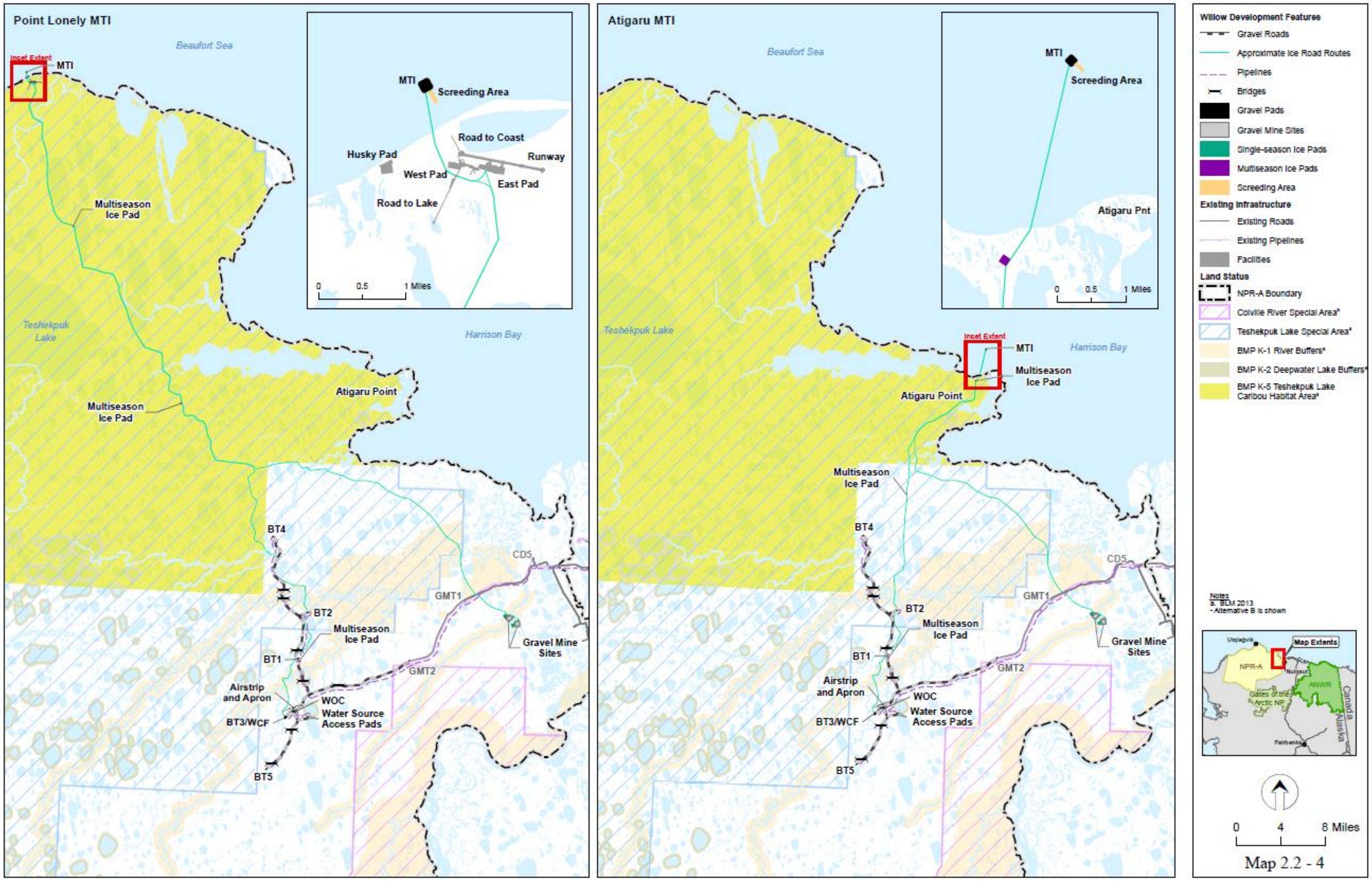


Figure 3.7-1 Module Transport Options Map: Options 1 and 2

3.7.2 Meteorological Data

Meteorological data for AERMOD were prepared using the Mesoscale Model Interface (MMIF) Program (Version 3.4.1) to extract five years (2009-2013) of AERMOD hourly surface and profile meteorological data sets for the Point Lonely MTI location from a Weather Research and Forecasting (WRF) model run for the North Slope of Alaska. This WRF model meteorological dataset was prepared for the Bureau of Ocean Energy Management (BOEM) to be utilized for air quality (AQ) modeling analyses in the Arctic (Ramboll 2016, 2017).

Figure 3.7-2 below shows a wind rose constructed from the Point Lonely location. The winds show the characteristic east-northeast to west-southwest bimodal pattern commonly observed on the North Slope. The average wind speed during 2009-2013 was 5.3 meters per second (m/s) and calm winds were infrequent, occurring for less than 1 percent of hours during the five-year period.

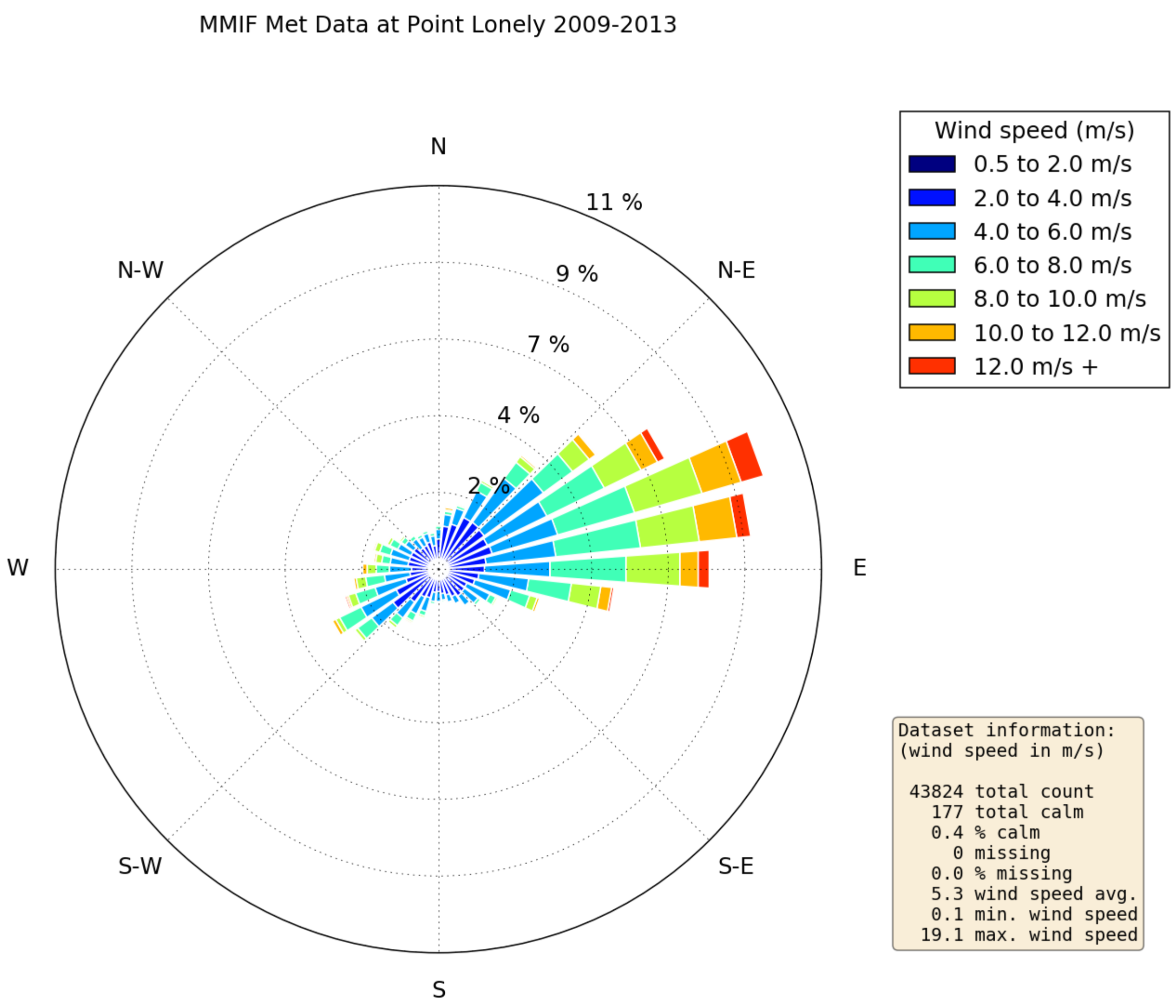


Figure 3.7-2 Point Lonely Location 2009-2013 Wind Rose

3.7.3 AERMOD Model Options

Regulatory default model settings were used, with the exception of the Ozone Limiting Method (OLM) model option, which was used for modeling NO_2 concentration estimates. Hourly ozone data is required to implement OLM. Since the best available meteorological dataset is not available for the period with the most current ozone measurements used for the AERMOD analyses described in Section 3.2.6, seasonal diurnal ozone concentration profiles were used instead of measurements that were concurrent with the meteorological data period. The seasonal diurnal ozone values used with OLM to analyze the Module Delivery impacts on NO_2 were developed using hourly ozone data measured at Nuiqsut during 2015-2017. These are the same calendar years that were used for developing the background NO_2 data presented in Section 3.2.6. The seasonal diurnal ozone data are shown in Table 3.7-1.

Downwash effects from buildings and structures were not considered in the analysis due to the large distance from the structures on the MTI and the closest onshore receptors.

Table 3.7-1 Nuiqsut 2015-2017 Seasonal Diurnal Ozone Concentrations (ppb)

Hour	Winter	Spring	Summer	Fall
01	40.2	38.8	26.1	36.7
02	40.4	38.4	26.1	37.0
03	39.8	38.4	25.5	36.9
04	39.8	37.9	24.2	36.5
05	40.0	38.1	25.0	37.0
06	40.2	38.2	25.4	36.7
07	40.0	38.3	26.0	36.6
08	40.0	38.7	26.4	36.8
09	40.0	38.2	27.1	36.7
10	40.2	38.5	28.3	36.8
11	39.8	39.2	28.3	36.7
12	39.4	39.1	28.3	36.6
13	39.5	39.3	29.1	36.4
14	39.5	39.2	29.1	36.6
15	39.5	39.5	30.4	36.3
16	39.3	39.6	30.3	36.8
17	39.6	40.5	30.0	36.6
18	39.2	40.9	30.2	36.5
19	39.6	40.1	29.6	36.6
20	39.9	39.2	29.2	36.6
21	39.7	39.2	28.5	36.3
22	39.6	38.9	27.5	36.5
23	39.8	39.7	27.2	36.8
24	39.8	39.1	26.2	36.9

3.7.4 Analysis Area and Model Receptors

The MTI analysis area is a 2,500 square kilometer area centered on the MTI. Model receptors were placed at 500-meter increments along the coastline and at inland locations extending to the southern edge of the analysis area. The receptors are shown in Figure F.1-1 of Attachment F. Flat terrain was assumed for all receptors.

3.7.5 Sources and Emissions

The Point Lonely MTI would include the construction of a gravel island with a design life of 5 to 10 years. Sources and emissions are described in the AQTSD under Section 2.1.6.

Modeled sources include point source emissions and volume sources. Equipment modeled as point sources include generator engines and heaters. Tug and barge, gravel island construction fugitive dust, and mobile sources tailpipe emissions were modeled as volume sources. A section along gravel access road was modeled as a series of volume sources to represent dust or tailpipe emissions from vehicle traffic. Stack parameters and volume sources characteristics selected are consistent with the parameters used for modeling Project Construction and Routine Operations activities.

Module Delivery Option 2 source locations are shown in Figure F.1-2 of Attachment F. Source descriptions and in-stack NO2/NOx ratios, stack parameters, and sources emissions rates for all modeled pollutants and averaging periods are included in Tables F.1-1, F.1-2, and F.1-3, respectively, within Attachment F.

3.7.6 Criteria Pollutant Impacts

Table 3.7-2 shows the modeled impacts to air quality anywhere in the analysis area for Module Delivery Option 2. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods.

Table 3.7-2 Module Delivery Option 2 AAQS Impacts*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	474.0	10,300.5	10,774.5	40,000	40,000	27%	27%
	8-Hour	106.8	3,433.5	3,540.3	10,000	10,000	35%	35%
NO_2	1-Hour	125.9	15.3	141.2	188	188	75%	75%
	Annual	0.6	3.8	4.4	100	100	4%	4%
SO_2	1-Hour	1.6	9.0	10.6	196	196	5%	5%
	3-Hour	1.1	10.0	11.1	1,300	1,300	1%	1%
	24-Hour	0.2	9.3	9.5	--	365	--	3%
	Annual	0.002	1.8	1.8	--	80	--	2%
PM_{10}	24-Hour	5.1	20.0	25.1	150	150	17%	17%
$PM_{2.5}$	24-Hour	2.1	7.0	9.1	35	35	26%	26%
	Annual	0.09	1.6	1.7	12	12	14%	14%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 µg/m³ - 24-hour and 0.05 µg/m³ - annual) from CAMx modeling.

3.8 Module Delivery Option 3

3.8.1 Overview of Scenario

Module Delivery Option 3 would make use of the existing Oliktok Dock for module delivery to the north slope by sealift barges. From Oliktok Dock, the modules would be transported to an existing 12-acre gravel staging pad approximately two miles south of the Dock for storage during and after sealift barge delivery. Modules would later be transported along existing gravel roads to Kuparuk DS2P. The modules would then travel on a heavy-haul ice road to GMT2, crossing the Colville River via grounded ice in the area of Ocean Point. From GMT2 to the WPF, the modules would be transported on the Willow access road under Alternatives B and C. Under Alternative D modules would be transported via the seasonal ice road between GMT2 and the WPF.

As stated in section 3.7.1, the Module Delivery Option 3 modeling scenario considers only emissions of criteria air pollutants. Impacts for HAPs were not directly modeled for module delivery options because HAP emissions and subsequent impacts from these activities would be substantially lower than the routine operations scenario in all action alternatives. Modeled sources include point source emissions and volume sources. Equipment modeled as point sources include stationary sources, such as engines and heaters, as well as large portable equipment and nonroad engines. Fugitive dust and mobile sources tailpipe emissions were modeled as volume sources.

Further information regarding sources of emissions can be found in Section 3.7.5; figures showing modeled sources relative to ambient air boundaries, structures, roads, and other Project features are presented in Attachment F. In addition, Attachment F includes detailed tables that provide a description of each modeled source, source emissions rates for all modeled pollutants and averaging periods, in-stack NO2-to-NOx ratio, modeled location, and stack- or volume-specific source parameters.

3.8.2 Meteorological Data

Meteorological data for Option 3 modeling was prepared using identical methods to Option 2 (see Section 3.6.2) but processed for the Oliktok Dock location (latitude of 70.51283, longitude of -149.86681).

Figure 3.8-1 below shows a wind rose constructed from the Oliktok location. The winds show the characteristic east-northeast to west-southwest bimodal pattern commonly observed on the North Slope. The average wind speed during 2009-2013 was 5.7 meters per second (m/s) and calm winds were infrequent, occurring for less than 1 percent of hours during the five-year period.

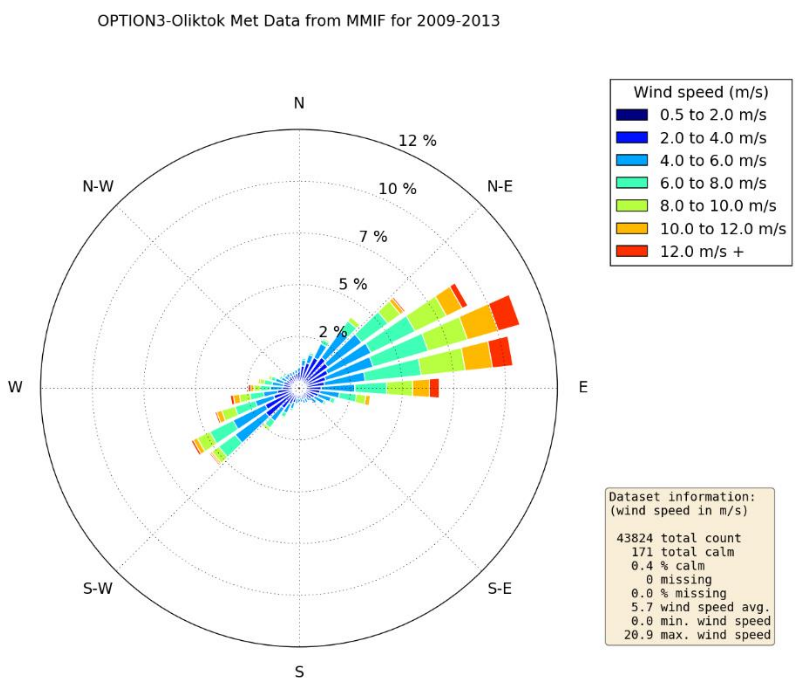


Figure 3.8-1 Oliktok Location 2009-2013 Wind Rose

3.8.3 AERMOD Model Options

Model options for Module Delivery Option 3 are identical to those used in Option 2 modeling except that AERMOD version 19191 was used to estimate the criteria pollutant (CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$) impacts during the modules transfer. For details on all model options, refer to Section 3.7.3.

3.8.4 Analysis Area and Model Receptors

The Module Delivery Option 3 analysis area is a 2,500 square kilometer area centered on Oliktok Dock. Model receptors were placed around the ambient air boundaries following the same spacing as the modeling for Project alternatives:

- 10 meter spacing along the ambient air boundary of Oliktok Dock and Staging Pad areas.
- 25 meter spacing from the ambient air boundary of Oliktok Dock and Staging Pad to 100 meters inland locations.
- 100 meter spacing from 100m of the ambient air boundary of Oliktok Dock and Staging Pad to 1km
- 250 meter spacing from 1 km of the ambient air boundary of Oliktok Dock and Staging Pad to 2 km
- 500 meter spacing from 2 km of the ambient air boundary of Oliktok Dock and Staging Pad to 5 km, as well as along the coastline
- 1,000 meter spacing from 5 km of the ambient air boundary of Oliktok Dock and Staging Pad at inlad locations extending to the southern edge of the analysis area

Flat terrain was assumed for all receptors. Receptor locations are shown in Figures F.2-1 to F.2-3 of Attachment F.

3.8.5 Sources and Emissions

Module Delivery Option 3 involves utilization of the existing Oliktok Dock for module offloading from sealift barges, as well as existing gravel roads and an existing 12-acre staging pad approximately two miles south of the dock. Minor improvements to gravel roads and the gravel staging pad are required, involving the addition of approximately 118,700 cubic yards of gravel to cover various roads and the staging pad. Additional gravel would also be required to raise the height of Oliktok Dock. Emissions from non-road construction equipment (including heater) and fugitive dust are modeled as volume sources at construction locations. Approximately 532 meters of roadway is modeled (100 meters exiting the dock offload area, plus 216 meters each to the north and south of the gravel staging pad), representing segments of road in the vicinity of construction and operational activities. Roadway sources are represented as series of separated volume sources, and include emissions of vehicle exhaust, module transport equipment exhaust, and fugitive road dust. Fugitive dust from the gravel staging pad is represented as a single volume source.

Emissions from vessel traffic are represented as distinct sources for each vessel type (Harbor Assist Tugs, Support Vessels, and Ocean-Going Vessels); all vessel traffic emissions are represented as series of separated volume sources. AERMOD source parameters were reviewed in publicly available dispersion modeling studies for marine sources. AERMOD release parameters for modeling Willow Option 3 are based on modeling of harbor craft and ocean-going vessels (LAHD, 2019). Dispersion parameters such as release heights, volume source spacing, initial lateral dimension (sigma y) and vertical dimension (sigma z) for ocean tugs/barges modeled for Willow Option 3 were assumed to be similar to those of cargo vessels. Similarly, the modeling parameters for assist tugs and support vessels in Willow Option 3 were assumed to be equivalent to harbor assist.

As a conservative approach, maximum-year emissions across all Option 3 activities were modeled. This includes construction improvements to gravel roads, staging pad, and Oliktok Dock in 2023; Vessel traffic in 2024; vehicle exhaust in 2025; staging pad fugitive dust from 2024; and module transport from 2024 into 2025. As additional conservative measure, fugitive road dust was modeled assuming emissions from both 2023 (during roadway construction activity) and 2026 (module transport operations).

Module Delivery Option 3 source locations are shown in Figure F.2-4 through F.2-9 of Attachment F. Source descriptions and in-stack NO_2/NOx ratios, stack parameters, and sources emissions rates for all modeled pollutants and averaging periods are included in Tables F.2-1, F.2-2, and F.2-3, respectively, within Attachment F.

3.8.6 Criteria Pollutant Impacts

Table 3.8-1 shows the modeled impacts to air quality anywhere in the Option 3 analysis area. Representative background concentrations are added to model results prior to comparing the total concentration to applicable AAQS. As shown, impacts would be below applicable AAQS for all criteria pollutants and averaging periods.

Table 3.8-1 Module Delivery Option 3 Activity AAQS Impacts*

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	255.6	10,300.5	10,556.1	40,000	40,000	26%	26%
	8-Hour	117.6	3,433.5	3,551.1	10,000	10,000	36%	36%
NO_2	1-Hour	112.6	10.1	122.7	188	188	65%	65%
	Annual	3.3	3.8	7.1	100	100	7%	7%
SO_2	1-Hour	1.4	9.0	10.4	196	196	5%	5%
	3-Hour	1.0	10.0	11.1	1,300	1,300	1%	1%
	24-Hour	0.4	9.3	9.7	--	365	--	3%
	Annual	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	23.4	30.0	53.4	150	150	36%	36%
$PM_{2.5}$	24-Hour	6.3	7.0	13.3	35	35	38%	38%
	Annual	0.4	1.6	2.0	12	12	17%	17%

Notes:
Modeled highest second-high values from 5 modeled years shown for all short-term averaging times, with the exception of:
NO_2 1-hour value is calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations, and the background value shown is the average of the 1-hour values that are paired in time with the modeled values;
SO_2 1-hour value is calculated as the 3-year average of the 4th highest daily maximum 1-hour concentrations;
PM_{10} 24-hour value is the 6th highest value from 5-year modeling period; and
$PM_{2.5}$ 24-hour value is calculated as the 3-year average of the 8th highest values.
Maximum annual values are shown for NO_2 and SO_2 and the $PM_{2.5}$ annual value is the annual mean averaged over the maximum 3 years.
PM_{10} and $PM_{2.5}$ 24-hour, and $PM_{2.5}$ annual modeled impacts include secondary $PM_{2.5}$ impacts (0.48 μg/m³ - 24-hour and 0.05 μg/m³ - annual) from CAMx modeling.

3.9 Speed Limit Change Analysis

In the Willow near-field modeling, the estimated impacts of Project activities for Alternatives B, C, and D were analyzed using emissions developed with a road speed limit of 25 mph throughout the Willow Project area. However, there are some roads in the Project area that would have a 35 mph speed limit. As a result, the modeled impacts described above are re-assessed in this section in consideration of the expected emissions changes. Shown below are the emissions increases that would potentially occur as well as a discussion of how those changes could influence the estimated air quality impacts.

3.9.1 Emission Rate Changes

The emissions that would increase due to the higher speed limit are vehicle tailpipe emissions that are based on emission rates from the MOVES model. Fugitive dust emissions are not affected because those are calculated using the AP-42 emission factor for industrial unpaved roads which depend on silt content and vehicle weight and not speed (USEPA, 2006b). For the emissions inventory for this project, the MOVES 2014a model was run in on-road emission factor mode for each pollutant of interest, vehicle type of interest, all averaging speeds, and all processes. The MOVES output result was then aggregated across processes to determine the emission factor for each averaging speed based on vehicle type and pollutant. To account for increased emissions for vehicles driving at 35 mph instead of 25 mph, the percent increase in the emissions factor was first calculated for each pollutant; these are shown in Table 3.9-1. A weighted average percent increase for the vehicle fleet calculated based on the vehicle miles travelled (VMT) (shown in Table 3.9-2) in Project Year 4 for the construction scenario for all alternatives and Year 6 for all other scenarios for Alternatives B and C and Year 7 for Alternative D. The resulting VMT-weighted average percent emissions increases for the on-road tailpipe emissions are shown in Table 3.9-3. These are a conservative over-estimate of actual emissions increases as it assumes that the speed limit on all Project roads is 35 mph.

Table 3.9-1. Percent Increase in On-Road Vehicle Tailpipe Emission Factors by Vehicle Type

Vehicle Type	Pollutant														
	VOC	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	Formaldehyde
Passenger Truck	18%	18%	13%	20%	23%	10%	10%	18%	25%	18%	18%	18%	18%	17%	18%
Light Commercial Truck	17%	23%	15%	14%	19%	10%	10%	19%	25%	18%	18%	18%	18%	16%	19%
Intercity Bus	17%	13%	12%	42%	30%	9%	9%	25%	25%	22%	20%	20%	21%	15%	25%
Single Unit Short-haul Truck	21%	14%	17%	40%	28%	15%	15%	24%	25%	22%	22%	22%	23%	20%	23%
Combination Short-haul Truck	14%	12%	11%	14%	11%	7%	7%	18%	25%	17%	15%	15%	16%	12%	18%

Table 3.9-2 Vehicle Miles Traveled by Vehicle Type*

Vehicle Type	Scenario							
	Alt B Construction –-– Year 4	Alt B All Non-construction –-– Year 6	Alt C Construction –- – Year 4	Alt C All Non-construction –-– Year 6	Alt D Construction – Year 4Alt D Construction – Year 4	Alt D All Non-construction –-– Year 7	Alt E Construction – Year 4	Alt E All Non-construction – Year 6
Passenger Truck	2,107,420	204,727	2,468,620	102,872	2,340,380	177,040	2,147,740	201,712
Light Commercial Truck	228,900	72,234	226,100	39,647	187,320	43,768	238,980	70,962
Intercity Bus	495,880	77,248	554,680	34,356	524,720	33,263	509,320	77,247
Single Unit Short-haul Truck	2,069,830	302,742	2,521,330	135,270	2,848,440	172,219	2,074,870	291,288
Combination Short-haul Truck	322,000	571,586	317,800	396,973	169,540	442,238	335,440	635,336

Table 3.9-3 Percent Increase in On-Road Vehicle Tailpipe Emissions Rates*

Alternative and Model Scenario	Pollutant														
	VOC	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	Formaldehyde
Alt B Construction –-– Year 4	19%	16%	14%	29%	25%	12%	12%	21%	25%	20%	20%	20%	20%	18%	21%
Alt B All Non-Construction Scenarios –-– Year 6	17%	14%	13%	23%	19%	10%	10%	20%	25%	19%	18%	18%	18%	15%	20%
Alt C Construction –-– Year 4	19%	16%	14%	30%	25%	12%	12%	21%	25%	20%	20%	20%	20%	18%	21%
Alt C All Non-Construction Scenarios –-– Year 6	17%	14%	13%	21%	18%	9%	9%	20%	25%	18%	17%	17%	18%	15%	20%
Alt D Construction –-– Year 4	19%	16%	15%	31%	26%	12%	12%	21%	25%	20%	20%	20%	20%	18%	21%

Alternative and Model Scenario	Pollutant														
	VOC	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	Formaldehyde
Alt D All Non-Construction Scenarios – Year 7Alt D All Non-Construction Scenarios – Year 7	17%	14%	13%	22%	18%	10%	10%	20%	25%	18%	18%	18%	18%	15%	20%

3.9.2 Potential Speed Adjusted Impacts

A conservatively high screening assessment was conducted to assess if a 35 mph speed limit affects the conclusions drawn from the air quality impact modeling analyses presented in Section 3.3 through 3.5. Through the screening assessment for all alternatives and scenarios and a refined assessment for a subset of model scenarios discussed below, it is determined that a speed limit of 35 mph would not change the conclusions of the near-field modeling analysis.

The conservatively high screening assessment was performed by applying the emissions rate changes for a 35 mph speed limit (shown above in Table 3.9-3) to the maximum modeled concentrations that occur anywhere in the analysis area. The screening assessment assumes that the total Project impact would increase due to the increase in vehicle speed, not just the fraction of the maximum impact that is due to the on-road tailpipe emissions. This screening assessment was performed for all scenarios and alternatives. The resulting impacts are shown in Table 3.9-4 through Table 3.9-16 for criteria pollutants and Table 3.9-17 through Table 3.9-22 for hazardous air pollutants. Since Alternative E was explicitly modeled with a speed limit of 35 mph on applicable roads and results are presented in Attachment H, the screening assessment presented below was not warranted for Alternative E.

This screening assessment results in an over-estimate of actual impacts for Alternatives B, C, and D because on-road tailpipe emissions contribute to only a portion of the total Project impacts. With regards to greenhouse gas (GHG) emissions, the estimated GHG emissions from on-road vehicle tailpipe emissions at the Project would be potentially higher by up to the percent increases shown for CO_2, CH_4 and N_2O in Table 3.9-3 due to increase in speed from 25 mph to 35 mph.

When using this conservatively high screening assessment, criteria pollutant cumulative impacts were below the NAAQS and AAAQS for all scenarios except four scenarios for which a refined assessment was conducted, as explained below. The four scenarios for which a refined assessment was conducted are: Alternative C Development Drilling 1-hour NO_2, Alternative C Routine Operations 1-hour NO_2, Alternative D Construction 24-hour PM_{10}, and Alternative D Development Drilling 1-hour NO_2. The refined assessment analyzes the impacts of increasing the emissions for just the mobile source impacts. For these four alternative/scenario combinations, as discussed below, all impacts would be well below the NAAQS and AAQS with a 35 mph speed limit. When using the conservatively high screening assessment, hazardous air pollutant impacts continue to be below relevant health-based thresholds with the change in speed limit from 25 mph to 35 mph.

The criteria pollutant impacts attributed to just on-road mobile sources were analyzed explicitly for those alternative/scenario/pollutant cases where the screening assessment showed values higher than the AAQS, i.e., Alternative C Development Drilling 1-hour NO_2, Alternative C Routine Operations 1-hour NO_2, Alternative D Construction 24-hour PM_{10}, and Alternative D Development Drilling 1-hour NO_2 by determining the on-road source contribution to receptors within 100 meters of the pads with maximum impacts. Then the on-road impacts were adjusted based on the emissions rates in Table 3.9-3 to evaluate the overall increase to the impacts.

For Alternative C Development Drilling, on-road sources contribute a maximum of 0.175 and 0.183 $\mu g/m^3$ to the three-year 1-hour NO_2 values in the vicinity of the WPF and South WOC, respectively. Increasing the traffic speed to 35mph (a 13% increase in emissions for this scenario as shown in Table 3.9-3) has a negligible effect on the maximum concentrations. The maximum increase in 1-hour NO_2 impacts under Alternative C Development Drilling would be approximately 0.023 $\mu g/m^3$ and

0.024 µg/m^3 at the WPF and South WOC, respectively. This shows that overall impacts for Alternative C Development Drilling, when adjusted for speed increases, would be well below NAAQS and AAAQS. The maximum 1-hour NO_2 impact for Alternative C Routine Operations is identical to Alternative C Development Drilling and thus the overall impacts for Alternative C Routine Operations, when adjusted for speed increases, would also be well below NAAQS and AAAQS.

For Alternative D Construction, on-road sources contribute a maximum of 7.02, 7.89 and 0.25 ug/m^3 to the maximum 24-hour average PM_{10} values in the vicinity of the BT2, WPF-BT3 and WOC, respectively. Increasing the traffic speed to 35mph (a 31% increase in emissions for this scenario as shown in Table 3.8-3) has an insignificant effect on the maximum concentrations. The maximum increase in 24-hour PM_{10} impacts under Alternative D Construction would be approximately 2.11, 2.37 and 0.08 ug/m3 at the BT2, WPF-BT3 and WOC, respectively. This demonstrates that overall impacts for Alternative D Construction, when adjusted for speed increases, would be well below NAAQS and AAAQS.

For Alternative D Development Drilling, on-road sources contribute a maximum of 0.353 and 0.048 ug/m^3 to the three-year average 1-hour NO_2 values in the vicinity of the WPF-BT3 and WOC, respectively. Increasing the traffic speed to 35mph (a 13% increase in emissions for this scenario as shown in Table 3.8-3) has a negligible effect on the maximum concentrations. The maximum increase in 1-hour NO2 impacts under Alternative D Development Drilling would be approximately 0.046 ug/m3 and 0.006 ug/m3 at the WPF-BT3 and WOC, respectively. The shows that overall impacts for Alternative D Development Drilling, when adjusted for speed increases, would be well below NAAQS and AAAQS.

In summary, as discussed above, all air quality impacts in all alternatives and scenarios would be below the NAAQS and AAAQS even with a 35 mph speed limit. This is shown either with the screening assessment in Table 3.9-4 through Table 3.9-16, or a detailed analysis of the on-road source contribution at peak receptors. Hazardous air pollutant impacts, shown in Table 3.9-17 through Table 3.9-22, would be below relevant health-based thresholds.

Table 3.9-4 Screening Test: BT1 Pre-Drill Activity AAQS Impacts with Speed Adjustment in Alternative B**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m^3)	Speed Adjusted Concentration* (µg/m^3)	Background Concentration (µg/m^3)	Total Concentration* (µg/m^3)	NAAQS (µg/m^3)	AAAQS (µg/m^3)	Percent of NAAQS*	Percent of AAAQS*
CO	1-Hour	1,483.3	1,716.0	10,300.5	12,016.6	40,000	40,000	30%	30%
	8-Hour	1,103.9	1,277.1	3,433.5	4,710.6	10,000	10,000	47%	47%
NO_2	1-Hour	64.3	73.5	26.7	100.2	188	188	53%	53%
	Annual	10.8	12.4	3.8	16.1	100	100	16%	16%
SO_2	1-Hour	4.2	4.7	9.0	13.6	196	196	7%	7%
	3-Hour	3.6	4.0	10.0	14.0	1,300	1,300	1%	1%
	24-Hour	2.0	2.3	9.3	11.6	--	365	--	3%
	Annual	0.2	0.2	1.8	2.0	--	80	--	3%
PM_{10}	24-Hour	16.7	21.6	20	41.6	150	150	28%	28%

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration* (µg/m³)	Background Concentration (µg/m³)	Total Concentration* (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS*	Percent of AAAQS*
$PM_{2.5}$	24-Hour	10.0	12.5	7.0	19.5	35	35	56%	56%
	Annual	2.0	2.5	1.6	4.1	12	12	34%	34%

Numbers may not add exactly due to rounding
* Values are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase
.

Table 3.9-5 Screening Test: BT1 and BT2 Pre-Drill Activity AAQS Impacts with Speed Adjustment in Alternative B*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	833.2	964.0	10,300.5	11,264.5	40,000	40,000	28%	28%
	8-Hour	641.0	741.6	3,433.5	4,175.1	10,000	10,000	42%	42%
NO_2	1-Hour	55.8	63.8	26.6	90.4	188	188	48%	48%
	Annual	6.7	7.6	3.8	11.4	100	100	11%	11%
SO_2	1-Hour	3.1	3.4	9.0	12.4	196	196	6%	6%
	3-Hour	2.8	3.1	10.0	13.1	1,300	1,300	1%	1%
	24-Hour	1.3	1.4	9.3	10.8	--	365	--	3%
	Annual	0.1	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	17.1	22.1	40	62.1	150	150	41%	41%
$PM_{2.5}$	24-Hour	7.5	9.3	7.0	16.3	35	35	47%	47%
	Annual	0.9	1.2	1.6	2.8	12	12	23%	23%

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-6 Screening Test: Routine Operations Activity AAQS Impacts with Speed Adjustment in Alternative B**

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Speed Adjusted Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,389.5	1,585.2	10,300.5	11,885.7	40,000	40,000	30%	30%
	8-Hour	921.7	1,051.5	3,433.5	4,485.0	10,000	10,000	45%	45%
NO_2	1-Hour	138.5	156.9	20.4	177.3	188	188	94%	94%
	Annual	24.9	28.2	3.8	31.9	100	100	32%	32%
SO_2	1-Hour	17.9	19.7	9.0	28.7	196	196	15%	15%
	3-Hour	16.6	18.2	10.0	28.2	1,300	1,300	2%	2%
	24-Hour	10.2	11.2	9.3	20.5	--	365	--	6%
	Annual	0.8	0.9	1.8	2.8	--	80	--	3%
PM_{10}	24-Hour	65.6	80.7	30	110.7	150	150	74%	74%
$PM_{2.5}$	24-Hour	22.6	26.9	7.0	33.9	35	35	97%	97%
	Annual	4.2	5.0	1.6	6.6	12	12	55%	55%

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-7 Screening Test: Construction Activity AAQS Impacts with Speed Adjustment in Alternative B**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	526.4	609.0	10,300.5	10,909.5	40,000	40,000	27%	27%
	8-Hour	390.0	451.2	3,433.5	3,884.7	10,000	10,000	39%	39%
NO_2	1-Hour	111.4	127.4	22.4	149.8	188	188	80%	80%
	Annual	17.0	19.4	3.8	23.2	100	100	23%	23%
SO_2	1-Hour	3.6	4.0	9.0	13.0	196	196	7%	7%
	3-Hour	5.2	5.8	10.0	15.8	1,300	1,300	1%	1%
	24-Hour	1.2	1.4	9.3	10.7	--	365	--	3%
	Annual	0.1	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	61.9	80.0	30	110.0	150	150	73%	73%
$PM_{2.5}$	24-Hour	11.6	14.3	7.0	21.3	35	35	61%	61%
	Annual	2.6	3.2	1.6	4.8	12	12	40%	40%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-8 Screening Test: Development Drilling Activity AAQS Impacts with Speed Adjustment in Alternative B**

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Speed Adjusted Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,389.5	1,585.2	10,300.5	11,885.7	40,000	40,000	30%	30%
	8-Hour	921.7	1,051.5	3,433.5	4,485.0	10,000	10,000	45%	45%
NO_2	1-Hour	138.5	156.9	20.4	177.3	188	188	94%	94%
	Annual	24.9	28.2	3.8	32.0	100	100	32%	32%
SO_2	1-Hour	17.9	19.7	9.0	28.7	196	196	15%	15%
	3-Hour	16.6	18.2	10.0	28.2	1,300	1,300	2%	2%
	24-Hour	10.2	11.2	9.3	20.5	--	365	--	6%
	Annual	0.8	0.9	1.8	2.8	--	80	--	3%
PM_{10}	24-Hour	65.6	80.8	30	110.8	150	150	74%	74%
$PM_{2.5}$	24-Hour	22.6	26.9	7.0	33.9	35	35	97%	97%
	Annual	4.2	5.0	1.6	6.6	12	12	55%	55%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-9 Screening Test: BT1 Pre-Drill Activity AAQS Impacts with Speed Adjustment in Alternative C**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,471.5	1,702.0	10,300.5	12,002.5	40,000	40,000	30%	30%
	8-Hour	1,128.2	1,304.9	3,433.5	4,738.4	10,000	10,000	47%	47%
NO_2	1-Hour	65.7	75.2	23.9	99.1	188	188	53%	53%
	Annual	12.7	14.6	3.8	18.3	100	100	18%	18%
SO_2	1-Hour	4.2	4.7	9.0	13.6	196	196	7%	7%
	3-Hour	4.1	4.6	10.0	14.6	1,300	1,300	1%	1%
	24-Hour	2.2	2.4	9.3	11.8	--	365	--	3%
	Annual	0.2	0.3	1.8	2.1	--	80	--	3%
PM_{10}	24-Hour	18.0	23.3	10	33.3	150	150	22%	22%
$PM_{2.5}$	24-Hour	11.4	14.3	7.0	21.3	35	35	61%	61%
	Annual	2.3	2.9	1.6	4.5	12	12	37%	37%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-10 Screening Test: BT1 and BT2 Pre-Drill Activity AAQS Impacts with Speed Adjustment in Alternative C**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	826.4	955.9	10,300.5	11,256.4	40,000	40,000	28%	28%
	8-Hour	635.7	735.3	3,433.5	4,168.8	10,000	10,000	42%	42%
NO_2	1-Hour	57.6	65.9	15.6	81.5	188	188	43%	43%
	Annual	12.6	14.4	3.8	18.1	100	100	18%	18%
SO_2	1-Hour	4.2	4.7	9.0	13.6	196	196	7%	7%
	3-Hour	4.1	4.6	10.0	14.6	1,300	1,300	1%	1%
	24-Hour	1.8	2.0	9.3	11.3	--	365	--	3%
	Annual	0.2	0.2	1.8	2.1	--	80	--	3%
PM_{10}	24-Hour	17.9	23.2	10	33.2	150	150	22%	22%
$PM_{2.5}$	24-Hour	11.4	14.2	7.0	21.2	35	35	61%	61%
	Annual	2.3	2.8	1.6	4.4	12	12	37%	37%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-11 Screening Test: Routine Operations Activity AAQS Impacts with Speed Adjustment in Alternative C**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,308.0	1,488.5	10,300.5	11,789.0	40,000	40,000	29%	29%
	8-Hour	930.9	1,059.4	3,433.5	4,492.9	10,000	10,000	45%	45%
NO_2	1-Hour	147.6	166.6	25.1	191.7	188	188	102.0%	102.0%
	Annual	24.0	27.1	3.8	30.9	100	100	31%	31%
SO_2	1-Hour	19.2	21.0	9.0	30.0	196	196	15%	15%
	3-Hour	16.9	18.5	10.0	28.5	1,300	1,300	2%	2%
	24-Hour	10.4	11.4	9.3	20.8	--	365	--	6%
	Annual	0.9	1.0	1.8	2.9	--	80	--	4%
PM_{10}	24-Hour	77.8	94.2	40	134.2	150	150	89%	89%
$PM_{2.5}$	24-Hour	19.0	22.3	7.0	29.3	35	35	84%	84%
	Annual	5.0	5.8	1.6	7.4	12	12	62%	62%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-12 Screening Test: Construction Activity AAQS Impacts with Speed Adjustment in Alternative C**

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Speed Adjusted Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	643.2	744.0	10,300.5	11,044.5	40,000	40,000	28%	28%
	8-Hour	488.1	564.5	3,433.5	3,998.0	10,000	10,000	40%	40%
NO_2	1-Hour	136.0	155.6	13.4	169.0	188	188	90%	90%
	Annual	35.4	40.5	3.8	44.2	100	100	44%	44%
SO_2	1-Hour	4.3	4.8	9.0	13.8	196	196	7%	7%
	3-Hour	5.2	5.8	10.0	15.8	1,300	1,300	1%	1%
	24-Hour	1.3	1.5	9.3	10.8	--	365	--	3%
	Annual	0.2	0.3	1.8	2.1	--	80	--	3%
PM_{10}	24-Hour	90.4	117.3	20	137.3	150	150	92%	92%
$PM_{2.5}$	24-Hour	16.7	20.7	7.0	27.7	35	35	79%	79%
	Annual	5.4	6.8	1.6	8.4	12	12	70%	70%

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-13 Screening Test: Development Drilling Activity AAQS Impacts with Speed Adjustment in Alternative C*

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,308.0	1,488.5	10,300.5	11,789.0	40,000	40,000	29%	29%
	8-Hour	930.9	1,059.4	3,433.5	4,492.9	10,000	10,000	45%	45%
NO_2	1-Hour	147.6	166.6	25.1	191.7	188	188	102.0%	102.0%
	Annual	24.1	27.2	3.8	30.9	100	100	31%	31%
SO_2	1-Hour	19.3	21.1	9.0	30.1	196	196	15%	15%
	3-Hour	16.9	18.5	10.0	28.5	1,300	1,300	2%	2%
	24-Hour	10.4	11.4	9.3	20.8	--	365	--	6%
	Annual	0.9	1.0	1.8	2.9	--	80	--	4%
PM_{10}	24-Hour	91.4	110.6	30	140.6	150	150	94%	94%
$PM_{2.5}$	24-Hour	19.0	22.3	7.0	29.3	35	35	84%	84%
	Annual	5.0	5.8	1.6	7.4	12	12	62%	62%

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-14 Screening Test: Routine Operations Activity AAQS Impacts with Speed Adjustment in Alternative D**

Pollutant	Averaging Time	Maximum Modeled Concentration (μg/m³)	Speed Adjusted Concentration (μg/m³)	Background Concentration (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)	AAAQS (μg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,535.5	1,752.1	10,300.5	12,052.6	40,000	40,000	30%	30%
	8-Hour	566.0	645.9	3,433.5	4,079.4	10,000	10,000	41%	41%
NO_2	1-Hour	143.6	162.2	24.5	186.7	188	188	99%	99%
	Annual	22.1	25.0	3.8	28.7	100	100	29%	29%
SO_2	1-Hour	17.9	19.6	9.0	28.6	196	196	15%	15%
	3-Hour	15.1	16.6	10.0	26.6	1,300	1,300	2%	2%
	24-Hour	11.8	13.0	9.3	22.3	--	365	--	6%
	Annual	0.8	0.9	1.8	2.7	--	80	--	3%
PM_{10}	24-Hour	63.9	77.5	20	97.5	150	150	65%	65%
$PM_{2.5}$	24-Hour	18.5	21.8	7.0	28.8	35	35	82%	82%
	Annual	3.9	4.6	1.6	6.2	12	12	52%	52%

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-15 Screening Test: Construction Activity AAQS Impacts with Speed Adjustment in Alternative D**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	528.1	610.3	10,300.5	10,910.8	40,000	40,000	27%	27%
	8-Hour	390.1	450.8	3,433.5	3,884.3	10,000	10,000	39%	39%
NO_2	1-Hour	111.5	127.9	22.4	150.3	188	188	80%	80%
	Annual	15.6	17.9	3.8	21.7	100	100	22%	22%
SO_2	1-Hour	3.6	4.0	9.0	13.0	196	196	7%	7%
	3-Hour	5.2	5.8	10.0	15.8	1,300	1,300	1%	1%
	24-Hour	1.2	1.4	9.3	10.7	--	365	--	3%
	Annual	0.1	0.1	1.8	1.9	--	80	--	2%
PM_{10}	24-Hour	102.8	134.5	30	164.5	150	150	110%	110%
$PM_{2.5}$	24-Hour	9.2	11.4	7.0	18.4	35	35	52%	52%
	Annual	2.4	3.0	1.6	4.6	12	12	39%	39%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-16 Screening Test: Development Drilling Activity AAQS Impacts with Speed Adjustment in Alternative D**

Pollutant	Averaging Time	Maximum Modeled Concentration (µg/m³)	Speed Adjusted Concentration (µg/m³)	Background Concentration (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)	AAAQS (µg/m³)	Percent of NAAQS	Percent of AAAQS
CO	1-Hour	1,535.5	1,752.2	10,300.5	12,052.7	40,000	40,000	30%	30%
	8-Hour	599.7	684.3	3,433.5	4,117.8	10,000	10,000	41%	41%
NO_2	1-Hour	150.7	170.2	25.0	195.2	188	188	104%	104%
	Annual	23.6	26.7	3.8	30.5	100	100	30%	30%
SO_2	1-Hour	18.0	19.7	9.0	28.7	196	196	15%	15%
	3-Hour	15.6	17.1	10.0	27.2	1,300	1,300	2%	2%
	24-Hour	12.2	13.4	9.3	22.7	--	365	--	6%
	Annual	0.9	0.9	1.8	2.8	--	80	--	3%
PM_{10}	24-Hour	66.2	80.3	30	110.3	150	150	74%	74%
$PM_{2.5}$	24-Hour	21.1	24.8	7.0	31.8	35	35	91%	91%
	Annual	5.1	6.1	1.6	7.7	12	12	64%	64%

Numbers may not add exactly due to rounding

* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase. See refined analysis in Section 3.8.2 for scenarios/pollutants where screening values are higher than AAQS.

Table 3.9-17 Screening Test: Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts with Speed Adjustment– Alternative B*

Pollutant	Max 1-hour (µg/m³)	Speed Adjusted Max 1-hour Concentration (ug/m3)	Acute REL (µg/m³)	Max 8-hour (µg/m³)	Speed Adjusted Max 8-hour Concentration (ug/m3)	Sub-Chronic AEGLs (µg/m³)	Max Annual (µg/m³)	Speed Adjusted max Annual Concentration (ug/m3)	RfC (µg/m³)
Benzene	8.8	10.4	27.0	6.0	7.1	29,000.0	0.2	0.2**	30.0
Ethylbenzene	230.7	272.1	140,000.0	155.4	183.3	140,000.0	5.0	5.8	260.0
Formaldehyde	1.4	1.7	55.0	0.8	0.9	1,100.0	0.0	0.0	9.8
n-hexane	562.9	648.4	10,000,000.0	379.1	436.8	10,000,000.0	12.1	13.9	700.0
Toluene	25.7	30.3	5,000.0	17.3	20.4	250,000.0	0.6	0.7	5,000.0
Xylene	454.5	538.4	22,000.0	306.2	362.7	560,000.0	9.8	11.6	100.0

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.
**The max annual concentration with and without the speed impact are the same because of rounding.

Table 3.9-18 Screening Test: Routine Operation Activity Carcinogenic HAPs Impacts with Speed Adjustment in Alternative B*

Pollutant	Max Annual (µg/m³)	Speed Adjustment Annual Concentration (ug/m3)	RfC (µg/m³)	Max Annual as a % of RfC	Cancer Unit Risk Factor thresholds (1/(µg/m³))	Exposure Adjustment Factor	Cancer Risk
Benzene	9.70E-04	1.15E-03	3.00E+01	0.004%	7.80E-06	4.30E-01	3.86E-09
Ethylbenzene	3.97E-03	4.68E-03	1.00E+03	0.0005%	2.50E-06		5.03E-09
Formaldehyde	3.70E-04	4.44E-04	9.80E+00	0.005%	1.30E-05		2.48E-09
						Total Cancer Risk:	1.1E-08

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-19 Screening Test: Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts with Speed Adjustment– Alternative C*

Pollutant	Max 1-hour (µg/m³)	Speed Adjusted max 1-hour Concentration (ug/m3)	Acute REL (µg/m³)	Max 8-hour (µg/m³)	Speed Adjusted max 8-hour Concentration (ug/m3)	Sub-Chronic AEGLs (µg/m³)	Max Annual (µg/m³)	Speed Adjusted max Annual Concentration (ug/m3)	RfC (µg/m³)
Benzene	8.7	10.2	27.0	5.9	6.9	29,000.0	0.2	0.2**	30.0
Ethylbenzene	226.8	266.3	140,000.0	152.5	179.1	140,000.0	4.8	5.6	260.0
Formaldehyde	1.4	1.7	55.0	0.8	0.9	1100.0	0.0	0.0	9.8
n-hexane	553.3	633.9	10,000,000.0	372.0	426.2	10,000,000.0	11.6	13.3	700.0
Toluene	25.3	29.7	5,000.0	17.0	20.0	250,000.0	0.5	0.6	5,000.0
Xylene	446.8	527.1	22,000.0	300.4	354.4	560,000.0	9.4	11.1	100.0

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.
**The max annual concentration with and without the speed impact are the same because of rounding.

Table 3.9-20 Screening Test: Routine Operation Activity Carcinogenic HAPs Impacts with Speed Adjustment in Alternative C*

Pollutant	Max Annual (µg/m³)	Speed Adjustment Annual Concentration (ug/m3)	RfC (µg/m³)	Max Annual as a % of RfC	Cancer Unit Risk Factor thresholds (1/(µg/m³))	Exposure Adjustment Factor	Cancer Risk
Benzene	1.03E-03	1.22E-03	3.00E+01	0.004%	7.80E-06	4.30E-01	4.08E-09
Ethylbenzene	3.97E-03	4.66E-03	1.00E+03	0.0005%	2.50E-06		5.01E-09
Formaldehyde	3.80E-04	4.55E-04	9.80E+00	0.005%	1.30E-05		2.54E-09
						Total Cancer Risk:	1.2E-08

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

Table 3.9-21 Screening Test: Routine Operation Activity Acute and Non-carcinogenic HAPs Impacts with Speed Adjustment– Alternative D*

Pollutant	Max 1-hour (µg/m^3)	Speed Adjusted max 1-hour Concentration (ug/m3)	Acute REL (µg/m^3)	Max 8-hour (µg/m^3)	Speed Adjusted max 8-hour Concentration (ug/m3)	Sub-Chronic AEGLs (µg/m^3)	Max Annual (µg/m^3)	Speed Adjusted max Annual Concentration (ug/m3)	RfC (µg/m^3)
Benzene	8.8	10.5	27.0	5.9	7.0	29,000.0	0.2	0.2**	30.0
Ethylbenzene	232.3	273.1	140,000.0	155.4	182.7	140,000.0	5.0	5.8	260.0
Formaldehyde	1.4	1.7	55.0	0.8	0.9	1,100.0	0.0	0.0	9.8
n-hexane	566.7	651.2	10,000,000.0	379.1	435.6	10,000,000.0	12.1	13.9	700.0
Toluene	25.9	30.4	5,000.0	17.3	20.3	250,000.0	0.6	0.7	5,000.0
Xylene	457.7	540.2	22,000.0	306.2	361.4	560,000.0	9.8	11.5	100.0

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.
**The max annual concentration with and without the speed impact are the same because of rounding.

Table 3.9-22 Screening Test: Routine Operation Activity Carcinogenic HAPs Impacts with Speed Adjustment in Alternative D*

Pollutant	Max Annual (µg/m^3)	Speed Adjustment Annual Concentration (ug/m3)	RfC (µg/m^3)	Max Annual as a % of RfC	Cancer Unit Risk Factor thresholds (1/(µg/m^3))	Exposure Adjustment Factor	Cancer Risk
Benzene	1.00E-03	1.18E-03	3.00E+01	0.004%	7.80E-06	4.30E-01	3.97E-09
Ethylbenzene	3.96E-03	4.65E-03	1.00E+03	0.0005%	2.50E-06		5.00E-09
Formaldehyde	3.70E-04	4.42E-04	9.80E+00	0.005%	1.30E-05		2.47E-09
						Total Cancer Risk:	1.1E-08

Numbers may not add exactly due to rounding
* Values shown are an over-estimate of actual impacts because only a fraction of the total Project impact is due to tailpipe emissions but in this screening test, the total Project impact is conservatively increased by the percent increase for each pollutant due to the speed increase.

4.0 REGIONAL MODEL CONFIGURATION AND ASSESSMENT METHODS

4.1 Overview and Modeling Domains

The photochemical grid model (PGM) CAMx was used to conduct the far-field analysis in this study. PGMs calculate the time-varying air quality concentrations of various pollutants in a spatial grid using emissions and meteorological data inputs. A PGM is a three-dimensional Eulerian model (horizontal and vertical) that simulates both chemical and physical (transport and removal) processes in the atmosphere. PGMs can be used to estimates source impacts for pollutants that are both directly emitted and those formed in the atmosphere through chemical reactions. The schematic in Figure 4.1-1 shows the various components in the regional modeling platform proposed for this study.

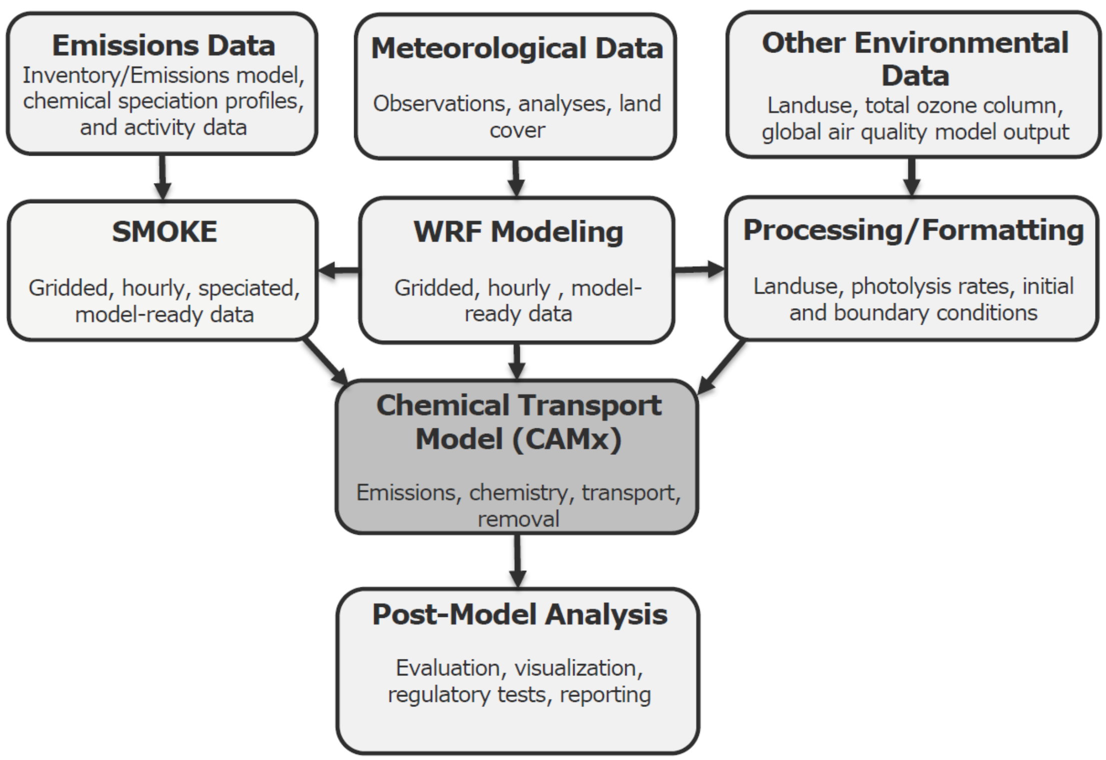


Figure 4.1-1 Schematic showing the overall regional modeling approach.

The CAMx regional air quality modeling methods and results for the Willow MDP Draft EIS were used for the Final EIS as well as this SEIS; the reasons are provided in Section 5.1. The CAMx air quality modeling was conducted on the same 4 km and 12 km grid resolution domains used in the BOEM Arctic modeling study (BOEM, 2017). The BOEM study included a model performance evaluation for ozone, $PM_{2.5}$ and precursors. The 4 km domain is centered on the northern Alaska coast, encompassing the North Slope Borough, and the 12 km domain includes the northern portion of Alaska and the Beaufort and Chukchi

Seas as shown in Figure 4.1-2. The 4 km domain covers almost roughly 300 km distance from the Willow drill sites in the north-south direction and more than 300 km in the east-west direction. Table 4.1-1 provides the 12 km and 4 km modeling domain horizontal definitions. The WRF model was run using 33 layers in the vertical dimension; these layers are collapsed to 24 layers in CAMx to improve computational efficiency (Table 4.1-2).

Table 4.1-1 CAMx and WRF Domain Definitions for 12 km and 4 km Domains

Resolution	Origin (lower-left corner)	Dimension
CAMx – 12 km	(-930 km, -822 km)	146 x 119
CAMx – 4 km	(-550 km, -238 km)	278 x 140
WRF – 12 km	(-990 km, -882 km)	157 x 130
WRF – 4 km	(-570km, -258 km)	289 x 151

Polar stereographic projection: 70°N, 155°W with true latitudes at 70°N

Table 4.1-2 Vertical Layer Interface Definition for WRF Simulations and the Layer-Collapsing Scheme for the CAMx Layers.

WRF					CAMx		
Layer Interface	Eta (η)	Pressure (mb)	Height (m)	Thickness (m)	Layer	Height (m)	Thickness (m)
33	0	100	15725.8	1208.7	24	15725.8	2449.2
32	0.027	124	14517	1240.5			
31	0.06	154	13276.6	1266.3	23	13276.6	2600.3
30	0.1	190	12010.2	1333.9			
29	0.15	235	10676.3	1140.8	22	10676.3	2141.6
28	0.2	280	9535.5	1000.8			
27	0.25	325	8534.8	894.2	21	8534.8	1704.2
26	0.3	370	7640.6	810			
25	0.35	415	6830.5	741.8	20	6830.5	1492.7
24	0.4	460	6088.8	750.9			
23	0.455	510	5337.9	814.8	19	5337.9	1508.6
22	0.52	568	4523.1	693.8			
21	0.58	622	3829.3	646.7	18	3829.3	1252.7
20	0.64	676	3182.6	606.1			

WRF					CAMx		
Layer Interface	Eta (η)	Pressure (mb)	Height (m)	Thickness (m)	Layer	Height (m)	Thickness (m)
19	0.7	730	2576.5	384.2	17	2576.5	754
18	0.74	766	2192.3	369.8			
17	0.78	802	1822.5	356.6	16	1822.5	616
16	0.82	838	1465.9	259.4			
15	0.85	865	1206.5	252.9	15	1206.5	252.9
14	0.88	892	953.6	165.2	14	953.6	165.2
13	0.9	910	788.4	122.2	13	788.4	122.2
12	0.915	924	666.2	120.7	12	666.2	120.7
11	0.93	937	545.5	79.7	11	545.5	79.7
10	0.94	946	465.8	79.1	10	465.8	79.1
9	0.95	955	386.7	78.5	9	386.7	78.5
8	0.96	964	308.2	77.9	8	308.2	77.9
7	0.97	973	230.3	77.3	7	230.3	77.3
6	0.98	982	152.9	53.8	6	152.9	53.8
5	0.987	988	99.2	38.2	5	99.2	38.2
4	0.992	993	60.9	22.9	4	60.9	22.9
3	0.995	996	38	15.2	3	38	15.2
2	0.997	997	22.8	11.4	2	22.8	11.4
1	0.9985	999	11.4	11.4	1	11.4	11.4
0	1	1000	0				

By convention, a 300 km distance from the Project is chosen for identifying areas of interest and assessing impacts from these sources. There are no Class I areas within 300 km of the Willow MDP; the nearest one is Denali National Park which is over 700 km away. Two federally managed areas that are within 300 km – the Gates of the Arctic National Park and Preserve, and the Arctic National Wildlife Refuge – have been previously identified by cooperating agencies for the previous GMT1 and GMT2 far-field analysis; these two areas were likewise evaluated for the Willow far-field analysis. In addition, a third area, the Noatak National Preserve, portions of which are within 300 km, has also been added for analysis. These three assessment areas are Class II areas, as is any area in Alaska that is not a designated Class I area. The assessment areas are shown in Figure 4.1-2. As shown Figure 4.1-2, the 4 km domain does not completely include the 300 km assessment area; however, all three assessment areas that are within 300 km of the project are partially within the 4 km domain. Therefore, only the 4 km domain was modeled and impacts for each of the three assessment areas within the 4 km domain were reported. Table 4.1-3 provides the list of the three assessment areas that are within 300 km of Willow (and thus also inside the 4 km modeling domain).

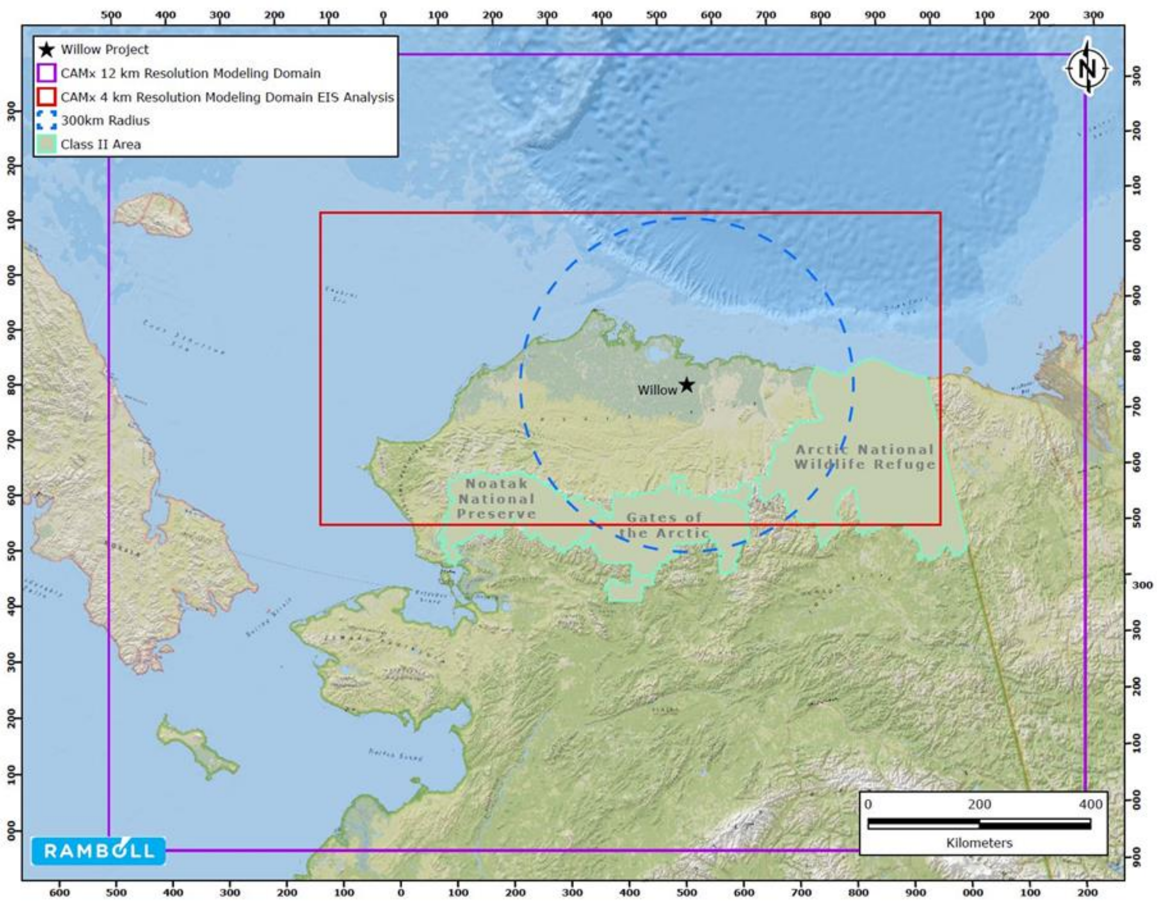


Figure 4.1-2 4 km and 12 km resolution model domains and three assessment areas analyzed.

Table 4.1-3 Three assessment areas considered for air quality analysis.

Area	Administrative Agency
Arctic National Wildlife Refuge	USFWS
Gates of the Arctic National Park	NPS
Noatak National Preserve	NPS

4.2 Meteorological Data

The BOEM Arctic study meteorological data were used for this modeling assessment. WRF v3.6.1 was used for the 4 km and 12 km domains, both these grids were defined on a Polar secant stereographic projection centered at 70°N, 155°W with true latitudes at 70°N. As stated in Brashers et al. (2016), version 3.6.1 of WRF was developed to improve the arctic modeling capabilities. Key physics options selected for the BOEM WRF modeling are shown in Table 4.2-1.

Table 4.2-1 Physics options used in BOEM Arctic WRF modeling

Physics	Parameterization Scheme	Description
Long/Shortwave Radiation	Rapid Radiative Transfer Model for GCM (RRTMG)	Scheme with the MCICA method of random cloud overlap
Micro physics	Thompson	Scheme with ice, snow and graupel processes suitable for high-resolution simulations
Cumulus physics	Grell-Freitas	Scheme that tries to smooth the transition to the cloud-resolving scales
PBL	Yonsei University (YSU)	Scheme with explicit entrainment layer and parabolic K profile in unstable mixed layer
Land surface model (LSM)	Noah land surface model with Polar WRF modifications	Scheme with soil temperature and moisture in four layers, fractional snow cover and frozen soil physics

The model performance of the BOEM Arctic WRF simulation was evaluated using METSTAT tool for both onshore and offshore analysis during 2009-2013 at a 4 km resolution (Brashers et al., 2016). The model BOEM Arctic WRF simulation provides outputs for onshore and offshore wind direction, humidity, wind speed, and temperature. These results are compared against the global-scale National Climate Data Center (NOAA-NCDC, 2014, 2015) DS-3505 observational data for onshore and data from the NOAA National Oceanographic Data Center (NOAA-NODC, 2014) database for offshore. METSTAT uses results for wind direction, humidity, wind speed, and temperature from the BOEM Arctic WRF simulation, NCDC datasets, and NODC datasets to calculate statistical performance metrics (bias, error) for the BOEM Arctic WRF simulation. These metrics were then compared against meteorological model performance benchmarks for simple and complex conditions as an indicator for model performance. Table 4.2-2 provides the simple and complex conditions from literature for various meteorological parameters. Onshore modeling for wind direction and humidity performed very well for all months within simple conditions benchmark. Onshore modelling for wind speed and temperature performed well with most months falling within complex conditions benchmark and several months falling within simple conditions benchmark. Overall, the WRF performed well when compared to onshore surface observations for wind speed, wind direction, humidity, and temperatures for all months of the 2009-2013 simulation period. For 2012, overall the model performance is good and only one or two-month parameter combinations fell outside the complex condition benchmark.

Offshore modeling for humidity performed very well for all open-water months within the simple conditions benchmark. Offshore modeling for wind direction performed satisfactory with most months displaying a slight positive bias and average direction error of 20-45 degree. Temperature performance was also satisfactory with slight negative bias and suggesting that in the warmer months WRF is underpredicting temperatures. The model had difficulties modeling wind speed in the transition month of October, however performed satisfactory in all other months. Overall, the WRF offshore performance did not perform as well as the onshore model. The METSTAT performance discrepancy can be partially attributed to the difficulty of taking offshore measurements due to size and limited number of available buoys for data collection when compared to onshore stations.

The WRF estimated precipitation data was compared with the Parameter-elevation Regressions on Independent Slopes Model (PRISM) datasets, which are spatial maps of climate elements across the United States built by the Spatial Climate Analysis Service (SCAS-OSU, 2001). The high-resolution Alaska PRISM contains 30 year average monthly precipitation for the entire onshore Alaska area at 400 m resolution which are compared with the 5 year average WRF precipitation. Overall WRF is able to reflect the spatial trend similar to PRISM and performed well. However, WRF slightly underpredicted winter-spring precipitation totals throughout much of the Brooks Mountain Range (southern border of North Slope) and underpredicted precipitation totals at areas with highest rainfall over more complex conditions.

For upper–air model evaluation, WRF performs well representing temperature and moisture vertical profiles of the atmosphere including the surface and subsidence-type inversion when compared with upper air data from Point Barrow (Nuvuk) radiosonde dataset. WRF estimated cloud cover fraction (CCF) reasonably well when compared with the Multi-angle Imaging Spectro-Radiometer (MISR) instrument satellite cloud retrievals and overall on average WRF CCF over land appear to show 5 – 15 % high bias.

Table 4.2-2 Meteorological Model Performance Benchmarks for Simple and Complex Conditions

Parameter	Emery et al. (2001)	Kemball-Cook et al., 2005; McNally et al., 2009
Conditions	Simple	Complex
Temperature Bias	⩽ ±0.5 K	⩽ ±1.0 K
Temperature Error	⩽ 2.0 K	⩽ 3.0 K
Temperature IOA	0.8	0.8
Humidity Bias	⩽ ±1.0 g/kg	⩽ ±1.0 g/kg
Humidity Error	⩽ 2.0 g/kg	⩽ 2.0 g/kg
Humidity IOA	0.6	0.6
Wind Speed Bias	⩽ ±0.5 m/s	⩽ ±1.5 m/s
Wind Speed Root Mean Square Error (RMSE)	⩽ 2.0 m/s	⩽ 2.5 m/s
Wind Speed IOA	0.6	0.6
Wind Dir. Bias	⩽ ±10 degrees	⩽ ±10 degrees
Wind Dir. Error	⩽ 30 degrees	⩽ 55 degrees

The WRF model output files were processed in the BOEM study using WRFCAMx v4.4 processor to generate CAMx model-ready meteorological data (Brashers et al., 2016). The Willow EIS used the same meteorological data. Some of the key updates in WRFCAMx v4.4 are the KVPATCH method that improves the surface layer ozone and an option to process sub-grid clouds.

4.3 Emissions Processing

The development and preparation of the regional emissions is described in Section 2.3.2 "Regional Emissions Inventories". In brief, the non-Willow emissions are based on data developed in the BOEM Arctic study (Field Simms et al., 2014) and the data sources for the regional emissions and natural emissions are summarized in Table 4.3-1. As described in Field Simms et al. (2014), the future year emissions are representative of full build-out scenarios that are based on the projections of anticipated development. The BOEM emissions were adjusted to reduce sea salt and unpaved road dust and to incorporate additional emissions for onshore RFD.

Table 4.3-1 Data Sources for BOEM Emission Inventory Platform

Emission sector	Data Source
North Slope Borough (NSB), Chukchi and Beaufort Sea Anthropogenic Emissions	BOEM Arctic Air Quality study developed for Onshore and Offshore sources.
Anthropogenic emissions for Canada	US EPA 2011 based modeling platform v6.2
Anthropogenic emissions outside US and Canada	GEOS-Chem global model (retrospective inventory and EDGAR inventory)
Biogenic	Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.03
Fire	Day-specific Fire Inventory (FINN) from the National Center for Atmospheric Research (NCAR) processed using Emissions Processing System version 3 (EPS3) model
Sea Salt emissions	The seasalt emissions are processed using revised seasalt v3.3 processor.
Lightning emissions	Inline lightning emissions derived from Community Multiscale Air Quality (CMAQ) model using the convective precipitation rate from meteorological data

The SMOKE system (version 3.6) was used to generate model ready emissions for the regional emissions shown in Section 2.3.2 "Regional Emissions Inventories" to develop hourly, speciated and gridded CAMx-ready emission inputs.

4.4 Regional Model Configuration

The CAMx photochemical grid model was applied over the 12 km and 4 km modeling domains shown in Figure 4.4-1. The NEPA analysis area for far-field air quality impacts is the spatial extent of the 4 km domain which is approximately 300 km north-south from Willow and farther out in the east-west directions. CAMx version 6.5 was applied with the CB6r4 gas phase mechanism. The CAMx model setup options for this modeling assessment are summarized in Table 4.4-1.

As described in Section 1.2.2.2 "Regional Modeling", CAMx was used to simulate various future year scenarios. Each Cumulative Alternative scenario includes all the cumulative sources detailed in Section 2.2 "Cumulative Emissions for the Willow Alternatives" as well as those sources specific to the Willow MDP alternatives. Willow MDP impacts are estimated using the difference between the cumulative 2025 Alternative (B or C) simulation and the Cumulative 2025 No Project simulation. The impacts derived using this approach are referred as using the "Brute Force" method. The cumulative No Action

Alternative simulation includes all the cumulative sources except those specific to each Willow MDP alternative. The only purpose of the Cumulative 2025 No Project simulation is to derive those impacts and no other modeling results from that simulation are reported here. The simulations were conducted over the spatial extent of the 4 km resolution modeling domain. The cumulative effects for NEPA were obtained directly from the Cumulative Alternative B (Proponent's Project) and C (Disconnected Infield Roads) Scenarios.

Table 4.4-1 CAMx Model Setup Configuration and Description

Science option	Configuration	Description
Gas phase chemistry	CB6r4	Updated isoprene chemistry; heterogeneous hydrolysis of organic nitrates; active methane chemistry and ECH4 excess methane tracer species (Ruiz and Yarwood, 2013).
Aerosol phase chemistry	SOAP2.1+ISORROPIA	Updated photolysis rates in SOAP2.1
Photolysis Rate	TUV V4.8 preprocessor	Clear-sky photolysis rates based on day-specific Total Ozone Mapping Spectrometer (TOMS) data; CAMx in-line adjustment based on modeled aerosol loading
Horizontal Diffusion	Explicit horizontal diffusion	Spatially varying horizontal diffusivities determined based on the methods of Smagorinsky (1963)
Vertical Diffusion	K-theory 1st-order closure	Vertical diffusivities from WRFCAMx and KVPATCH; land-use dependent minimum diffusivity (minimum vertical eddy diffusivity = 0.1 to 1.0 square meters/second)
Dry Deposition	ZHANG03	Dry deposition scheme by Zhang et al. (2001; 2003)
Wet deposition	CAMx-specific formulation	Scavenging model for gases and aerosols (Seinfeld and Pandis, 1998)

The initial and lateral boundary conditions (ICBC) for the 4 km modeling domain for all scenarios were derived from the 3-D model outputs of corresponding 12 km simulations. Note that for the 4 km Base Year scenario the ICBC are derived from the corresponding 12 km 2012 simulation, while the future year simulations are derived from a 12 km 2020 simulation. The hourly varying boundary conditions for the 4 km domain are generated for each day in the modeling period. The CAMx simulations were conducted by splitting the runs into four quarters and initializing the runs with a 10-day spin-up period as is conventionally done.

The day specific ozone column data were based on the TOMS data measured using the Ozone Monitoring Instrument (OMI) satellite. The in-line photolysis rates were calculated using Tropospheric Ultraviolet Visible (TUV) v4.8 preprocessor to generate day-specific lookup tables. The cloud cover and aerosol loadings effects on photolysis rates are crucial, so CAMx was configured to use in-line TUV with these adjustments. The same clear-sky rates were used for both base and future years.

The EIS did not include any Source Apportionment model runs. Instead impacts for each alternative were derived via “brute force”, that is by direct difference between scenarios and the No Action Alternative modeling results. Cumulative impacts were derived from the total concentrations estimated in the Cumulative Alternative B (Proponent’s Project) and C (Disconnected Infield Roads) scenarios.

A model performance evaluation (MPE) was conducted on the 2012 Base Year scenario in the 4 km domain. The model data were compared with the ambient observational data at the monitoring sites available in the 4 km domain. As mentioned in previous reports (ADEC, 2011; BOEM, 2017) the ambient data available near the Arctic region is very limited and sparse. Table 4.4-2 lists the air monitoring sites in the 4 km domain and the chemical species that were evaluated. Figure 4.4-1 shows the locations of the monitoring sites. The sites are in coastal portions of the North Slope and were originally established to satisfy PSD permitting requirements for new major sources. The monitoring data at these sites are from the BOEM study (BOEM 2017); additionally, Nuiqsut, Deadhorse and Wainwright sites have been included in the analysis. Additional details on how the MPE was conducted can be found in Attachment B.

Table 4.4-2 Monitoring Sites Used in Model Performance Evaluation

Site Name	Site ID	Source[a]	Lat	Lon	Species
APAD	02185APAD	AK Permit Data	70.26611	-148.7563	O_3
DS1F	02185DS1F	AK Permit Data	70.29917	-149.6847	O_3
BRW	02185XBRW	NOAA	71.323	-156.6114	O_3
CCP	02185XCCP	AK Permit Data	70.31936	-148.5166	O_3, $PM_{2.5}$
Nuiqsut		CPAI	70.22361	-150.9996	$PM_{2.5}$
Deadhorse		ADEC	70.22201	-148.4223	$PM_{2.5}$ components (Nitrate [NO3], SO4, EC, Organic Carbon (OC), Ammonium [NH4])
Wainwright		ADEC	70.64111	-160.007	$PM_{2.5}$ components (NO3, SO4, EC, OC, NH4)

[a] AK Permit Data from ADEC air quality permit files as supplied for use in BOEM study by the ADEC; NOAA ESRL published data for the Barrow Atmospheric Baseline Observatory (http://www.esrl.noaa.gov/gmd/obop/brw/); ConocoPhillips Alaska, Inc. (CPAI)

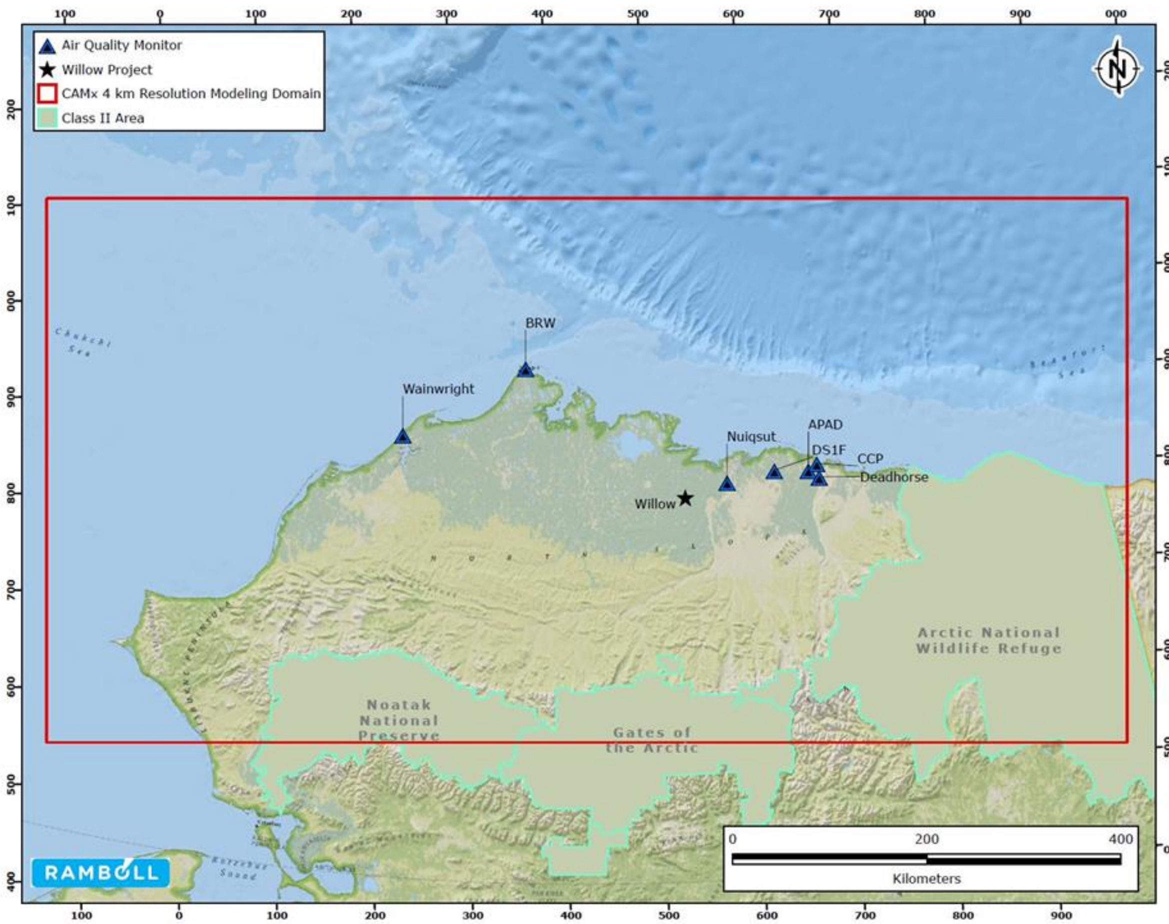


Figure 4.4-1 4 km model domain and the monitoring sites considered for the MPE analysis.

The CAMx model data were spatially and temporally paired with the monitoring data. As performed in BOEM study, the model data were averaged over the 9-grid cell block centered on the individual monitoring site and were used to conduct the site-by-site comparison. The paired model and observational data were used to calculate the Normalized Mean Bias, Normalized Mean Error, Fractional Bias and Fractional Error statistical metrics as shown in Table 4.4-3. These metrics were compared with the photochemical modeling performance goals and criteria standards shown in

Table 4.4-4 for O_3 and $PM_{2.5}$ (Emery et al., 2017) to understand the model performance in this Arctic region. The benchmark "Goal" indicates the performance that the best current models are expected to achieve, and the "Criteria" indicates the performance most of the models have achieved. These goals and criteria standards are developed mainly for model applications within the continental US, but as no other information exists the same standards were applied to this arctic modeling application. In the EIS, plots were provided for the sites listed in Table 4.4-2 to document the model performance for the 4 km domain. Model performance for the speciated $PM_{2.5}$ components listed in Table 4.4-2 were evaluated using the criteria in

Table 4.4-4 from Emery et al. (2017) and by using the "bugle plots" of Boylan and Russell (2006).

Table 4.4-3 Normalized Mean Bias and Error Statistical Metrics Formulae

Statistical Measure	Mathematical Expression
Normalized Mean Error (NME) (%)	$\frac{\sum_{i=1}^{N} \lvert P_i - O_i \rvert}{\sum_{i=1}^{N} O_i}$
Normalized Mean Bias (NMB) (%)	$\frac{\sum_{i=1}^{N} (P_i - O_i)}{\sum_{i=1}^{N} O_i}$
Fractional Bias (FB)	$\frac{2}{N}\sum\frac{(P_j - O_j)}{(P_j + O_j)} \times 100$
Fractional Error (FE)	$\frac{2}{N}\sum\frac{\lvert P_j - O_j \rvert}{(P_j + O_j)} \times 100$

Table 4.4-4 Photochemical Model Performance Goals and Criteria from Emery et al., 2017.

Species	Normalized Mean Bias		Normalized Mean Error	
	Goal	Criteria	Goal	Criteria
1-hr or MDA8 Ozone	< ±5%	< ±15%	< 15%	< 25%
24-hr $PM_{2.5}$, SO_4, NH_4	< ±10%	< ±30%	< 35%	< 50%
24-hour NO_3	< ±15%	< ±65%	< 65%	< 115%
24-hour OC	< ±15%	< ±50%	< 45%	< 65%
24-hour EC	< ±20%	< ±40%	< 50%	< 75%

4.5 Assessment Methods

The CAMx modeling system was used to estimate the potential cumulative air quality and AQRV impacts in the three assessment areas in Table 4.1-3 as well as the overall 4 km domain. Model predicted concentrations were further post-processed in the form of the NAAQS for multiple pollutants and for visibility impairment from particulate matter and nitrogen and sulfur deposition. The modeled hourly values were carefully averaged to the appropriate time range for comparison with standards and criteria.

4.5.1 Air Quality Impacts

CAMx simulation outputs were processed to analyze the air quality impacts with respect to the NAAQS, PSD increments and AQRV metrics. Presented below is the description for each analysis. These metrics were processed for analyzing both the cumulative effects and the project specific impacts.

Impacts for the three assessment areas have been derived using Geographical Information Systems (GIS) and by intersecting the three assessment areas with the modeling domain to extract the 4 km model grid-cells that lie in these areas. The impacts are predicted for the three assessment areas by considering the air quality impacts from these modeling grids.

4.5.2 NAAQS and AAAQS

The cumulative and project air quality impacts were calculated from the CAMx modeling results for the criteria pollutants CO, O_3, $PM_{2.5}$, PM_{10}, NO_2 and SO_2 and compared to the NAAQS primary and secondary standards and the AAAQS. The primary NAAQS protect public health including sensitive populations and the secondary NAAQS protect public welfare. The photochemical grid model provides hourly concentrations for multiple pollutants at each grid cell in the modeling domain. To provide model predictions consistent with the NAAQS and AAAQS, these model results are post-processed and summarized in tables. The criteria pollutants concentrations for each grid cell in the modeling domain are compared with the respective species' AAQS standard to evaluate the impacts due to each alternative plus other cumulative sources. Tabulated results and spatial plots of concentrations are provided in Chapter 5 in the form of the applicable AAQS.

For ozone, there is one averaging period to evaluate and the level of the standard is identical for both primary and secondary NAAQS and the AAAQS. The following steps were conducted to process model results for comparison to the ozone standard. First the maximum daily 8-hour average (MDA8) is calculated for each day in the annual simulation, then the fourth-highest concentration (H4MDA8) is determined for each grid cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum H4MDA8 from the collection of modeling grid cells that lie in these areas. As mentioned above project impacts are derived using the brute force method. For ozone, this is performed by calculating the difference between the cumulative H4MDA8 values of the action alternative and the No Action Alternative. Note that the difference is performed over the maximum H4MDA8 without matching cumulative values in either space (different cells) or time (different days).

For CO, there are two averaging times to evaluate for comparison to NAAQS and AAAQS; both of the averaging periods are primary standards. The 8-hour standard is calculated from the hourly concentrations using non-overlapping 8-hour averages (3 values for each day). After this averaging is performed the second-highest value for the annual simulations is saved for each grid cell in the modeling domain. The 1-hour standard is calculated by first keeping the 1-hour maximum for each day and then selecting the second-highest value for the annual simulations for each grid cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for each standard for those model grid cells that lie in these areas. Project impacts are derived using the brute force method.

For NO_2, there are two averaging times to evaluate for comparison to NAAQS and AAAQS: a 1-hr averaging time, which is a primary NAAQS, and an annual averaging time, which is both a primary and secondary NAAQS. The 1-hr standard is calculated by first calculating the 1-hour maximum for each day and then selecting the eighth-highest value for the annual simulations (equivalent to the 98^{th} percentile) for each grid cell in the modeling domain. The annual standard is calculated from the annual average of hourly concentrations for each grid cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for each standard for those model grid cells that lie in these areas. Project impacts are derived using the brute force method.

For $PM_{2.5}$ there are two averaging times to evaluate for comparison to NAAQS and AAAQS: a 24-hour averaging time, which is both a primary and secondary NAAQS, and an annual averaging time, which is has two separate NAAQS. The primary annual $PM_{2.5}$ NAAQS is of 12 μg/m^3 and the secondary annual $PM_{2.5}$ NAAQS is 15 μg/m^3. The annual average results are compared to the annual average of hourly concentrations for each cell in the domain. The 24-hr average results are calculated from the hourly concentrations by first producing daily 24-hr averages and then selecting the eighth-highest value (equivalent to the 98th percentile) for each grid cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for each standard for those model grid cells that lie in these areas. Project impacts are derived using the brute force method.

For PM_{10} averaging period to evaluate and the level of the standard is identical for both primary and secondary NAAQS and the AAAQS. The 24-hr average results are calculated from the hourly concentrations by first producing daily 24-hr averages and then selecting the second-highest value for each grid cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for each standard for those model grid cells that lie in these areas. Project impacts are derived using the brute force method.

For SO_2 there are four averaging periods to evaluate for comparison to NAAQS and AAAQS: a 1-hour averaging time, which is a primary NAAQS; a 3-hour averaging time, which is a secondary NAAQS; a 24-hour averaging time, which is only an AAAQS; and an annual averaging time, which is only an AAAQS. The 1-hr average results are calculated by first keeping the 1-hour maximum for each day and then selecting the fourth-highest value for the annual simulations (equivalent to the 99th percentile) for each modeling grid cell. The 3-hr average results are calculated from the hourly concentrations using non-overlapping 3-hours averages (8 values for each day). After this averaging is performed the second-highest value over the full annual simulation is reported for each cell in the modeling domain. For the Alaska, the 24-hr average results are calculated by selecting the second-highest value from the daily 24-hr averages, while the annual average results are calculated from the annual average of hourly concentrations for each cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for each standard for those model grid cells that lie in these areas. Project impacts are derived using the brute force method.

4.5.3 PSD Impacts

Project impacts at the three assessment areas are compared with PSD Class II increments listed in Table 1.2-2. The comparison to the Class II increments does not represent a regulatory PSD increment consumption analysis and is presented for information only. Note that PSD increments are reported in μg/m^3 and when the species is a gaseous pollutant the mixing ratio has been converted to concentration using standard ambient temperature and pressure.[13]

For NO_2 the PSD increment is calculated from the annual average of hourly concentrations for each cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for those model grid cells that lie in these areas.

For both the 24-hour PM_{10} and $PM_{2.5}$ PSD increment, the hourly concentrations are first averaged to daily 24-hr averages and then the second-highest value selected for each modeling grid cell in the

[13] T= 298K, P= 1 atm

computational domain. The annual PM_{10} and $PM_{2.5}$ PSD increment is calculated from the annual average of hourly concentrations for each cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for those model grid cells that lie in these areas.

For the 3-hr SO_2 PSD increment, hourly concentrations are averaged using non-overlapping 3-hours periods (8 values for each day). After this averaging is performed the second-highest value for the annual simulations is saved for each cell in the computational domain. For the 24-hr SO_2 PSD increment, the hourly concentrations are first averaged to daily 24-hr averages and then the second-highest value selected for each modeling grid cell in the computational domain. The annual SO_2 PSD increment is calculated from the annual average of hourly concentrations for each cell in the modeling domain. Finally, the cumulative values reported for the three assessment areas correspond to the maximum value for those model grid cells that lie in these areas.

4.5.4 <u>Visibility</u>

Project Impacts

Particulate matter concentrations in the atmosphere contribute to the visibility degradation by both scattering and absorption of visible light. The combined effect of scattered and absorbed light is called light extinction. Changes in the light extinction for each modeling scenario was calculated at the three assessment areas. The visibility metric used in this analysis is called Haze Index (HI) which is measured in dv units and is defined as follows:

$$HI = 10 \times \ln [b_{ext}/10]$$

Where b_{ext} is the atmospheric light extinction measured in inverse megameters (Mm^{-1}) and is calculated primarily from atmospheric concentrations of particulates.

The project's contribution is determined by calculating the incremental changes in the extinction from background concentrations due to the project emissions. This quantity that measures the extinction changes in the Haze Index is referred to as "delta deciview" (Δdv):

$$\Delta dv = 10 \times \ln[b_{ext(SC+background)}/10] - 10 \times \ln[b_{ext(background)}/10]$$

$$\Delta dv = 10 \times \ln[b_{ext(SC+background)}/b_{ext(background)}]$$

Here $b_{ext(SC+background)}$ refers to atmospheric light extinction due to impacts from the source category plus background concentrations, and $b_{ext(background)}$ refers to atmospheric light extinction due to natural background concentrations only.

For this study we calculated the project impacts on visibility from the CAMx modeling results using a brute force method. These are the overall steps followed in calculating the visibility impacts:

1. The project impacts are derived from the difference in the hourly modeling results between the Cumulative Alternative Scenario and the No Action Alternative Scenario. The differences are then averaged to daily concentrations in the 4 km modeling domain.
2. The concentration differences in (1) are extracted from the grid cells that fall in the three assessment areas.

3. The Interagency Monitoring of Protected Visual Environments (IMPROVE) equation is used to calculate reconstructed extinction for the impacts (b_{ext_SC}) following the FLAG (2010) procedures at the three assessment areas.
4. The natural (background) monthly extinction ($b_{ext\_background}$) is calculated using the IMPROVE equation and the relative humidity adjustment factors reported in FLAG (2010) tables 5 to 9.
5. With the results in (2) and (3) delta deciviews are calculated using the Δdv formula above. The highest Δdv across all grid cells overlapping an assessment area is selected to represent the daily value at each of the three assessment areas.
6. Results in (5) are sorted from lowest to highest Δdv and then the maximum, the 98th percentile (eighth-highest value) and the number of days with a Δdv greater than 0.5 and 1.0 are reported for each assessment area. Also, the 20th percentile and 80th percentiles are reported and used to represent the 20% best days (B20) and 20% worst days (W20) respectively.

Note that the relative humidity adjustment factors reported in FLAG (2010) tables 5 and 9 are only provided for Class I areas. The calculations described in this section rely on the adjustment factors for Denali National Park (NP) which is the closest Class I area to the project but located outside the 4 km computational domain.

Cumulative Impacts

For this analysis cumulative visibility design values are assessed using the Software for Model Attainment Test- Community Edition (SMAT-CE) version 1.2 (South China University of Technology, 2015). SMAT-CE provides model-adjusted visibility design values that are consistent with USEPA's "Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (USEPA 2018). Photochemical models are affected by biases, i.e., model results are a simplification of natural phenomena and, as such, model results tend to over- or under-estimate particulate matter concentrations. The use of SMAT-CE aids in mitigating model bias for visibility calculations by pairing model estimates with actual measured concentrations.

SMAT-CE calculates baseline and future-year visibility levels for both the 20 percent best and 20 percent most impaired days for each of the 156 Class I Areas. To do this, SMAT-CE adjusts the modeled air quality concentrations based on measured air quality concentrations to account for possible model bias utilizing the relative response factor approach described below. Within SMAT-CE, model-predicted concentrations of chemical compounds that scatter or absorb light are converted to estimates of light extinction using the IMPROVE equation (Hand and Malm 2006). The IMPROVE equation reflects empirical relationships derived between measured mass of PM components and measurements of light extinction at IMPROVE monitoring sites in Class I areas. The IMPROVE equation calculates light extinction as a function of relative humidity for large and small particulate matter. As a final step in SMAT-CE, light extinction values are converted into dv, a measure for describing the ability for the human eye to perceive changes in visibility.

The USEPA guidance for estimating future-year visibility levels recommends using the photochemical grid model results in a relative sense to scale the visibility current design values (DVC). The visibility DVCs are based on a 5-year average of monitored IMPROVE data centered on the typical modeling year. For this analysis, the Typical Year is 2012, so the 5-year period centered on 2012 is 2010 through 2014.

Scaling factors, called relative response factors (RRFs), are calculated from the modeling results. RRFs are applied to the DVC to predict future-year design values (DVF) at a given monitoring location using the following equation:

DVF = DVC x Relative Response Factor (RRF)

RRFs are the ratio between the model-predicted concentrations in the future-year modeling scenario and the Typical Year modeling scenario. RRFs are calculated for each individual chemical component that contributes to light extinction based on the model grid cells surrounding a monitoring site.

SMAT-CE depends on IMPROVE monitors to assess visibility impacts. Note that there are no Class I areas within the 4 km computational domain. So the Denali NP IMPROVE monitor was selected for this analysis. The following steps indicate how the analysis was performed for each assessment area in the study:

1. Hourly concentrations of modeled particulate matter were averaged to daily values for each component of the IMPROVE equation for all the grid cells in the 4 km domain. This is step is performed for both the 2012 Base scenario and the corresponding Cumulative Alternative scenario modeling results.
2. Modeled concentrations from (1) were extracted for a 3x3 matrix centered around the corresponding assessment area centroid. The centroid was determined by the area left within the 4 km domain using GIS.
3. The latitude and longitude values that correspond to the IMPROVE monitor at Denali and the surrounding 3x3 points at a 4 km distance to the monitor were assigned to the modeled concentrations in step (2).
4. The files in step 3 were used as the model input for SMAT-CE Denali NP data.

All the steps described above are applied to all the three assessment areas for this study.

SMAT-CE was configured using the settings provided in Table 4.5-1 and was run with the modeling results for each of the future-year 2025 modeling scenarios. The changes in Table 4.5-1 from SMAT-CE defaults and other changes necessary to accurately incorporate the model year selected for the Typical Year and other data that is dependent on the Typical Year.

Table 4.5-1 SMAT-CE Configuration Settings

Option	Main category	Setting	Default	This Study
Desired Output	Scenario Name	Name		
	Forecast	Temporally-adjust visibility levels at class 1 area	Yes	Yes
		Improve algorithm	use new version	use new version
		Use model grid cells at monitors	Yes	Yes
		Use model grid cells at class 1 area centroid	No	No
	Actions on run completion	Automatically extract all selected output files	Yes	Yes
Data Input	Monitor data	File name	ClassIareas_NEWIMPROVEALG_2000to2015_2017feb13_TOTAL.csv	ClassIareas_NEWIMPROVEALG_2000to2015_2017april27_IMPARIMENT.csv[a]
	Model data	Baseline file	SMAT.PM.Large.12.SE_US2.2011eh.camx.grid.csv	Willow base output 2012[b]
		Forecast file	SMAT.PM.Large.12.SE_US2.2017eh.camx.grid.csv	Willow Run 3 output Year 2025[c]
	Using model data	Temporal adjustment at monitor	3x3	3x3
Filtering	Choose visibility data years	Start monitor year	2009	2010[d]
		End monitor year	2013	2014[d]
		Base model year	2011	2012[d]
	Valid visibility monitors	Minimum years required for valid monitor	3	3

[a] Monitor data that selects the 20% most impaired days is used instead of the 20% worst days
[b] Baseline file changed from default (2011) to the Year (2012) base modeling year.
[c] Forecast file changed from default year to the modeled future-year (2025) scenario for this analysis. SMAT-CE was run three times once for the three assessment areas since the model data required translating for SMAT program to spatially match an IMPROVE monitor (Denali) with co-located model data.
[d] The values for the Start, End and Base model years are set to reflect a year centered on the Base Year (2012) and to perform the current deciview calculation with the 5-year period surrounding this year (2010 to 2014).

4.5.5 Deposition

Model-predicted fluxes of total sulfur (S) and nitrogen (N) compounds have been used to estimate the deposition impacts at the three assessment areas for this project. Total deposition includes the sum of wet and dry deposition fluxes for all modeled sulfur and nitrogen containing compounds presented in Table 4.5-2. Total nitrogen and sulfur deposition cumulative model estimates are derived by adding the hourly model output to annual totals for each individual grid cell in the computational domain. This study reports both the maximum and the average total deposition from all the cells in a given assessment area.

Table 4.5-2. List of Modeled Species Included in Calculation of Total Nitrogen and Sulfur Deposition

Deposition	Species Included
Nitrogen	NO: Nitric oxide NO2: Nitrogen dioxide PAN: Peroxyacetyl nitrate NO3: Nitrate radical N2O5: Dinitrogen pentoxide PNA: Peroxynitric acid HONO: Nitrous acid HNO3: Nitric Acid NTR1: Simple organic nitrate NTR2: Multi-functional organic nitrates PANX: C3 and higher peroxyacyl nitrate NH3: Ammonia OPAN: Peroxyacyl nitrate (PAN compound) from peroxyacyl radical from Aromatic ring opening product (unsaturated dicarbonyl) PNH4: Particulate ammonium PNO3: Particulate nitrate
Sulfur	SO2: Sulfur dioxide SULF: Sulfur acid (gaseous) PSO4: Particulate sulfate

Cumulative assessment is performed by comparing the modeled predictions for total nitrogen deposition from all sources with critical loads derived by NPS. A critical load is the level of deposition below which no harmful effects are expected to an ecosystem. The critical load values available from the NPS website (NPS, 2018) for Alaska are protective of the tundra ecoregion and range from 1.0 to 3.0 kg/ha-yr.

The project impacts, annual nitrogen and sulfur deposition fluxes due to each alternative at the three assessment areas is compared with the DAT developed by the NPS and USFWS of 0.005 kg/ha-yr for nitrogen and sulfur deposition as specified by FLAG (2010). Note that the deposition analysis threshold is not an adverse impact threshold; rather, it is an approximate value of the naturally occurring deposition where values below are considered negligible. The project impacts are derived from the difference in total deposition between each Cumulative Alternative scenario and the No Action Alternative scenario.

Acid Neutralizing Capacity

Previous studies in the region such as GMT2 did not include an analysis of the effect on the acid neutralizing capacity (ANC) of sensitive lakes due to the lack of ANC data. Since the necessary ANC data are not available for sensitive lakes in the region, the change in ANC was not calculated for this study.

5.0 REGIONAL AIR QUALITY IMPACT ASSESSMENT RESULTS

CAMx simulation outputs were processed to analyze the air quality impacts with respect to NAAQS and AAAQS metrics, Prevention of Significant Deterioration (PSD) increments and AQRV metrics. These metrics were processed for analyzing Project impacts in Alternative B and Alternative C as well as Cumulative Effects. The Project impacts were obtained via "brute force" modeling method by difference between the Cumulative No Action Alternative scenario and the Cumulative Alternative scenario. Cumulative impacts were derived from the total concentrations estimated in the Cumulative scenario, i.e., the CAMx run with all regional sources included.

Impacts at the three assessment areas shown in Figure 4.1-2 were obtained using GIS and intersecting the three assessment areas evaluated within the modeling domain (Arctic National Wildlife Refuge, Gates of the Arctic National Park and Preserve, and Noatak National Preserve) to identify the 4 km model grid cells that lie in these areas. The impacts are predicted for the three assessment areas by considering the air quality impacts from these modeling grid cells.

The cumulative and Project air quality impacts were calculated from the CAMx modeling results for the criteria pollutants CO, O_3, $PM_{2.5}$, PM_{10}, NO_2 and SO_2 and compared to the NAAQS and AAAQS standards in Table 1.2-1. The criteria pollutants concentrations for each grid cell in the modeling domain are compared with the respective NAAQS metric to evaluate the impacts due to the Project plus other cumulative sources. Tabulated results and figures are provided below to illustrate the spatial representation of the overall modeled impacts in terms of the standards.

Project impacts at the three assessment areas (shown in Figure 4.1-2) were also compared with PSD Class II increments listed in Table 1.2-2. The comparison to the Class II increments does not represent a regulatory PSD increment consumption analysis and is presented for information only. Sulfur and Nitrogen deposition values are calculated as described in Chapter 4 and are compared with the Critical loads and Deposition Analysis Thresholds (DATs).

5.1 Summary of Air Quality and Air Quality Related Value Impacts*

Impacts are discussed for Alternative B and Alternative C which were previously modeled and for Alternative D and Alternative E that were not modeled.

Modeling was performed for Alternative B and Alternative C with the Willow MDP emissions inventories developed during the DEIS. Remodeling with updated emissions inventories for this SDEIS was not necessary and therefore not performed for the reasons discussed below. The air concentrations modeled in the DEIS due to all cumulative sources were below applicable air quality thresholds. The modeled air concentrations due to Project sources alone were well below the ambient air quality standards anywhere in the modeling domain and the cumulative concentrations are primarily due to other regional sources rather than Project emissions. Emissions from the Project are responsible for a very small fraction of regional emissions (up to 6.0% depending on pollutant). Moreover, peak annual Project emissions under Alternative E are lower than under Alternative B. In addition, changes to Project emissions between this SDEIS and those modeled in the DEIS and included in the FEIS constitute a very small fraction of regional emissions (up to 4.5% depending on pollutant). For details, see the emissions inventories discussed in Chapter 2 of this AQTSD and in Chapter 2 of the AQTSD for the Draft EIS.

The modeled cumulative and Project-specific impacts under Alternative B and Alternative C were compared with the NAAQS and AAAQS standards for criteria pollutants and were found to be below all standards throughout the modeling domain. The cumulative air quality impacts at the three assessment areas are well below the NAAQS and AAAQS standards. The Project-specific impacts are higher near the Willow MDP area and drop off rapidly with distance from the Project. The Project impacts are below the PSD increment thresholds for all criteria pollutants at all three assessment areas. Project-specific impacts of both nitrogen and sulfur deposition at three assessment areas are below the 0.005 kg/ha-yr DATs. The nitrogen cumulative deposition impacts were compared with the critical loads value of 1.0 – 3.0 kg/ha-yr and were found to be below or within this range at all three assessment areas. Visibility was examined for Project specific impacts with the FLAG (2010) screening method and also cumulatively using the SMAT-CE tool. At all three assessment areas examined, the Project visibility impairment impacts did not exceed either 1 or 0.5 delta deciview thresholds. With regards to cumulative visibility impairment, modeled results show that among the three assessment areas examined the area with the worst cumulative visibility during the 20 percent best days is Noatak, while Gates of the Arctic has the worst cumulative visibility during the 20 percent most impaired days.

Alternative D impacts would likely be lower than those in Alternative C due to lower emissions in the former in general. Alternative E impacts would likely be lower than those in Alternative B due to lower peak annual emissions.

5.2 Base Year Model Performance Evaluation

The CAMx 2012 Base Case simulation at 4 km resolution was evaluated for maximum daily 8-hour ozone (MDA8) and 24-hr averaged $PM_{2.5}$ and $PM_{2.5}$ species (sulfate, nitrate, ammonium, elemental carbon (EC), organic carbon (OC), crustal soil, and sodium). Details of the model performance evaluation (MPE) are provided in Attachment B.

Overall, the model performs reasonably well, with the best annual-based performances for MDA8 ozone and the worst annual-based performance for crustal soil. Specifically, annual-based NMB for ozone fall within the goal range listed in Emery, et al. (2017) of ±5%. However, the model presents temporal biases for MDA8 ozone and $PM_{2.5}$ with underprediction in the colder months and overprediction in the warmer months, especially when observations are very low. The performance for these species during individual quarters is worse than the annual-based performance, and annual-based errors are generally higher than annual-based biases because the opposing signs of the biases throughout the year cancel each other out. For example, the annual-based NMB for MDA8 ozone falls within the goal range listed in Emery, et al (2017) while the annual-based and quarterly-based NME values for MDA8 ozone fall outside the criteria value of 25% listed in Emery, et al. (2017). These and other criteria discussed here are not bright-line (pass/fail) thresholds. A similar trend is observed for $PM_{2.5}$, with annual NMB values falling within the criteria range for $PM_{2.5}$ listed in Emery, et al. (2017) of ±30% but NMB values for each quarter, excluding the 2nd quarter (Q2) for the domain-wide analysis, falling outside the criteria range and annual-based NME values above the criteria value of 30%.

For $PM_{2.5}$ species, the model performs best for nitrate and ammonium with MFE and MFB values throughout the year at Deadhorse and Wainwright within criteria ranges established in bugle plots. Most of the MFB and MFE values for EC and sodium fall within criteria ranges. MFB and MFE results for sulfate and crustal soil are more mixed. Similar to $PM_{2.5}$, speciated data like sulfate, nitrate, and ammonium are biased high in quarter 3 when observational data tends to be very low. Crustal soil is generally overpredicted in the year. OC is systematically biased low with all MFB and MFE values falling outside criteria ranges.

In summary, the model performs reasonably well excluding difficulties reproducing very low observational data and systematic biases for OC and soil. Details of the model performance evaluation are provided in Attachment B.

5.3 Alternative B (Proponent's Project)

This section presents the analysis for Project and cumulative impacts for Alternative B. The model outputs are processed following the methodology discussed in Chapter 4. The concentrations are compared with NAAQS and AAAQS standards, PSD increments and deposition thresholds for the full domain and at the three assessment areas.

5.3.1 NAAQS and AAAQS Analysis

Table 5.3-1 provides a summary of maximum ambient air quality concentrations from the cumulative scenario for all criteria pollutants at all assessment areas. In the modeling domain, the air quality concentrations for all criteria pollutants are below the NAAQS and AAAQS.

Table 5.3-2 shows the maximum Project impacts for all criteria pollutants in terms of the standards. The Project impacts for all pollutants are well below the NAAQS and AAAQS standards and show negligible contribution to the cumulative air quality concentrations.

Table 5.3-1 Comparison of Modeled Cumulative Concentrations under Alternative B (Proponent's Project) with AAQS

	CO		NO_2		O_3	$PM_{2.5}$		PM_{10}	SO_2			
	8 hours	1 hour	1 hour	Annual	8 hours	Annual	24 hours	24 hours	1 hour	3 hours	24 hours	Annual
	ppm	ppm	ppb	ppb	ppb	μg/m³	μg/m³	μg/m³	ppb	ppm	ppm	ppm
Primary NAAQS and AAAQS[a, b]	9	35	100	53	70	12	35	150	75	0.5	0.14	0.03
Secondary NAAQS[b]	NA	NA	NA	53	70	15	35	150	NA	0.5	NA	NA
Modeled Concentrations												
Full Domain[1]	3.1	0.9	72.4	22.0	55.5	10.1	31.4	121.3	58.1	0.057	0.035	0.009
Arctic National Wildlife Refuge	0.6	0.4	21.0	1.6	55.5	2.5	7.3	30.5	0.7	0.002	0.001	0.000
Gates of the Arctic	0.2	0.2	1.2	0.2	53.4	1.4	3.9	9.9	0.7	0.001	0.001	0.000
Noatak National Preserve	3.1	0.9	13.0	0.5	46.8	2.6	8.8	105.6	3.2	0.010	0.002	0.000

NA indicates "not applicable"
1 Full Domain values represent the maximum modeled concentration in the numerical form of the air quality standard in the entire domain.
[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.
[b] The methods to prepare model results for comparison to the primary and secondary NAAQS and AAAQS are described in Chapter 4.

Table 5.3-2 Comparison of Modeled Project Concentrations under Alternative B (Proponent's Project) with AAQS

	CO		NO_2		O_3	$PM_{2.5}$		PM_{10}	SO_2			
	8 hours	1 hour	1 hour	Annual	8 hours	Annual	24 hours	24 hours	1 hour	3 hours	24 hours	Annual
	ppm	ppm	ppb	Ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm	ppm	ppm
Primary NAAQS and AAAQS[a, b]	9	35	100	53	70	12	35	150	75	0.5	0.14	0.03
Secondary NAAQS[b]	NA	NA	NA	53	70	15	35	150	NA	0.5	NA	NA
	Modeled Concentrations											
Full Domain[1]	0.0	0.0	7.1	2.6	1.1	0.7	0.3	2.3	0.2	0.0	0.0	0.0
Arctic National Wildlife Refuge	0.0000	0.0000	0.0000	0.0004	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gates of the Arctic	0.0000	0.0000	0.0000	0.0003	0.0014	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Noatak National Preserve	0.0000	0.0000	0.0006	0.0002	0.0000	0.0002	0.0000	0.0029	0.0000	0.0000	0.0000	0.0000

NA indicates "not applicable"
1 Full Domain values represent the maximum modeled concentration in the numerical form of the air quality standard in the entire domain.
[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.
[b] The methods to prepare model results for comparison to the primary and secondary NAAQS and AAAQS are described in Chapter 4.

Figure 5.3-1 through Figure 5.3-6 show the spatial distribution of cumulative and Project impacts for O_3, NO_2, $PM_{2.5}$, PM_{10}, SO_2 and CO concentrations respectively.

The 4th highest 8-hour cumulative O_3 impacts (Figure 5.3-1(left)) are below the NAAQS throughout the domain and the maximum of 55.5 ppb is modeled near the Arctic National Wildlife Refuge. The Project contribution to this maximum is negligible at this location. The maximum Project impact in the modeling domain is 1.1 ppb (Figure 5.3-1 (right)) and is modeled near the Project Area. Some of the Project impacts ranging from 0.1-1 ppb occurred further downwind south of the Project area. The Project has little to no impact on O_3 concentrations for the vast majority of the modeling domain, including within the three assessment areas.

The spatial maximum of annual average and 8th highest daily average $PM_{2.5}$ cumulative impacts (Figure 5.3-2, left) are 10.1 and 31.4 µg/m^3 respectively. Both of these maximum impacts are below NAAQS and occurred near the northern coastline close to Wainwright monitoring station. The annual $PM_{2.5}$ cumulative concentrations are less than 2 µg/m^3 for the vast majority of the modeling domain, including the three assessment areas, although certain areas near the coast and along roadways show concentrations between 2 to 4 µg/m^3. The cumulative 8th highest daily average $PM_{2.5}$ near the Project area falls in the range of 4 to 6 µg/m^3. Overall the Project area and all three assessment areas are well below the NAAQS. The annual average and 8th highest daily average $PM_{2.5}$ Project impacts (Figure 5.3-2, right) from Alternative B shows a spatial maxima of 0.7 µg/m^3 and 0.3 µg/m^3 respectively. The Project impacts are the highest near the Willow MDP and decrease in magnitude rapidly with distance. For the rest of the modeling domain, including the three assessment areas, the impacts from the Project are essentially negligible.

The maximum second-highest daily cumulative PM_{10} of 121.3 µg/m^3 is modeled near the Noatak National Preserve as shown in Figure 5.3-3; this value is below the NAAQS of 150 µg/m^3. The maximum Project impact of 2.3 µg/m^3 is modeled near the Project area. The high PM_{10} concentrations modeled near Noatak are due to the emissions from wildland fires as modeled in the BOEM base case 2012 regional inventory. The modeled maximum cumulative concentrations of the annual average NO_2 and 8th highest (98th percentile) daily maximum NO_2 are 22 ppb and 72.4 ppb respectively and occurred near coastline and off the coast as shown in Figure 5.3-4. These high values are mainly due to the offshore oil and gas emissions sources and shipping activity in the Chukchi Sea. Near the Project area, the cumulative concentrations for annual average NO_2 and 8th highest daily max NO_2 are in the range of 2-5 ppb and 5-20 ppb and the Project impacts from Alternative B show spatial maxima of 2.6 ppb and 7.1 ppb for annual mean and 98th percentile, respectively. The Project impacts maximum occurred mainly near the Project area and decrease with distance from the Project area. The 8th highest 1-hour NO_2 spatial distribution shows some Project impacts offshore in the Beaufort Sea (up to approximately 0.8 ppb) and southwest of the Project area (up to approximately 7 ppb).

The spatial maxima of the cumulative impacts of the annual average SO_2 (9.1 ppb), second-highest 24-hour SO_2 (34.6 ppb), second-highest 3-hour SO_2 (57.4 ppb) and fourth-highest daily maximum 1-hour SO_2 (58.1 ppb) occurred off the coast and well away from the Project area. Cumulative SO_2 concentrations in the inland portion of the modeling domain, including near the Project area and the three assessment areas, are generally less than 2 ppb. The maximum Project impacts of SO_2 occur southwest of the Willow MDP area and the maximum increases are less than 0.2 ppb.

The spatial distributions of cumulative impacts on 1-hour and 8-hour CO concentrations are shown in Figure 5.3-6**.** The spatial maxima of the second-highest 1-hour and 8-hour CO are 3.1 ppm and 0.9 ppm, both are well below the corresponding NAAQS (35 ppm for 1-hour and 9 ppm for 8-hour). These high CO concentrations are modeled near Noatak and are due to the emissions from wildland fires as modeled in the BOEM base case 2012 regional inventory. The Project impacts from Alternative B are almost negligible with zero impacts farther away from the Project.

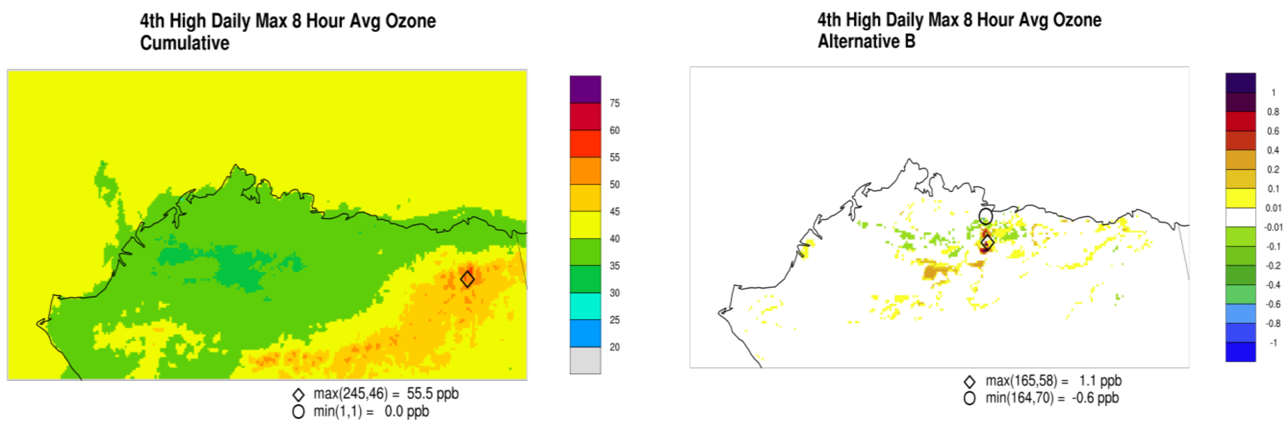


Figure 5.3-1 Alternative B (Proponent's Project): Fourth-Highest Daily Maximum 8-hour Ozone Cumulative (left) and Project Impacts (right)

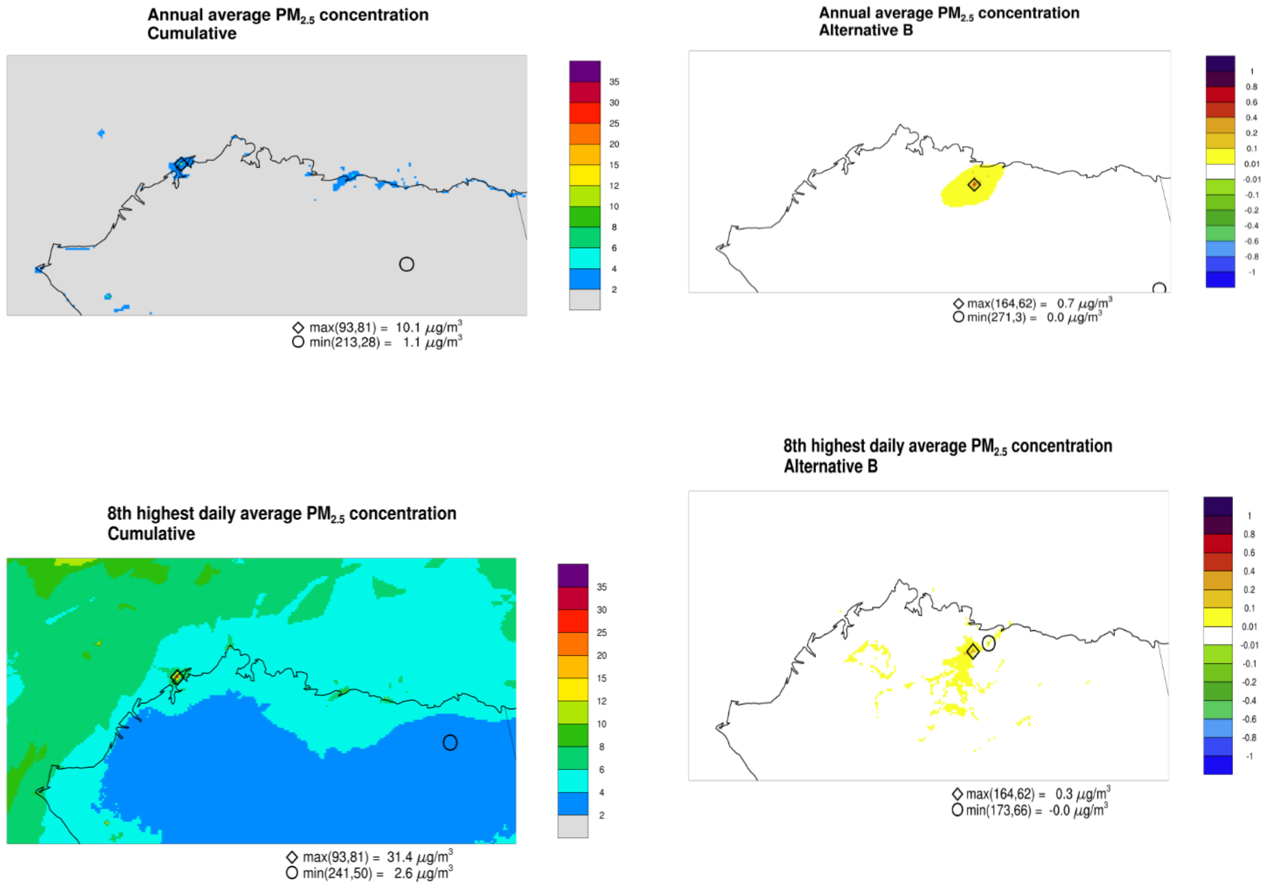


Figure 5.3-2 Alternative B (Proponent's Project): Annual Average (top) and 8th Highest Daily Average (bottom) $PM_{2.5}$ Cumulative (left) and Project (right) Impacts

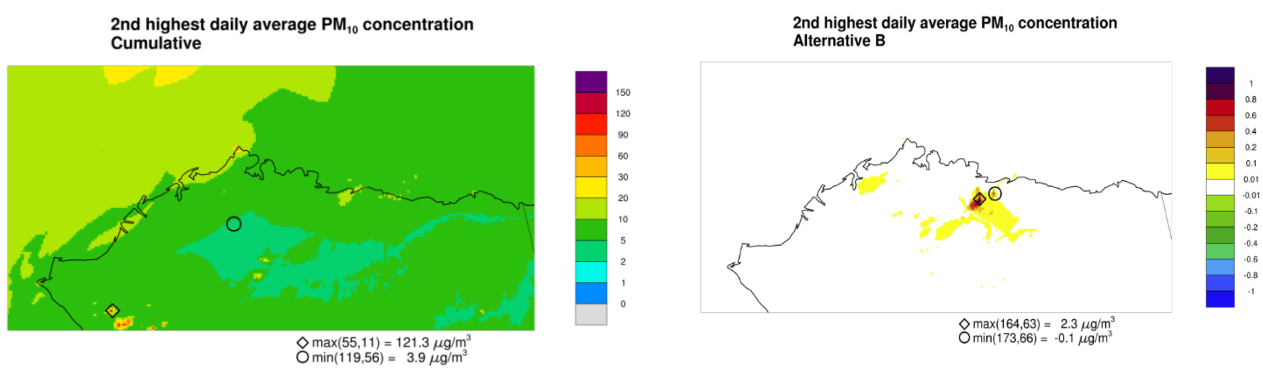


Figure 5.3-3 Alternative B (Proponent's Project): 2nd Highest Daily Average PM_{10} Cumulative (left) and Project (right) Impacts

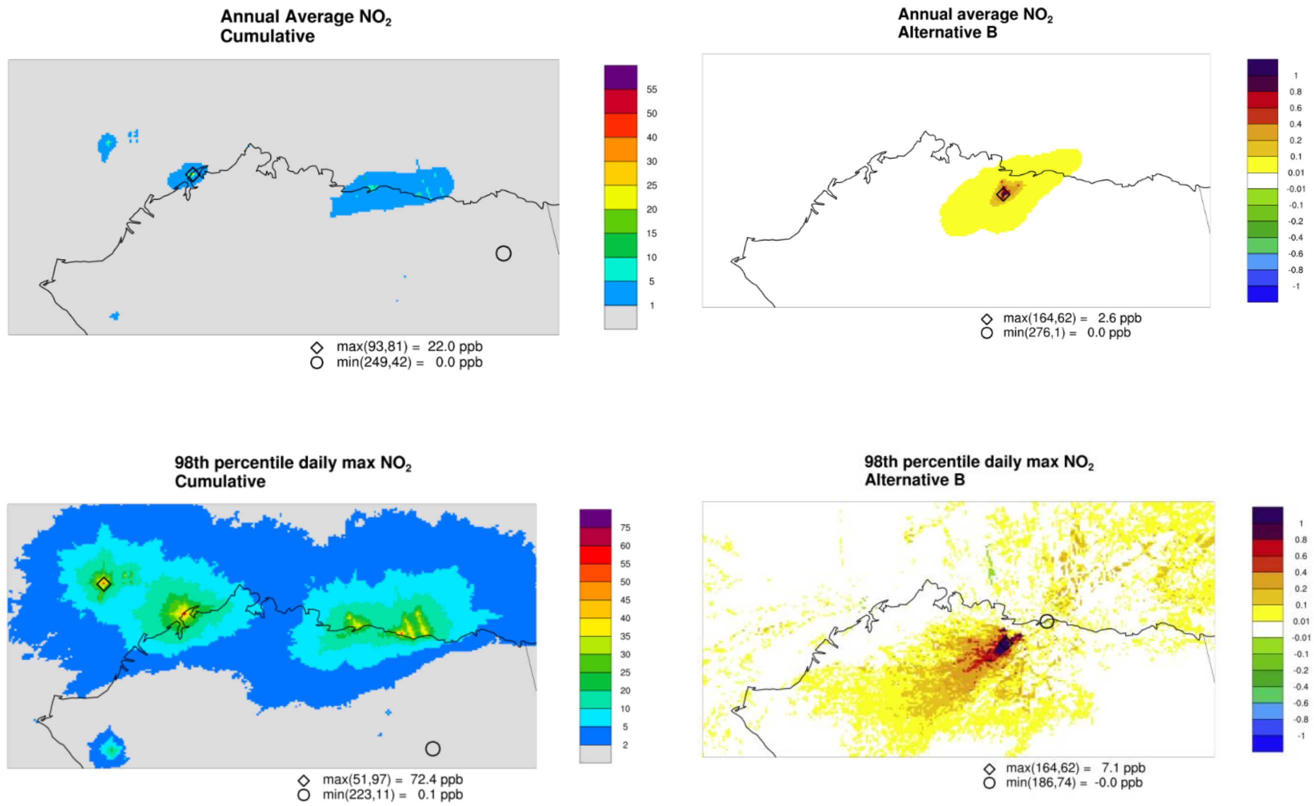
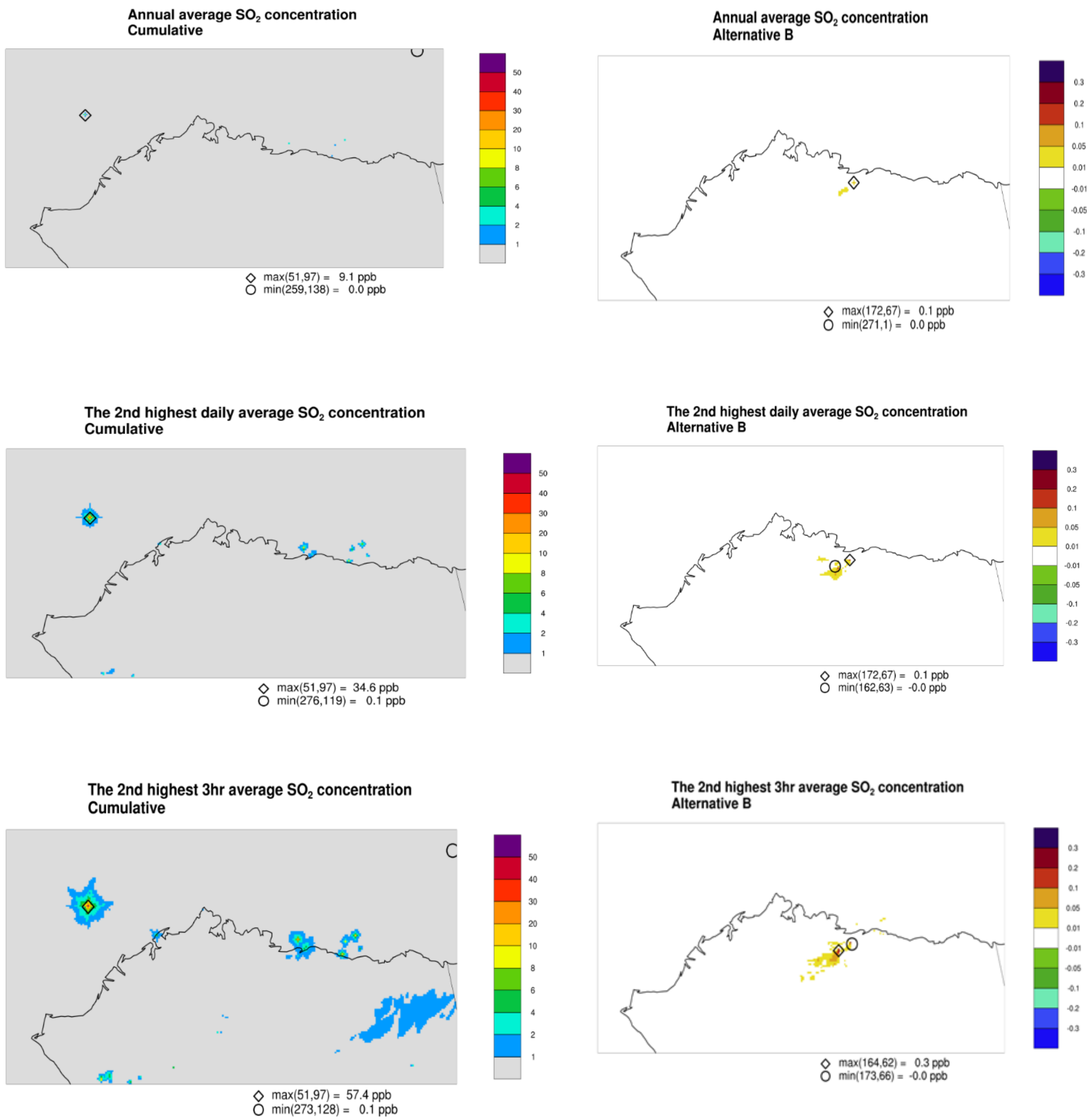


Figure 5.3-4 Alternative B (Proponent's Project): Annual Average (top) and 8th Highest 1-hr Daily Maximum (bottom) NO_2 Cumulative (left) and Project (right) Impacts


Annual average SO2 concentration
Cumulative
max(51,97) = 9.1 ppb
min(259,138) = 0.0 ppb
Annual average SO2 concentration
Alternative B
max(172,67) = 0.1 ppb
min(271,1) = 0.0 ppb
The 2nd highest daily average SO2 concentration
Cumulative
max(51,97) = 34.6 ppb
min(276,119) = 0.1 ppb
The 2nd highest daily average SO2 concentration
Alternative B
max(172,67) = 0.1 ppb
min(162,63) = -0.0 ppb
The 2nd highest 3hr average SO2 concentration
Cumulative
max(51,97) = 57.4 ppb
min(273,128) = 0.1 ppb
The 2nd highest 3hr average SO2 concentration
Alternative B
max(164,62) = 0.3 ppb
min(173,66) = -0.0 ppb

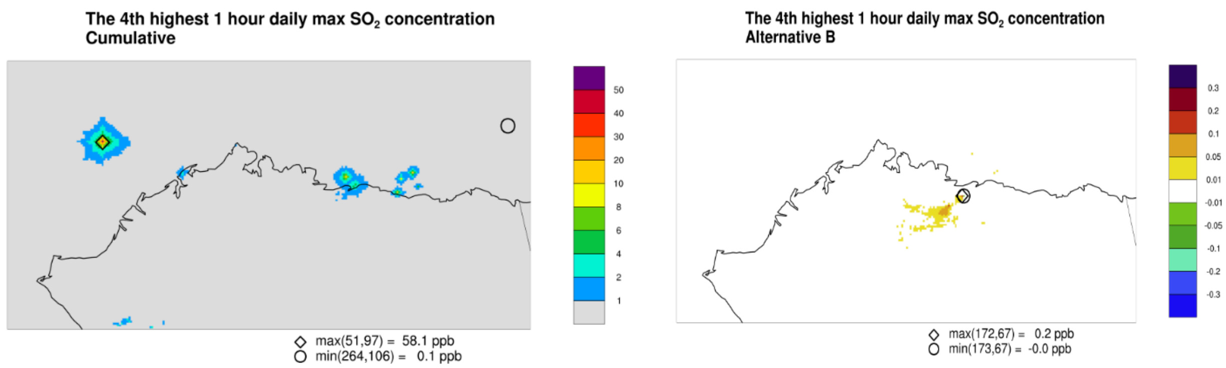


Figure 5.3-5 Alternative B (Proponent's Project): Annual Average, 2nd Highest Daily Average, 2nd Highest 3-hr Average and 4th Highest 1-hr Daily Maximum SO_2 Cumulative (left) and Project (right) Impacts

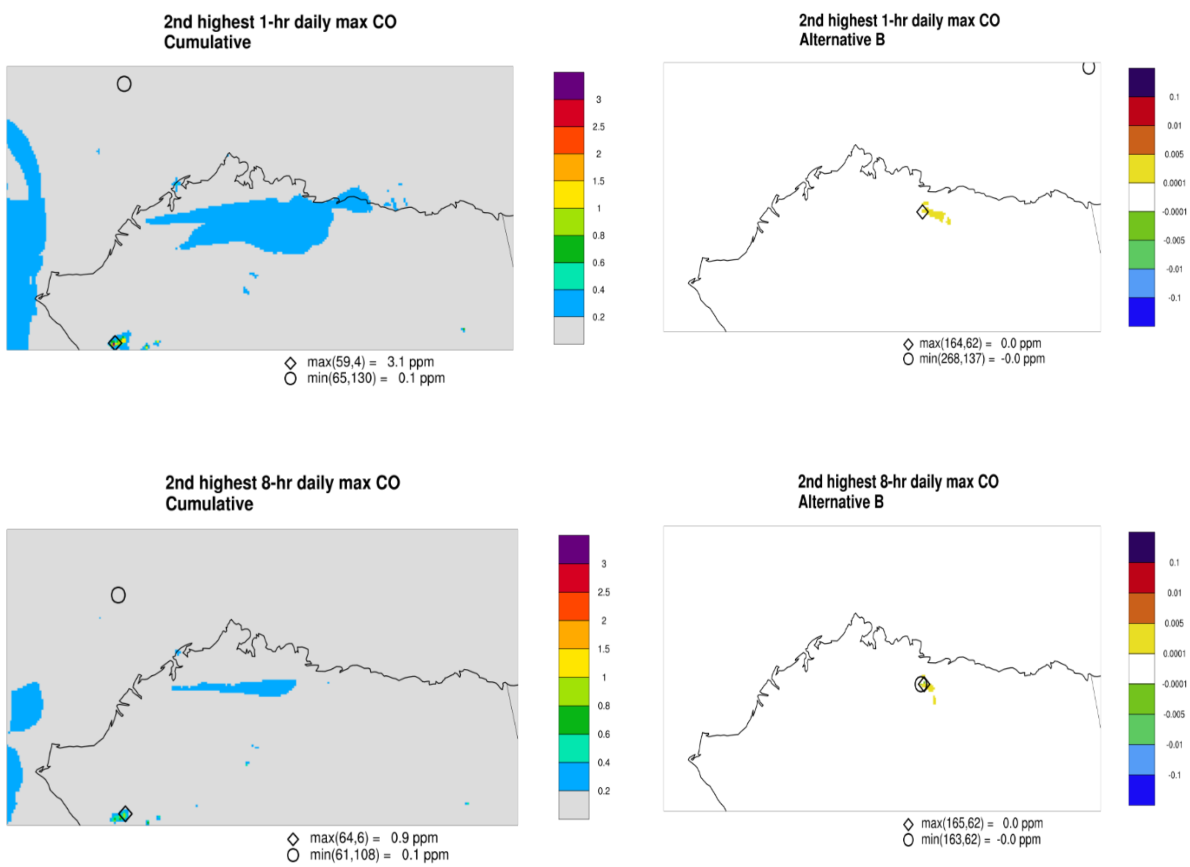


Figure 5.3-6 Alternative B (Proponent's Project): 2nd Highest 1-hr and 8-hr Average Daily Maximum CO Cumulative (left) and Project (right) Impacts

5.3.2 PSD Increments

The PSD regulations are established to prevent significant deterioration of air quality in the areas that already meet the NAAQS. In this section we compare the Alternative B Project modeled impacts at the three assessment areas and for the full domain with the respective Class II area PSD increments. As shown in Table 5.3-3 throughout the modeling domain and at the three assessment areas, the Alternative B maximum Project increments for all pollutants (NO_2, PM_{10}, $PM_{2.5}$, SO_2) are significantly below the PSD increments. Near the three assessment areas the impacts ranges between 0.0001 – 0.02 μg/m^3. Overall the modeled PSD increments indicate that the Project impacts are very small and are unlikely to deteriorate the air quality values at the three assessment areas.

Table 5.3-3 Alternative B (Proponent's Project) Model-Predicted Project Maximum Impacts Compared with Class II Area PSD Increments

	NO_2	PM_{10}		PM_{25}		SO_2		
	Annual	24-hour	Annual	24-hour	Annual	3-hour	24-hour	Annual
PSD Class II Increment (μg/m^3)								
Standard	25	30	17	9	4	512	91	20
Modeled Concentrations								
Full Domain[1]	4.86	5.45	1.06	1.84	0.65	1.55	0.71	0.14
Arctic National Wildlife Refuge	0.0053	0.0288	0.0017	0.0287	0.0015	0.0116	0.0047	0.0003
Gates of the Arctic	0.0022	0.0233	0.0011	0.0192	0.0009	0.0067	0.0041	0.0002
Noatak National Preserve	0.0029	0.0115	0.0008	0.0114	0.0008	0.0098	0.0043	0.0002

[1] Full Domain values represent the maximum modeled concentration concentration in the numerical form of the air quality standard in the entire domain.

5.3.3 Deposition Analysis

The modeled deposition fluxes were processed as discussed in Chapter 4 to estimate the total annual nitrogen (N) and sulfur (S) values at each of the three assessment areas. Table 5.3-4 and Table 5.3-5 show the summary of the spatial maximum and average across each of the three assessment areas for cumulative impacts and Project impacts. As shown in Table 5.3-4 the nitrogen cumulative impacts are below or within the critical load range at all three assessment areas. Annual cumulative nitrogen deposition varies from 0.5 -1.1 kg/ha-yr across these three assessment areas when considering the spatial maximum and varies from 0.3-0.5 kg/ha-yr when considering the average of each area. Annual cumulative sulfur deposition varies from 0.6 -1.5 kg/ha-yr across these three assessment areas when considering the spatial maximum and varies from 0.3 – 0.6 kg/ha-yr when considering the average of each area. Among the three assessment areas, Noatak National Preserve is modeled to experience the highest nitrogen deposition and sulfur deposition due to cumulative impacts.

Table 5.3-5 shows the maximum and average Alternative B Project impacts for nitrogen and sulfur impacts. These Project impacts are below the DAT of 0.005 kg/ha-yr. Overall both the maximum and average Project impacts at all three assessment areas are small and contribute little to the total cumulative impacts.

Figure 5.3-7 presents the spatial distribution of the cumulative and Project impacts for sulfur and nitrogen deposition. The Alternative B cumulative sulfur deposition (Figure 5.3-7, top-left) maximum impact of 15.2 kg/ha-yr is modeled off the coast due to offshore oil and gas activity. Overall, the rest of the domain shows impacts in the range of 0.2 – 1.2 kg/ha-yr. The cumulative nitrogen deposition maximum impact of 2.1 kg/ha-yr occurred close to Noatak National Preserve. Both of these cumulative maximum impacts occurred far away from the Project area. Project impacts on nitrogen deposition and sulfur deposition are highest near the Willow MDP and decrease rapidly as we move away from the Project area.

Table 5.3-4 Alternative B (Proponent's Project) Nitrogen and Sulfur Deposition Cumulative Impacts: Spatial Maximum and Average

Assessment Area	Nitrogen (kg N/ha-yr)			Sulfur (kg S/ha-yr)	
	Maximum	Average	Below/Within/Above Critical Load Range (1.0-3.0 kg/ha-yr)	Maximum	Average
Arctic National Wildlife Refuge	0.71	0.34	Below	0.71	0.31
Gates of the Arctic	0.59	0.38	Below	0.68	0.37
Noatak National Preserve	1.12	0.49	Within/Below	1.58	0.61

Table 5.3-5 Alternative B (Proponent's Project) Nitrogen and Sulfur Deposition Project Impacts: Spatial Maximum and Average

Assessment Area	Nitrogen (kg N/ha-yr)			Sulfur (kg S/ha-yr)		
	Maximum	Average	Below Deposition Analysis Threshold (0.005 kg/ha-yr)	Maximum	Average	Below Deposition Analysis Threshold (0.005 kg/ha-yr)
Arctic National Wildlife Refuge	3.6E-03	4.5E-04	Yes	1.50E-05	3.93E-05	Yes
Gates of the Arctic	8.7E-04	5.0E-04	Yes	1.40E-05	5.27E-05	Yes
Noatak National Preserve	3.2E-03	8.6E-04	Yes	4.09E-05	8.06E-05	Yes

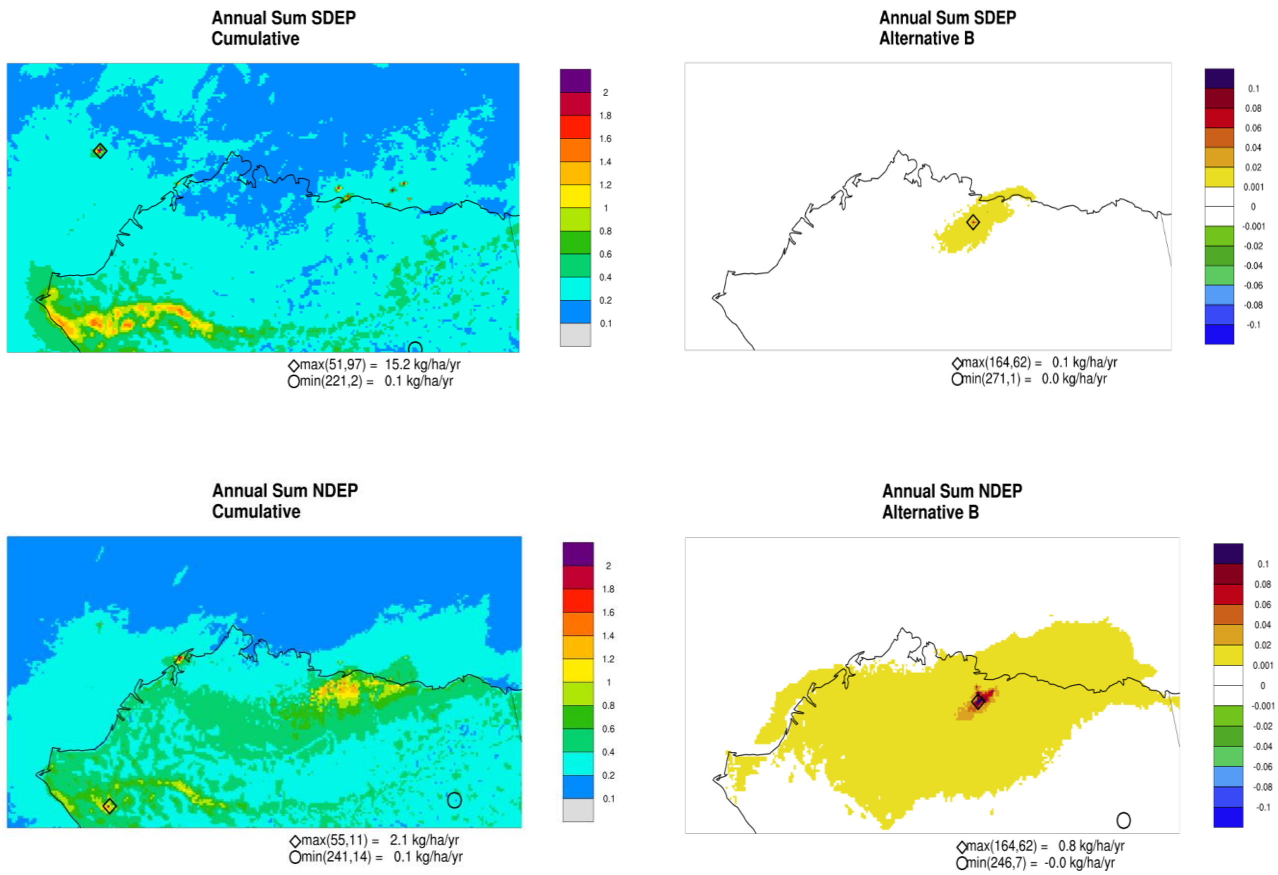


Figure 5.3-7 Alternative B (Proponent's Project): Annual Sum of Sulfur (S) (top) and Nitrogen (N) (bottom) Deposition Cumulative (left) and Project (right) Impacts

5.3.4 Visibility Analysis

The analysis of the effects on visibility from this Project follows the approach explained in detail in Chapter 4. The cumulative impacts on visibility were calculated using the SMAT-CE tool, while Project impacts are assessed following the FLAG (2010) screening method.

Table 5.3-6 shows the cumulative visibility design values estimated for Alternative B at each of the three assessment areas. As described in Chapter 4, these values are derived from the monitoring data at Denali NP and therefore the Base Year design value is unchanged among all the areas. For both the 20 percent best and the 20 percent most impaired days the projected visibility will slightly degrade from current values at all three assessment areas. The area with the worst cumulative visibility during the 20 percent best days is Noatak National Preserve, while Gates of the Arctic has the worst cumulative visibility during the 20 percent most impaired days. The design values account for the cumulative visibility changes in the whole domain between the base and future year and thus reflects not only the Project contributions but also the contributions from all other sources.

Table 5.3-6 Alternative B (Proponent's Project): Base (2012) and Future (2025) Cumulative Visibility Impacts for the 20 Best and Most Impaired Days

Assessment Area	20 Percent Best Days (dv)		20 Percent Most Impaired Days (dv)	
	Base Year	Future Year	Base Year	Future Year
Arctic National Wildlife Refuge	2.671	2.682	7.245	7.248
Gates of the Arctic		2.684		7.279
Noatak National Preserve		2.739		7.249

Table 5.3-7 shows the Willow MDP impacts on visibility when compared to natural background conditions under the Alternative B. These estimates indicate that the direct visibility impacts under Alternative B are all small and would not significantly degrade visibility at any of the three assessment areas. None of the three assessment areas exceeds either the 1 and 0.5 delta deciview thresholds, furthermore the largest impacts observed at Arctic National Wildlife Refuge are only half of the 0.5 delta deciview threshold. Modeling results indicate that the impacts are more likely to be observed during the spring as both Arctic National Wildlife Refuge and the Noatak National Preserve experience the peak delta deciview values in April. The visibility impacts during the 20 percent worst days are generally an order of magnitude lower than the maximum values.

Table 5.3-7 Alternative B (Proponent's Project): Project Visibility Impacts

Assessment Area	Δdv (Max)	Δdv (98th percentile)	Δdv (W20)	Δdv (B20)	Number of Days	
					Δdv > 1	Δdv > 0.5
Arctic National Wildlife Refuge	0.36026	0.11401	0.03110	0.00009	0	0
Gates of the Arctic	0.17987	0.05501	0.01170	0.00001	0	0
Noatak National Preserve	0.08118	0.04246	0.01074	0.00001	0	0

5.4 Alternative C (Disconnected Infield Roads)

This section presents the Project and cumulative impacts for Alternative C. The model outputs are processed following the methodology discussed in Chapter 4. The concentrations are compared with NAAQS and AAAQS standards, PSD increments and deposition thresholds for the full domain and at the three assessment areas.

5.4.1 NAAQS Analysis

Table 5.4-1 provides a summary of maximum ambient air quality concentrations from the cumulative Alternative C scenario for all criteria pollutants at the assessment areas. Air concentrations for all criteria pollutants are below the NAAQS and AAAQS anywhere in the modeling domain.

Table 5.4-2 shows the maximum Project impacts for all criteria pollutants in terms of the standards. For all pollutants, the Project impacts are well below the NAAQS and AAAQS and show negligible contribution to the cumulative air quality concentrations.

Table 5.4-1 Comparison of Modeled Cumulative Concentrations under Alternative C (Disconnected Infield Roads) with AAQS

	CO		NO_2		O_3	PM_{25}		PM_{10}	SO_2			
	8 hours	1 hour	1 hour	Annual	8 hours	Annual	24 hours	24 hours	1 hour	3 hours	24 hours	Annual
	ppm	ppm	ppb	ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm	ppm	ppm
Primary NAAQS and AAAQS[a, b]	9	35	100	53	70	12	35	150	75	0.5	0.14	0.03
Secondary NAAQS[b]	NA	NA	NA	53	70	15	35	150	NA	0.5	NA	NA
Modeled Concentrations												
Full Domain[1]	3.1	0.9	72.4	22.0	55.5	10.1	31.4	121.3	58.1	0.1	0.0	0.0
Arctic National Wildlife Refuge	0.6	0.4	21.0	1.6	55.5	2.5	7.3	30.5	0.74	0.002	0.001	0.000
Gates of the Arctic	0.2	0.2	1.2	0.2	53.4	1.4	3.9	9.9	0.68	0.001	0.001	0.000
Noatak National Preserve	3.1	0.9	13.0	0.5	46.8	2.6	8.8	105.6	3.17	0.010	0.002	0.000

NA indicates "not applicable"
[1] Full Domain values represent the maximum modeled concentration seen in the entire domain.
[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.
[b] The methods to prepare model results for comparison to the primary and secondary NAAQS and AAAQS are described in Chapter 4.

Table 5.4-2 Comparison of Modeled Project Concentrations under Alternative C (Disconnected Infield Roads) with AAQS

	CO		NO_2		O_3	PM_{25}		PM_{10}	SO_2			
	8 hours	1 hour	1 hour	Annual	8 hours	Annual	24 hours	24 hours	1 hour	3 hours	24 hours	Annual
	ppm	ppm	ppb	ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm	ppm	ppm
Primary NAAQS and AAAQS[a, b]	9	35	100	53	70	12	35	150	75	0.5	0.14	0.03
Secondary NAAQS[b]	NA	NA	NA	53	70	15	35	150	NA	0.5	NA	NA
	Modeled Concentrations											
Full Domain[1]	0.0	0.0	11.0	4.4	1.4	0.9	0.6	2.1	0.1	0.0	0.0	0.0
Arctic National Wildlife Refuge	0.0000	0.0000	0.0000	0.0004	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gates of the Arctic	0.0000	0.0000	0.0001	0.0004	0.0011	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Noatak National Preserve	0.0000	0.0000	0.0001	0.0003	0.0000	0.0002	0.0000	0.0033	0.0000	0.0000	0.0000	0.0000

[1] Full Domain values represent the maximum modeled concentration in the numerical form of the air quality standard in the entire domain.

Figure 5.4-1 through Figure 5.4-6 show the spatial distribution of cumulative and Project impacts for all O_3, NO_2, $PM_{2.5}$, PM_{10}, SO_2 and CO respectively.

The 4th highest 8-hour cumulative O3 impacts (Figure 5.4-1 (left)) are below the NAAQS throughout the domain and the maximum of 55.5 ppb is modeled to occur near the Arctic National Wildlife Refuge. The Project contribution to this maximum is negligible at this location. The maximum Project impact anywhere in the analysis area is 1.4 ppb (Figure 5.4-1 (right)) and is modeled near the Willow MDP area. Some of the Project impacts ranging from 0.1-1 ppb occurred further downwind south of the Project area. The Project has little to no impact on O3 concentrations for the vast majority of the modeling domain, including within the three assessment areas.

The spatial maximum of annual average and 8th highest daily average $PM_{2.5}$ cumulative impacts (Figure 5.4-2, left) are 10.1 and 31.4 µg/m^3 respectively. Both these maximum impacts are below the NAAQS and occurred near the northern coastline near Wainwright. The annual $PM_{2.5}$ cumulative concentrations are less than 2 µg/m^3 for the vast majority of the modeling domain, including the three assessment areas, although certain areas near the coast and along roadways show concentrations ranging from 2 to 4 µg/m^3. The cumulative 8th highest daily average $PM_{2.5}$ near the Project area falls in the range of 4 to 6 µg/m^3. Overall the Project area and all three assessment areas are well below the NAAQS. The maximum Project impacts (Figure 5.4-2, top-right) on annual $PM_{2.5}$ concentrations ranges between 0.1 and 0.7 µg/m^3. The annual average and 8th highest daily average $PM_{2.5}$ Project impacts show spatial maxima of 0.9 µg/m^3 and 0.6 µg/m^3 respectively. The Project impacts are the highest within the Willow MDP area and decrease in magnitude rapidly with distance. Project impacts in the rest of the modeling domain, including the three assessment areas, range from extremely small to negligible.

The maximum second-highest daily cumulative PM_{10} of 121.3 µg/m^3 is modeled near the Noatak National Preserve as shown in Figure 5.4-3; this is below the NAAQS of 150 µg/m^3. The high PM_{10} concentrations modeled near Noatak are due to the emissions from wildland fires as modeled in the BOEM base case 2012 regional inventory. The maximum Project impact of 2.3 µg/m^3 is modeled near the Project area and impacts appear to be less in the vicinity of the Project area.

The modeled maximum cumulative concentrations of the annual average NO_2 and 8th highest (98th percentile) daily maximum NO_2 are 22 ppb and 72.4 ppb respectively and are near coastline and off the coast as shown in Figure 5.4-4. These high values are mainly due to the offshore oil and gas emissions sources and shipping activity in the Chukchi Sea. Near the Project area the cumulative concentrations for annual average NO_2 and 8th highest daily max NO_2 are in the range of 2-5 ppb and 5-20 ppb and the Project impacts from Alternative C shows a spatial maxima of 4.4 ppb and 11.0 ppb respectively. The Project impacts maximum occurred mainly near the Project area and decreases moving away from the Project area. The 8th highest 1-hour NO_2 shows some Project impacts offshore in the Beaufort Sea (up to approximately 0.8 ppb) and south-west of the Project area (up to approximately 11 ppb).

The cumulative impact spatial maxima of the annual average SO_2 (9.1 ppb), second-highest 24-hour SO_2 (34.6 ppb), second-highest 3-hour SO_2 (57.4 ppb) and fourth-highest daily maximum 1-hour SO_2 (58.1 ppb) are modeled off the coast and away from the Project area as shown in Figure 5.4-5. Cumulative SO_2 concentrations in the inland portion of the modeling domain, including near the Project area and the three assessment areas, are generally less than 2 ppb. The maximum Project impacts of SO_2 occur southwest of the Willow MDP area and the maximum increases are less than 0.2 ppb.

The spatial distributions of cumulative impacts on 1-hour and 8-hour CO concentrations are shown in Figure 5.4-6**.** The spatial maxima of the second-highest 1-hour and 8-hour CO are 3.1 ppm and 0.9 ppm, both are well below the corresponding NAAQS (35 ppm for 1-hour and 9 ppm for 8-hour). The high PM_{10} concentrations modeled near Noatak are due to the emissions from wildland fires as modeled in the BOEM base case 2012 regional inventory. The Project impacts from Alternative C are extremely small away from the Project area.

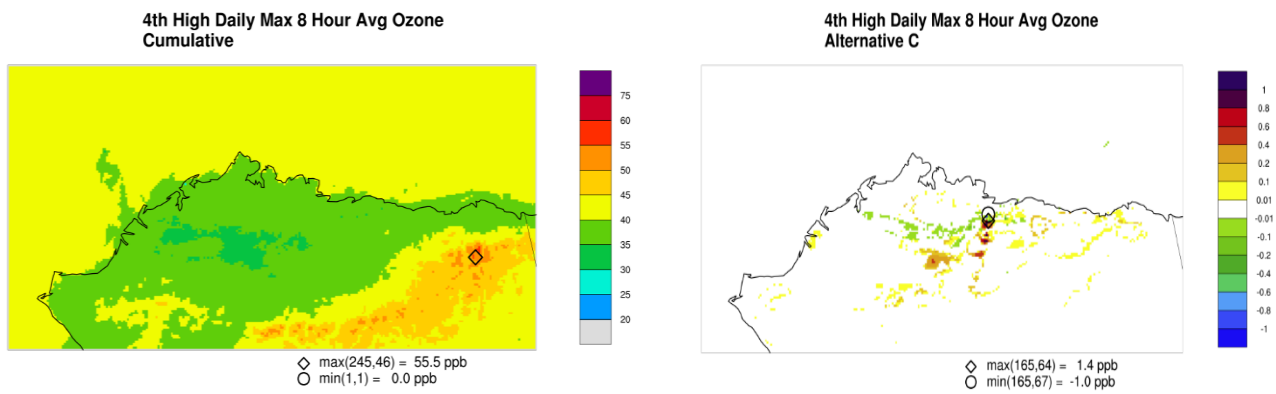


Figure 5.4-1 Alternative C (Disconnected Infield Roads): Fourth-Highest Daily Maximum 8-hour Ozone Cumulative (left) and Project Impacts (right)

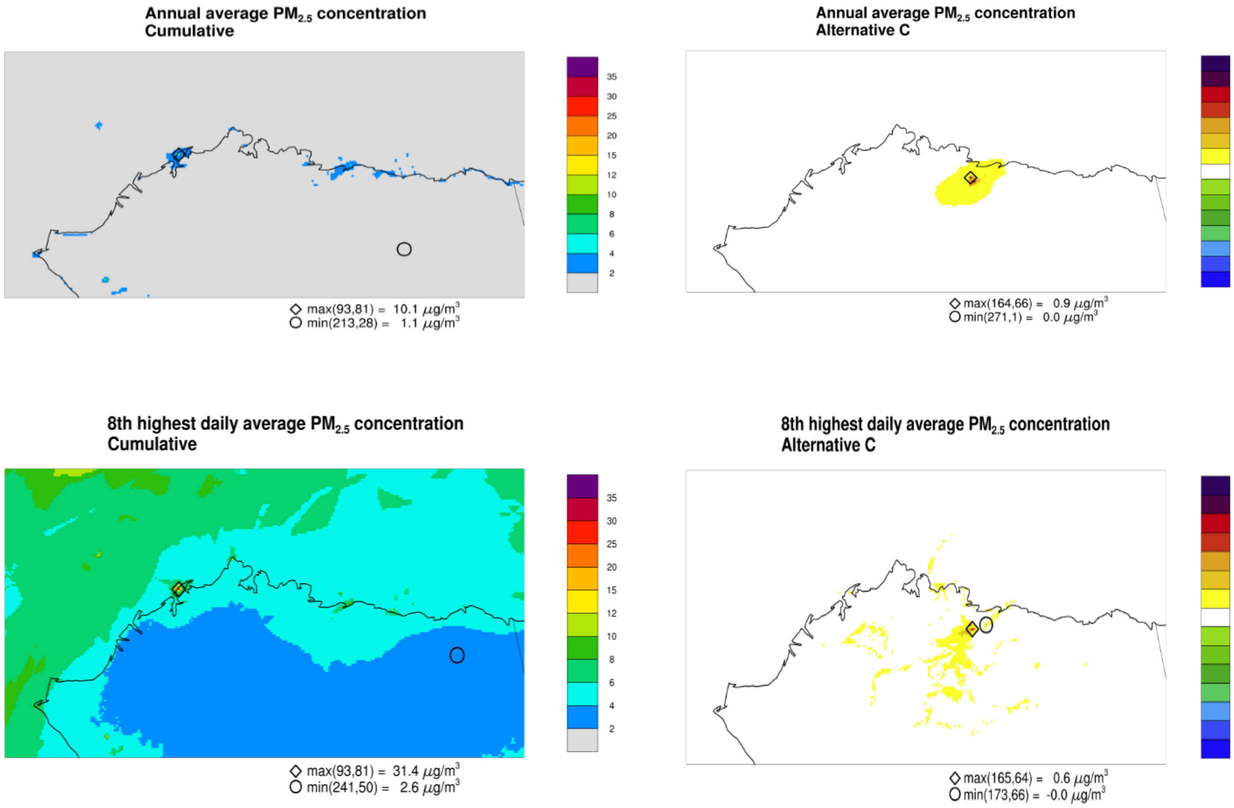


Figure 5.4-2 Alternative C (Disconnected Infield Roads): Annual Average (top) and 8th Highest Daily Average (bottom) $PM_{2.5}$ Cumulative (left) and Project (right) Impacts

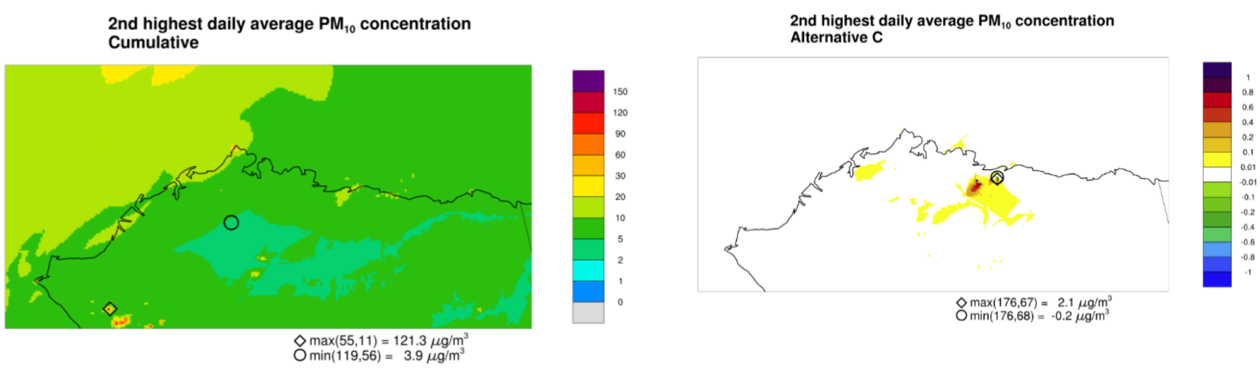


Figure 5.4-3 Alternative C (Disconnected Infield Roads): 2nd Highest Daily Average PM_{10} Cumulative (left) and Project (right) Impacts

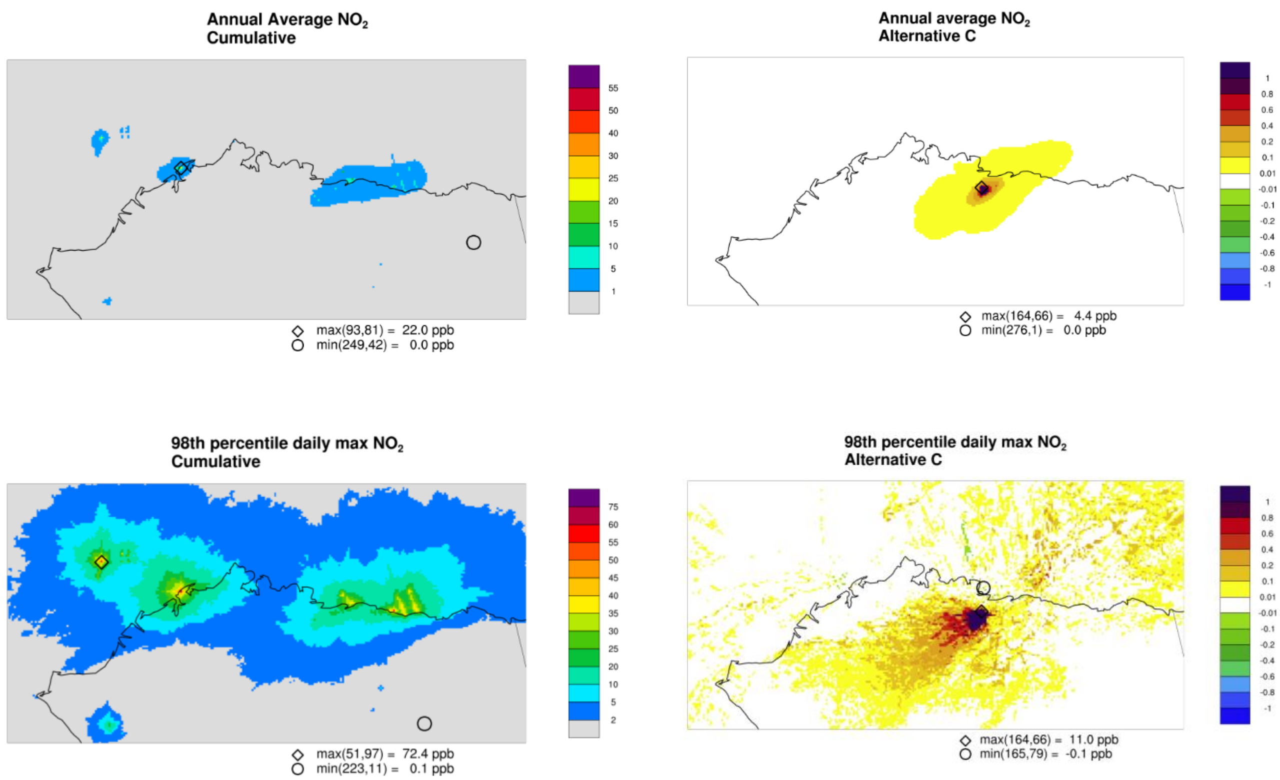


Figure 5.4-4 Alternative C (Disconnected Infield Roads): Annual Average (top) and 8th Highest 1-hr Daily Maximum (bottom) NO_2 Cumulative (left) and Project (right) Impacts

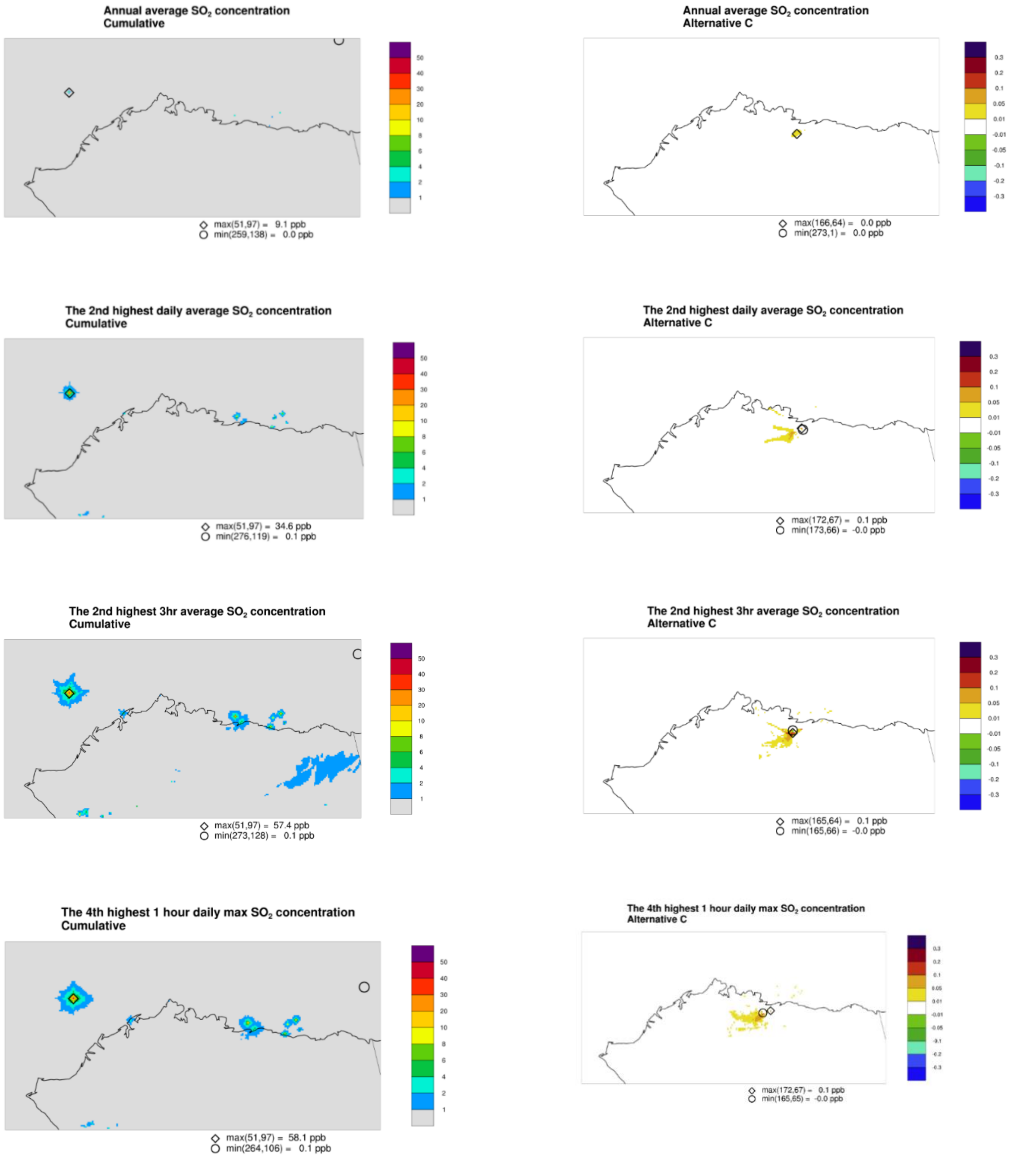


Figure 5.4-5 Alternative C (Disconnected Infield Roads): Annual average, 2nd Highest Daily Average, 2nd highest 3-hr Average and 4th Highest 1-hr Daily Maximum SO_2 Cumulative (left) and Project (right) Impacts

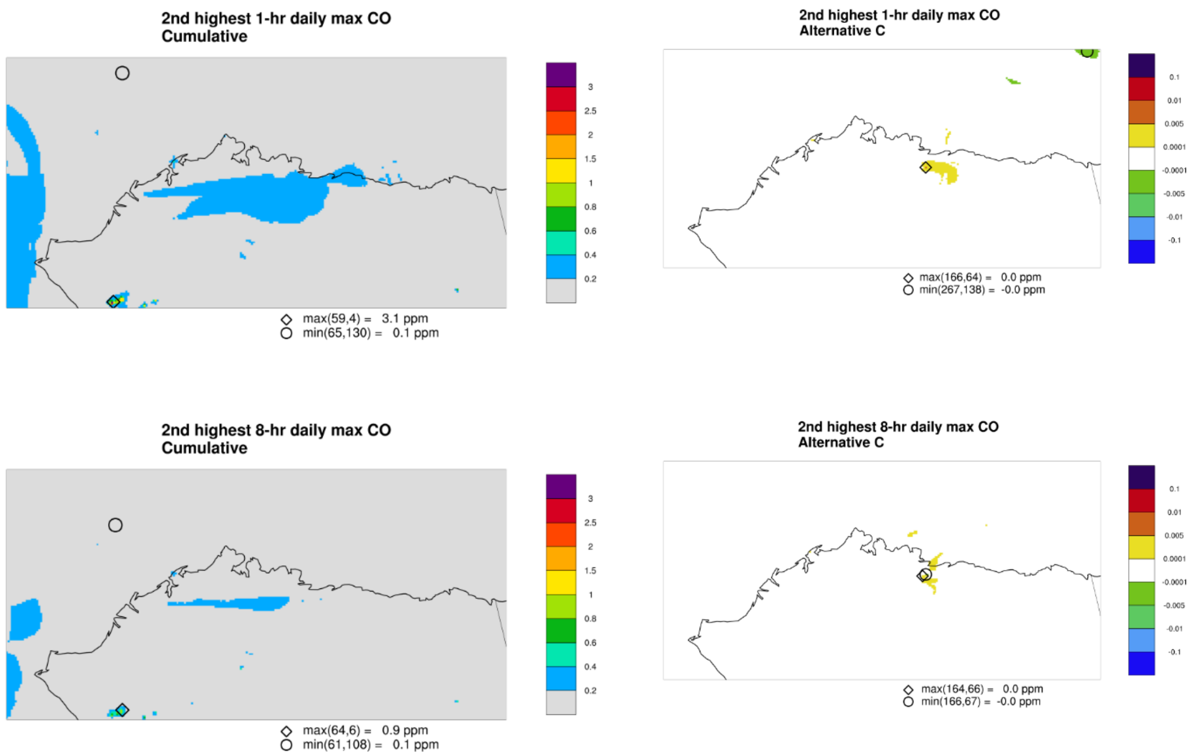


Figure 5.4-6 Alternative C (Disconnected Infield Roads): 2nd Highest 1-hr and 8-hr Average Daily Maximum CO Cumulative (left) and Project (right) Impacts

5.4.2 PSD Increments

The Alternative C Project modeled impacts at the three assessment areas and in the whole domain were compared with the respective Class II area PSD increments. As shown in Table 5.4-3 throughout the modeling domain and three assessment areas, the Alternative C maximum Project increments for all pollutants (NO_2, PM_{10}, $PM_{2.5}$, SO_2) are well below the PSD increments. Near the three assessment areas the impacts range from 0.0001 to 0.03 micrograms per cubic meter (µg/m^3). Overall the PSD increments indicate that the Project impacts are very small and are unlikely to deteriorate the air quality values at the three assessment areas.

Table 5.4-3 Alternative C (Disconnected Infield Roads) Modeled Project Impacts Compared with Class II Area PSD Increments

	NO_2	PM_{10}		PM_{25}		SO_2		
	Annual	24-hour	Annual	24-hour	Annual	3-hour	24-hour	Annual
PSD Class II Increment (µg/m³)								
Standard	25	30	17	9	4	512	91	20
Modeled Concentrations								
Full Domain[1]	8.25	3.50	1.12	3.27	0.89	1.31	0.65	0.12
Arctic National Wildlife Refuge	0.0065	0.0299	0.0018	0.0298	0.0016	0.0126	0.0041	0.0003
Gates of the Arctic	0.0026	0.0210	0.0011	0.0198	0.0010	0.0065	0.0042	0.0001
Noatak National Preserve	0.0033	0.0123	0.0009	0.0122	0.0008	0.0090	0.0039	0.0002

1 Full Domain values represent the maximum modeled concentration in the numerical form of the air quality standard in the entire domain.

5.4.3 Deposition Analysis

Table 5.4-4 and Table 5.4-5 provide a summary of maximum and average cumulative impacts and Project impacts at the three assessment areas. As shown in Table 5.4-4 the nitrogen deposition cumulative impacts are below or within the critical load range at all three assessment areas. The annual cumulative nitrogen deposition varies from 0.59 – 1.12 kg/ha-yr across these three assessment areas when considering the spatial maximum and from 0.34 – 0.49 kg/ha-yr when considering the average for each area. Annual cumulative sulfur deposition varies from 0.7 – 1.6 kg/ha-yr across these three assessment areas when considering the spatial maximum and from 0.3 – 0.6 kg/ha-yr when considering the average of each area. Among the three assessment areas, Noatak National Preserve is modeled to experience the highest nitrogen deposition and sulfur deposition due to cumulative impacts.

Table 5.4-5 shows the maximum and average nitrogen and sulfur Project impacts for Alternative C. These Project impacts are below the DAT of 0.005 kg/ha-yr. In general, the Project impacts at all three assessment areas have a very small contribution to the total cumulative deposition values.

Figure 5.4-7 shows the spatial extent of the sulfur and nitrogen deposition cumulative and Project impacts. The Alternative C cumulative sulfur deposition (Figure 5.4-7, top-left) maximum impact of 15.2 kg/ha-yr occurs in the ocean and is related to offshore oil and gas activities in the Chukchi Sea region; for the rest of the domain cumulative impacts range between 0.2 and 1.8 kg/ha-yr (Figure 5.4-7). The maximum cumulative nitrogen deposition maximum of 2.1 kg/ha-yr occurs at the location of maximum impacts from the Project area. The Project contributes to almost 50 percent of the cumulative nitrogen deposition, but this effect decreases substantially with distance with impacts of less than 0.02 kg/ha-yr beyond the 300 km radius around the Project. Maximum sulfur impacts for 0.01 kg/ha-yr occur within the Project area and substantially decrease to values in the range of 0.001 – 0.02 kg/ha-yr.

Table 5.4-4 Alternative C (Disconnected Infield Roads): Nitrogen and Sulfur Deposition Cumulative Impacts – Spatial Maximum and Average

Assessment Area	Nitrogen (kg N/ha-yr)			Sulfur (kg S/ha-yr)	
	Maximum	Average	Below/Within/Above Critical Load Range (1.0-3.0 kg/ha-yr)	Maximum	Average
Arctic National Wildlife Refuge	0.71	0.34	Below	0.71	0.31
Gates of the Arctic	0.59	0.38	Below	0.68	0.37
Noatak National Preserve	1.12	0.49	Within/Below	1.58	0.61

Table 5.4-5 Alternative C (Disconnected Infield Roads): Nitrogen and Sulfur Deposition Project Impacts – Spatial Maximum and Average

Assessment Area	Nitrogen (kg N/ha-yr)			Sulfur (kg S/ha-yr)		
	Maximum	Average	Below Deposition Analysis Threshold (0.005 kg/ha-yr)	Maximum	Average	Below Deposition Analysis Threshold (0.005 kg/ha-yr)
Arctic National Wildlife Refuge	4.7E-03	5.8E-04	Yes	1.4E-05	3.8E-05	Yes
Gates of the Arctic	1.1E-03	6.4E-04	Yes	1.4E-05	5.0E-05	Yes
Noatak National Preserve	3.9E-03	1.1E-03	Yes	3.9E-05	7.6E-05	Yes

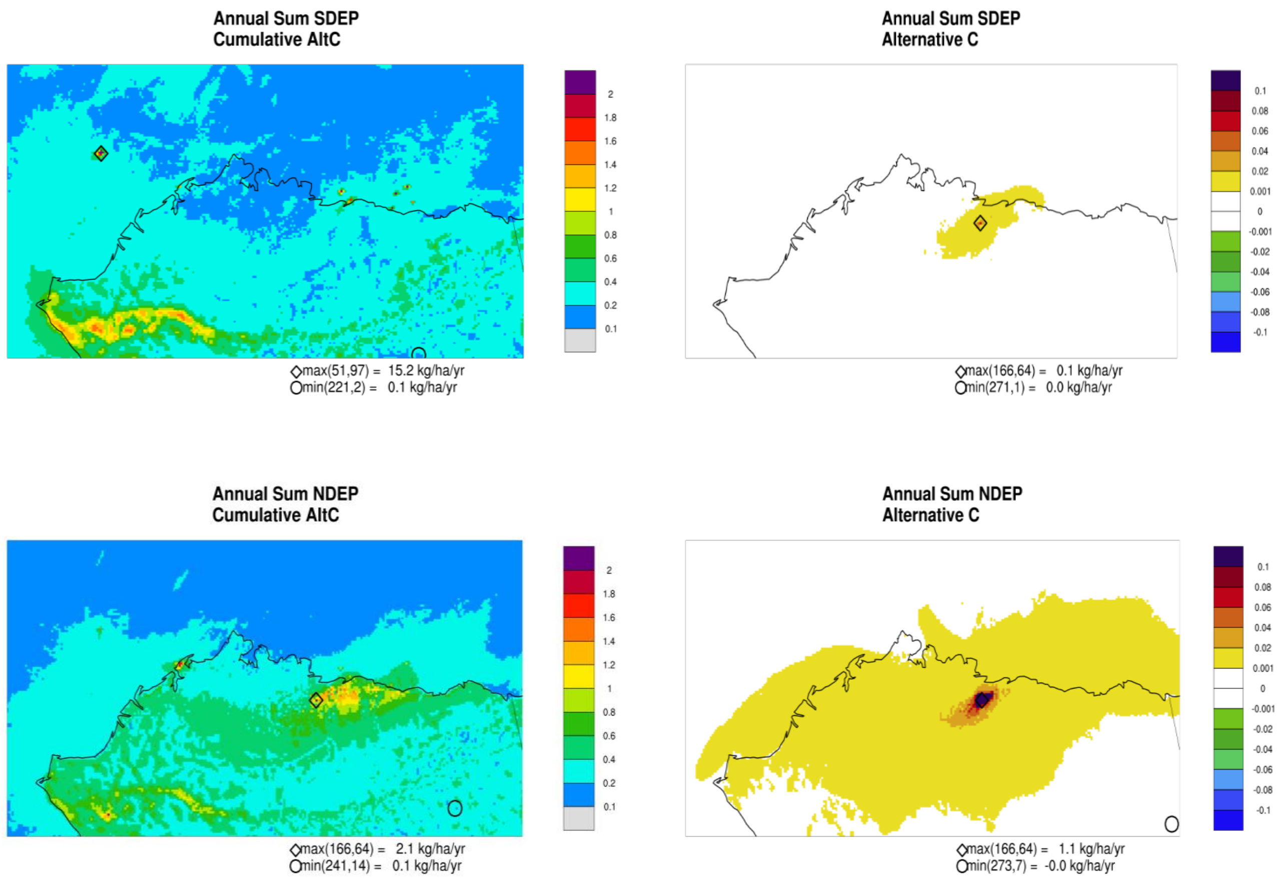


Figure 5.4-7 Alternative C (Disconnected Infield Roads): Annual Sum of Sulfur (S) (top) and Nitrogen (N) (bottom) Deposition: Cumulative (left) and Project (right) Impacts

5.4.4 Visibility Analysis

The analysis of the effects on visibility from Alternative C is similar to that of Alternative B and follows the approach explained in detail in Chapter 4. The cumulative impacts on visibility were calculated using the SMAT-CE tool, while Project impacts are assessed following the FLAG (2010) screening method.

Table 5.4-6 shows the cumulative visibility design values estimated for Alternative C at the three assessment areas. As described in Chapter 4, these values are derived from the monitoring data at Denali NP and therefore the Base Year design value is unchanged among all the areas. For both 20 percent best and 20 percent most impaired days the cumulative visibility will slightly degrade from current values at all three assessment areas. The area with the worst cumulative visibility during the 20 percent best days is Noatak National Preserve, while Gates of the Arctic has the worst cumulative visibility during the 20 percent most impaired days. As in the case of Alternative B, the design values account for the cumulative visibility changes in the whole domain between the base and future year and reflect the contributions from all sources.

Table 5.4-6 Alternative C (Disconnected Infield Roads): Base (2012) and Future (2025) Cumulative Visibility Impacts for the 20 Best and Most Impaired Days

Assessment Area	20 Percent Best Days (dv)		20 Percent Most Impaired Days (dv)	
	Base Year	Future Year	Base Year	Future Year
Arctic National Wildlife Refuge	2.671	2.682	7.245	7.248
Gates of the Arctic		2.684		7.281
Noatak National Preserve		2.741		7.253

Table 5.4-7 shows the Project specific impacts on visibility when compared to natural background conditions under Alternative C. These estimates indicate that the direct visibility impacts under Alternative C are all small and would have little contribution to visibility degradation at the three assessment areas. None of the three assessment areas exceeds either the 1 and 0.5 delta deciview thresholds. The largest impacts are modeled at the Arctic National Wildlife Refuge; these impacts are 60 percent of the 0.5 delta deciview threshold. Modeling results indicate that the higher impacts are more likely during the spring as both Arctic National Wildlife Refuge and Noatak show maximum delta deciview values in April. The delta deciview impacts during the 20 percent worst days are generally an order of magnitude lower than the maximum values.

Table 5.4-7 Alternative C (Disconnected Infield Roads): Project Visibility Impacts

Assessment Area	Δdv (Max)	Δdv (98th percentile)	Δdv (W20)	Δdv (B20)	Number of Days	
					Δdv > 1	Δdv > 0.5
Arctic National Wildlife Refuge	0.30573	0.11276	0.03223	0.00009	0	0
Gates of the Arctic	0.23194	0.06161	0.01126	0.00001	0	0
Noatak National Preserve	0.08033	0.04192	0.01016	0.00001	0	0

5.5 Comparison between Alternative B (Proponent's Project) and C (Disconnected Infield Roads)

In general, the direct impacts to AQ and AQRV from both alternatives are very small and therefore the comparison of cumulative concentrations and other AQRVs shows very little difference between Alternative B and C. A comparison of Project specific impacts between Alternative B and C for pollutants subject to the NAAQS indicates in general that Alternative C has larger domain-wide impacts than Alternative B but these large impacts occur in the immediate vicinity of the Project area. The most noticeable difference can be observed for NO_2 and $PM_{2.5}$ as the larger total annual NOx emissions for Alternative C lead to larger impacts to both NO_2 and particulate nitrate. For ozone the domain-wide maximum is larger for Alternative C compared to Alternative B but the difference is small (0.3 ppb). The spatial distribution of ozone due to either alternatives is very similar and the effect on ozone from both alternatives is same. The main driver of PM_{10} impacts is related to primary particulates. In case of PM_{10}, the emissions for Alternative C are smaller than Alternative B and therefore the impacts are also smaller for Alternative C. The impacts at the three assessment areas from both alternatives are extremely low for all pollutants with no noticeable differences modeled between the two alternatives.

Regarding PSD increments, a similar conclusion to NAAQS is observed in that increased NO_2 emissions in Alternative C lead to higher impact for both NO_2 and $PM_{2.5}$. The lower emission of PM_{10} in Alternative C lead to lower PM_{10} impacts compared to Alternative B. SO_2 impacts are similar in both alternatives as the emissions are similar in both.

Nitrogen deposition related impacts for Alternative C are slightly larger compared to those for Alternative B. However, the main impacts occur within the Project area for both alternatives. Sulfur deposition impacts for both alternatives are very similar and show no distinct differences with the largest impacts occurring within the Project area for both.

The location of the three assessment areas is far from the Project and therefore Project specific maximum deposition impacts are very similar between the two alternatives. In both cases, no alternative will exceed the 0.5 Δdv threshold on any day. The cumulative visibility impacts are very similar between these two alternatives. However, Alternative C shows slightly higher impacts during the 20% most impaired days at Gates of the Arctic and the Noatak National Preserve. The key differences between Alternative B and C that were discussed above are tabulated in Table 5.5-1.

Table 5.5-1 Comparison of Regional Modeling Impacts Across Alternatives

Metric	Impact
NAAQS and AAAQS	Domain-wide impacts for $PM_{2.5}$ and NO_2 are higher for Alternative C compared to Alternative B. Both alternatives show similar impacts for ozone. All pollutants analyzed are below the NAAQS and AAAQS for both alternatives. Alternative D is also anticipated to be below all standards because its emissions are between Alternatives B and C or lower than both of them.
PSD Increment	Domain-wide impacts for $PM_{2.5}$ and NO_2 are higher for Alternative C compared to Alternative B. All pollutants analyzed are below the PSD increment thresholds for both alternatives. Alternative D is also anticipated to be below all PSD increments because its emissions are between Alternatives B and C or lower than both of them.
Deposition	Nitrogen deposition is larger for Alternative C relative to Alternative B. Sulfur deposition for both alternatives is similar. The nitrogen and sulfur deposition for both alternatives are below the Deposition Analysis Thresholds. Alternative D is also anticipated to be below the DATs because its emissions are between Alternatives B and C or lower than both of them.
Visibility	Impacts for both alternatives are similar. Both are well below 0.5 delta dv threshold, so they do not contribute to visibility impairment. Alternative D is also anticipated to be below visibility thresholdsbecause its emissions are between Alternatives B and C or lower than both of them.

5.6 Comparison between Alternative B (Proponent's Project) and Alternative D (Disconnected Access)*

Alternative D was not assessed with the regional model because its CAP emissions (and therefore regional air quality impacts) would be typically lower than Alternative C and higher than Alternative B, or lower than both Alternative B and C in the case of PM_{10}. Therefore, all CAPs would be below the AAQS under Alternative D. The Project impacts related to PSD increments for Alternative D would be higher than Alternative B but lower than Alternative C, or lower than both alternatives in the case of PM_{10}. The Project impacts would be below the PSD increment thresholds for all CAPs in all three assessment areas. Visibility impacts would be between those for Alternatives B and C and would be well below the 0.5 dv threshold based on the emissions, so Alternative D would not contribute to or cause visibility impairment in the three assessment areas. Nitrogen deposition for Alternative D is anticipated to be lower than Alternative C and higher than Alternative B based on the projected emissions. Sulfur deposition for Alternative D would be similar to the other action alternatives. The Project-specific nitrogen and sulfur deposition under Alternative D would be below the DATs and the cumulative nitrogen deposition would be below or within the critical loads for nitrogen deposition. The location of the three assessment areas is far from the Project and therefore Project specific maximum visibility impacts are very similar between the two alternatives. Neither alternative will exceed the 0.5 Δdv threshold on any day. The cumulative visibility impacts are expected to be very similar between these two alternatives.

5.7 Comparison between Alternative B (Proponent's Project) and E (Three-Pad Alternative)*

Alternative E far-field modeling was not performed because the changes in the emissions inventory between Alternative B and Alternative E are minor and impacts to AQ and AQRV can be assessed instead by comparison to modeled impacts disclosed for Alternative B. Table 5.7-1 shows a subset of the emissions presented in Chapter 2 of this AQTSD and shows the maximum year emissions for each criteria pollutant for all Project activities for both Alternatives. As shown, Alternative E maximum year emissions are lower than Alternative B.

Table 5.7-1 Alternative E Maximum Year Emissions from All Project Activities Compared to Alternative B*

Alternative	Peak Annual Emissions (tons per year [tpy])					
	Criteria Pollutants					
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC
Alternative B	903.8	893.9	56.2	554.3	128.1	666.7
Alternative E	838.6	839.9	54.9	545.7	126.9	641.8
Percent Difference (Alt E – Alt B)	-7.2%	-6.0%	-2.3%	-1.6%	-0.9%	-3.7%

Table 5.7-1 shows that the total project emissions for all criteria pollutants and VOCs are lower under Alternative E compared with Alternative B, therefore it is expected the direct impacts to AQ and AQRV for Alternative E would be less or about the same as those of Alternative B, which are already very small. Cumulative concentrations and other AQRVs under both alternatives are expected to show very little

differences. Project specific impacts for Alternative E are expected to be similar or lower than the impacts under Alternative B. In general, it is expected that Alternative B shows larger domain-wide impacts than Alternative E and that these impacts will occur in the vicinity of the Project area. The largest difference in emissions from Table 5.7-1 is in the annual NOx emissions that for Alternative E are 7% smaller than in Alternative B and this will lead to smaller impacts to both NO_2 and particulate nitrate, thus reducing the expected impacts to $PM_{2.5}$. For ozone the domain-wide maximum is expected to be larger for Alternative B compared to Alternative E since the VOC and NOx precursor emissions are both smaller under Alternative E. The spatial distribution of ozone due to either alternative will be similar and the effect on ozone from both alternatives about the same. The main driver of PM_{10} impacts is related to primary particulates. In the case of PM_{10}, the emissions for Alternative E are 1.6% smaller than Alternative B and therefore the impacts are expected to be smaller for Alternative E. The impacts at the three assessment areas for Alternative E are likely to be extremely low for all pollutants since the modeled impacts on Alternative B are shown to be low as well.

Regarding PSD increments[14], a similar conclusion to NAAQS is observed in that decreased NO_2 emissions in Alternative E will lead to smaller impacts for both NO_2 and $PM_{2.5}$. The lower emissions of PM_{10} in Alternative E will lead to lower PM_{10} impacts compared to Alternative B. SO_2 impacts are expected to be smaller for Alternative E given that the SO_2 emissions are 2.3% smaller than Alternative B.

Nitrogen deposition related impacts for Alternative E are expected to be smaller compared to those for Alternative B. However, the main impacts will still occur within the Project area for both alternatives. Sulfur deposition impacts for both alternatives are likely to be similar and show no distinct differences with the largest impacts occurring within the Project area for both.

The location of the three assessment areas is far from the Project and therefore Project specific maximum visibility impacts are expected to be very similar between the two alternatives. Neither alternative will exceed the 0.5 Δdv threshold on any day. The cumulative visibility impacts are expected to be very similar between these two alternatives.

[14] As indicated previously, this is not a formal PSD increment consumption analysis and is presented only for background information

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