U.S. Department of the Interior
Bureau of Land Management
U.S. Fish and Wildlife Service

August 2023

Coastal Plain Oil and Gas Leasing Program Supplemental Environmental Impact Statement

DRAFT

Volume 3: Appendixes B–R

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Cover photo by Lisa Hupp (USFWS)

NEPA Number: DOI-BLM-AK-0000-2021-0006-EIS

Publication Number: BLM/AK/PL-22/002+1610+930

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Appendix B

Updated Reasonably Foreseeable Development Scenario for Oil and Gas Resources in the Public Law 115-97 Coastal Plain, Alaska

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ACRONYMS AND ABBREVIATIONS

Acronym	Full Phrase
3D	three-dimensional
ADEC	Alaska Department of Environmental Conservation
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act of 1980
Arctic Refuge	Arctic National Wildlife Refuge
BBO	billion barrels of oil
CFR	Code of Federal Regulations
Coastal Plain	Public Law 115-97 Coastal Plain
CPF	central processing facility
EIA	Energy Information Administration
EIS	environmental impact statement
EOR	enhanced oil recovery
Leasing EIS	Coastal Plain Oil and Gas Leasing Program Environmental Impact Statement
NEPA	National Environmental Policy Act
NPR-A	National Petroleum Reserve Alaska
PL	Public Law
ROD	Record of Decision
TAPS	Trans-Alaska Pipeline System
TCF	trillion cubic feet
USGS	United States Geological Survey
VSM	vertical support member

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Appendix B. Updated Reasonably Foreseeable Development Scenario for Oil and Gas Resources in the Public Law 115-97 Coastal Plain, Alaska

B.1 Summary

This hypothetical development scenario represents a good faith effort to project reasonably foreseeable oil and gas exploration, development, production, and abandonment in accordance with the Tax Cuts and Jobs Act of 2017, Public Law 115-97 (Dec. 22, 2017) (PL 115-97) Coastal Plain (Coastal Plain), and 40 Code of Federal Regulations (CFR) 1508.8(b). Estimating the level of future oil and gas activity in this area is difficult at best. Timing and location of future commercially viable discoveries cannot be more accurately projected until these undiscovered resources are explored. The hypothetical unconstrained scenario projects development under standard lease terms and encompasses restrictions in the enacting legislation. Scenarios by alternative incorporate the leasing stipulations and required operating procedures in the Coastal Plain Oil and Gas Leasing Program Environmental Impact Statement (Leasing EIS) into the hypothetical projections.

The Coastal Plain encompasses approximately 1,563,500 acres of federal land in the northernmost end of the Arctic National Wildlife Refuge (Arctic Refuge). Alaska Native Claims Settlement Act (ANCSA) corporation lands that are patented or interim conveyed are excluded from the program area.

Very little oil and gas exploration has occurred in this area, and there are no proven plays[1] at this point. The United States Geological Survey (USGS) estimated that there is a 95 percent probability that the federal lands in the 1002 Area (as defined by ANILCA) of the Arctic Refuge[2] contain a technically recoverable volume of least 4.25 billion barrels of oil (BBO). There is a 5 percent probability that the technically recoverable volume of oil could exceed 11.80 BBO. The mean estimate of technically recoverable oil for the federal lands in the ANILCA 1002 Area of the Arctic Refuge is 7.69 BBO. Of this, a mean of 7.14 BBO was estimated to be economically recoverable at $55 per barrel (2005 dollars, approximately $85 in 2023 dollars; Attanasi 2005). Alaska North Slope crude was priced around $81 per barrel in December 2022, down from a high of $112 in July of 2022 but up from $68 per barrel one year earlier (EIA 2023a), and the US Energy Information Administration (EIA) projects that crude oil prices may increase or decrease depending on multiple factors (EIA 2023b). More recent estimates published by the EIA estimate mean oil production in the Coastal Plain at 3.4 BBO produced by 2050 (Van Wagner 2018).

Technically recoverable associated and unassociated natural gas resources are estimated at 7.04 trillion cubic feet (TCF; Attanasi 2005). Any proposed gas pipelines connecting the North Slope to potential markets would first connect to better understood and established fields before connecting to the Coastal

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[1]A play is a group of oil fields or prospects in the same region that are controlled by the same set of geological circumstances.
[2]Similar in area and boundary, but not identical to the Coastal Plain program area boundary.

Plain. There are estimated to be 225 million barrels of natural gas liquids in the program area; some amount of natural gas liquids would be produced as a byproduct of oil production in some formations.

Crude oil and natural gas resource assessments often use different classifications to describe estimated oil and natural gas resource volumes that might be produced at some time in the future. Such classifications generally range, in order of decreasing volume, from original oil in place, to technically recoverable resources, to economically recoverable resources, and finally to proved reserves. For a thorough description of each of these categories, and useful visual aids, the reader is referred to the EIA at https://www.eia.gov/todayinenergy/detail.php?id=17151.

According to the EIA, the "volumes of oil and natural gas that ultimately will be produced cannot be known ahead of time. Resource estimates change as extraction technologies improve, as markets evolve, and as oil and natural gas are produced. Consequently, the oil and gas industry, researchers, and government agencies spend considerable time and effort defining and quantifying oil and natural gas resources" (EIA, 2019). For instance, the United States Geological Survey (USGS) often conducts resource estimates under the Technically Recoverable Resources classification, while the Securities and Exchange Commission maintains a definition of Proved Oil and Gas Reserves for oil and gas reporting disclosures to assist investors in a more meaningful and comprehensive understanding of the oil and gas industry. The definition of proved reserves has been established by SEC rulemaking at 17 CFR 210.4-10, which can be read at https://www.sec.gov/rules/final/2008/33-8995.pdf (SEC 2010). All of these classifications of resource estimates, as described above and as used herein, involve speculation and uncertainty.

In addition, it is noted that the projections of oil and gas reserves across the North Slope as cited herein, and predictions of likely future production levels resulting from those reserves, are necessarily highly speculative. For instance, USGS has repeatedly revised their prior assessments of producible oil and gas for the NPR-A and surrounding areas, as new information has become available and additional analysis has been conducted. These assessments have proven to fluctuate significantly over time, as evidenced by the fact that the assessments of technically recoverable reserves for NPR-A and surrounding areas were projected by USGS to be 10.5 billion barrels of oil and 61 trillion cubic feet of gas in 2002, then were revised to be 896 million barrels of oil and 53 trillion cubic feet of gas in 2010, and again were revised to be 8.7 billion barrels of oil and 25 trillion cubic feet of gas in 2017 (USGS 2002, 2010, 2017). Future studies and assessments, whether by the USGS or others, will likely continue to evolve and shift based on advancements in geophysical assessment and drilling technology. They also may include new methods of development not currently contemplated on the North Slope, such as methane hydrates. A 2008 USGS resource assessment of methane hydrate potential for the North Slope, including areas of the Coastal Plain, are estimated to contain up to 590 trillion cubic feet of in-place methane hydrate gas (USGS 2008) though the study acknowledges that "the production potential of the known and seismically inferred gas-hydrate accumulations in northern Alaska has not been adequately field tested." To date, there is no known commercial production of natural gas from gas hydrate formations, and the Department of Energy stipulates that "the commercial viability of gas hydrate reservoirs is not yet known" (DOE 2019). In some cases, whether in the Coastal Plain or elsewhere on the North Slope, future estimates may change drastically based on new discoveries, ongoing exploration activities, and market conditions. Often exploration and development activities are the only sure way to confirm the size and extent of oil and gas reserves.

B.2 INTRODUCTION

This hypothetical development scenario provides an estimate of the levels of petroleum-related activities and associated surface disturbances under an unconstrained scenario. Under the unconstrained scenario, the lessee is bound to the terms and conditions set forth on the standard lease form. The hypothetical development scenario is a discussion of how those projected activities may vary under each alternative. In addition, this document presents a description of the subsurface geology and the oil and gas resource estimates of the Coastal Plain and identifies the assumptions used to develop hypothetical projections.

The petroleum-related activities projected in this hypothetical development scenario is useful only in a general sense. This is because the timing and location of future commercial-sized discoveries cannot be accurately predicted until exploration drilling begins; however, it is reasonable to expect that new technologies and designs developed in the future will augment exploration and development and may enhance the safety and efficiency of operations, while minimizing the effects of oil activity on the environment. The hypothetical scenarios described in this document represent successful discovery and optimistic high-production development scenarios in a situation of favorable market prices. This is to minimize the chance that the resultant impact analysis will understate potential impacts.

Current state-of-the-art technologies, methods, and designs are used to project hypothetical scenarios for future petroleum development. Petroleum-related activities include such major undertakings as conducting seismic operations; constructing ice roads and snow trails for transporting equipment and supplies for winter drilling of exploration wells; drilling exploration and delineation wells; constructing gravel pads, roads connecting production pads to main facilities, and landing strips; drilling production and service wells; installing pipelines; and constructing oil and gas processing facilities. The location and size of any future infrastructure proposed as part of development will be described in future National Environmental Policy Act (NEPA) documentation.

Impacts caused by the extraction of energy resources cannot be assessed without estimating future activity on at least a hypothetical level. A fundamental assumption of these scenarios is that the level of future activities is directly related to the petroleum resource potential made available for leasing and development; however, industry’s interest in exploring for new resources is influenced by profit motives, where opportunities for new production in northern Alaska must compete with projects elsewhere. Consequently, future development and associated potential impacts are influenced by several factors, as follows:

- The perceptions of economic potential of the area
- The prospective locations available for leasing
- Industry’s ability to identify prospects to drill
- The distance to existing infrastructure
- The competitive interest in exploring for new fields and encumbrances placed on the land
- Resource demand for hydrocarbons resulting from climate change policies, technological developments, etc.

Until a transportation system to move gas to market is constructed, the assumption is that gas produced with oil would be separated and reinjected into the reservoir as part of the enhanced oil recovery (EOR) process.

B.3 DESCRIPTION OF GEOLOGY

Due to a lack of bedrock exposure in outcrops within the majority of the coastal plain, information regarding subsurface geology has been obtained from limited remote sensing, observations in the mountains south of the area, and wells drilled west and north of the area (Bird 1999). As a result, localized geology is not as well understood as it is in most prospective lease areas, where data collected from wells are used to inform geologic understanding.

The geology of the Coastal Plain is split into undeformed and deformed areas, demarcated by the Marsh Creek anticline, which runs northeast-southwest across the Coastal Plain (see **Map B-1**, Hydrocarbon Potential). Northwest of the Marsh Creek anticline, the undeformed area rocks are generally gently dipping to nearly horizontal. Southeast of the anticline, the deformed area rocks show significantly more folding and faulting. Rocks with petroleum potential in the Coastal Plain area are mostly younger than Devonian and are divided into the Ellesmerian sequence of Mississippian to Triassic age, the Beaufortian sequence of Jurassic to Early Cretaceous age, and the Brookian sequence of Early Cretaceous to Cenozoic age (USGS 1998). The Ellesmerian sequence is up to two-thirds of a mile thick, primarily composed of equal amounts of carbonate and clastic rocks. The Brookian sequence consists of up to 4 miles of marine and nonmarine siliciclastic deposits originating from the ancestral Brooks Range (USGS 1998).

Possible petroleum reservoir rocks beneath the Coastal Plain are intra-basement carbonate rocks, Beaufortian sandstone similar to that of the Kemik sandstone or Thomson sand of local usage, and Brookian turbidite sandstone in the Canning Formation or deltaic sandstone in the Sagavanirktok and Jago River Formations. The timing of hydrocarbon generation relative to the formation of traps is judged to be favorable for the retention of oil in the Coastal Plain. Structural traps are believed to have formed before, during, and after oil generation and migration (Bird and Magoon 1987).

B.3.1 Undeformed Area

Approximately 80 percent of petroleum resources are estimated to be in the undeformed northwestern portion of the ANILCA 1002 Area (USGS 1998). The identified potential plays in this area, in order of greatest to least potential, are the Topset play, Turbidite play, Wedge play, Thompson play, Undeformed Franklinian play, and Kemik play. Total undiscovered, technically recoverable resources from these plays are estimated to be 6.420 BBO (Attanasi 2005).

Table B-1, below, gives estimates of recoverable petroleum resources in the undeformed area. Development is expected to begin in the Topset play, which is estimated to contain over half the recoverable undiscovered oil in the program area. Initial interest is expected to be in test wells drilled in areas where seismic data reveals traps or where the formation is particularly thick. Areas where multiple plays overlap are also expected to receive early exploration and development interest.

Table B-1
Estimated Mean Undiscovered Petroleum Resources in the Undeformed ANILCA 1002 Area

Play Name	Oil (BBO)	Gas (TCF)	Natural Gas Liquids (Billion Barrels of Liquid)
Topset	4.325	1.193	0.010
Turbidite	1.279	1.12	0.065
Wedge	0.438	0.226	0.005
Thompson	0.246	0.47	0.039
Kemik	0.047	0.116	0.010
Undeformed Franklinian	0.085	0.30	0.029
Total	**6.420**	**3.424**	**0.159**

Source: Attanasi 2005
Note: Totals are technically recoverable amounts.
Note: Totals are for federal lands only.
Note: The ANILCA 1002 Area is similar in area and boundary, but not identical to the Coastal Plain program area boundary.

B.3.2 Deformed Area

Potential plays in the deformed area, in order of greatest to least potential, are the Thin-Skinned Thrust belt play, Niguanak/Aurora play, Deformed Franklinian play, and Ellesmerian Thrust Belt play. Total undiscovered resources from these plays are estimated to be 1.267 BBO (Attanasi 2005). **Table B-2**, below, gives estimates of recoverable petroleum resources in the deformed area. Plays in the deformed area are expected to be developed only in localized areas if seismic data and test wells indicate a promising field.

Table B-2
Estimated Mean Undiscovered Petroleum Resources in the Deformed ANILCA 1002 Area

Play Name	Oil (BBO)	Gas (TCF)	Natural Gas Liquids (Billion Barrels of Liquid)
Thin-Skinned Thrust Belt	1.038	1.608	0.017
Ellesmerian Thrust Belt	0.000	0.876	0.018
Deformed Franklinian	0.046	0.86	0.046
Niguanak/Aurora	0.183	0.273	0.016
Total	**1.267**	**3.617**	**0.096**

Source: Attanasi 2005
Note: Totals are estimated technically recoverable amounts.
Note: The ANILCA 1002 Area is similar in area and boundary, but not identical to the Coastal Plain program area boundary.

B.4 Past Oil Exploration

Due to a prohibition on oil and gas leasing until the passage of PL 115-97, very little exploration has occurred in the Coastal Plain. A single oil and gas exploratory well was drilled within the boundary of the Coastal Plain (although it was drilled on Kaktovik Iñupiat Corporation surface estate). Results of the KIC#1 exploration well drilled in 1985/1986 have been maintained strictly confidential by the data owners. A two-dimensional seismic survey was conducted by an industry group in the winters of 1984/1985 and 1985/1986 (DOI 1987). The data collected have contributed to every analysis of oil and gas potential in the Coastal Plain since.

B.5 Oil Occurrence and Development Potential

Estimates of oil occurrence and development potential were developed based on the locations of the plays discussed above in *Description of Geology*. Areas where plays with larger estimated undiscovered resources overlap were considered as high occurrence potential, areas where only one or two plays with significant undiscovered resources overlap were considered moderate potential, and areas with only minor plays were considered low potential. Based on these definitions, the highest estimated potential areas are in the western and northern part of the Coastal Plain. See **Map B-1**, below, for a depiction of potential areas.

Since no infrastructure exists in the Coastal Plain, developers are expected to follow oil occurrence potential very closely, rather than trying to build off existing infrastructure, as might occur in a field with existing development; however, the closest infrastructure outside the Coastal Plain is near the northwest border of the area. This coincides with the area of highest occurrence potential. Moving farther from the existing infrastructure near the northwest border of the Coastal Plain, areas would be increasingly less economical to reach; therefore, estimated development potential (which accounts for economic considerations in addition to resource occurrence) coincides with estimated occurrence potential for the Coastal Plain.

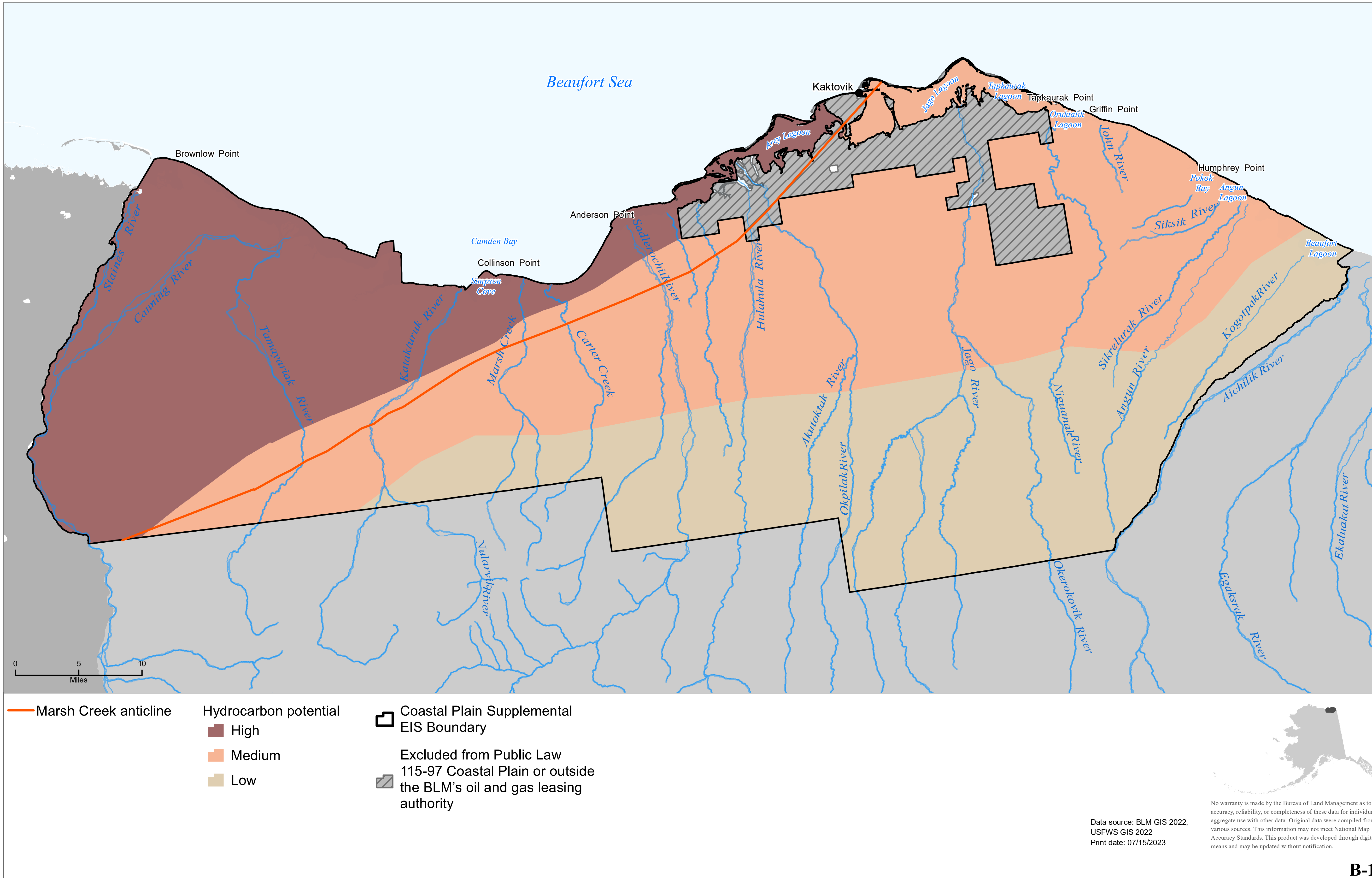
B.6 Method and Assumptions for Hypothetical Development Scenario Projections

There are many uncertainties associated with projecting future petroleum exploration and development. These uncertainties include the amount and location of technically and economically recoverable oil; the timing of oil field discoveries and associated development; the future prices of oil and gas, and more to the point, the many exploration companies' individual assessment of future prices and other competitive calculations that play into corporate investment decisions; and the ability of industry to find petroleum and to mobilize the requisite technology to exploit it.

To address these uncertainties, the BLM has made reasonable assumptions based on the previous two-dimensional seismic exploration of the Coastal Plain, the history of development in the National Petroleum Reserve-Alaska (NPR-A) and other North Slope developments, its own knowledge of the almost entirely unexplored petroleum endowment of the Coastal Plain and current industry practice, and professional judgment. In making these assumptions, the BLM has striven to minimize the chance that the resultant impact analysis will understate potential impacts; therefore, the hypothetical scenarios are intended to represent optimistic high-production, successful discovery, and development scenarios in a situation of favorable market prices. The amount of infrastructure that would be necessary to develop the projected amount of oil is also estimated at upper, but reasonable, limits. For example, the assumption is that each satellite production pad could disturb approximately 12 acres and contain 30 wells (approximately 2.5 wells per acre); however, as ConocoPhillips develops newer well pads in the Colville River Unit (commonly referred to as Alpine) and the Greater Moose's Tooth Unit, this suggests that, on average, pad sizes for that many wells may be closer to 10 acres (approximately 3.3. wells per acre)[3].

These estimates account for advances in technology that have allowed development on the North Slope to become less impactful on the surrounding environment. For example, the older well pads in Alpine had a ratio of 1.6 to 2.2 wells per acre. Increasing the number of wells per acre on a pad does have some drawbacks. For example, wells spaced too tightly can make it difficult to get a workover rig on a well.

[3]Nanushuk Draft EIS measured 2.75 wells per acre of well pad; Alpine, which is newer development, measures approximately 2.5 wells per acre of well pad (USACE 2017).


Beaufort Sea
Kaktovik
Brownlow Point
Anderson Point
Camden Bay
Collinson Point
Simpson Cove
Arey Lagoon
Jago Lagoon
Tapkaurak Lagoon
Tapkaurak Point
Griffin Point
Oruktalik Lagoon
Humphrey Point
Pokok Bay
Angun Lagoon
Beaufort Lagoon
Staines River
Canning River
Tamayariak River
Katakturuk River
Marsh Creek
Carter Creek
Sadlerochit River
Hulahula River
Akutoktak River
Okpilak River
Jago River
Niguanak River
Okerokovik River
Sikrelurak River
Angun River
Siksik River
Jolin River
Kogotpak River
Aichilik River
Egaksrak River
Ekaluakat River
Nularvik River
0
5
10
Miles
Marsh Creek anticline
Hydrocarbon potential
High
Medium
Low
Coastal Plain Supplemental EIS Boundary
Excluded from Public Law 115-97 Coastal Plain or outside the BLM's oil and gas leasing authority
Data source: BLM GIS 2022, USFWS GIS 2022
Print date: 07/15/2023
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

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The time frame used for the hypothetical development scenarios assumes that a rapid rate of development would occur. Development at this rate is only likely to occur under certain conditions such as very high oil prices or if oil accumulations are found to be larger or easier to produce than expected based on current information. Because there is very little data on geologic conditions and petroleum accumulations, and because no infrastructure currently exists in the Coastal Plain, there would be a lag time between lease issuance and the beginning of production in the area. The activities that are projected to occur and the estimated timing of those activities are further described in the *Hypothetical Unconstrained Scenario*, below. The minimum time anticipated for all wells to be completed in the Coastal Plain under any hypothetical scenario is up to 50 years, recognizing the timeframe for production could be more than 50 years given the speculative nature of the long-range development scenarios. Because it is unlikely that all projected wells would be producing at the same time, peak production from the Coastal Plain is anticipated at some point before 50 years, potentially as early as 20 years after the first lease sale. Once peak production is reached, production from a field is anticipated to continue for up to another 35 years, depending on resource production, market forces, and operator financial decisions; therefore, it could be 85 years or more after the first lease sale before all facilities described in the development scenarios are abandoned and reclaimed. However, just as development is expected to occur in phases, reclamation would occur in phases.

Additional assumptions, some of which also tend to support an optimistic set of hypothetical development scenarios, are as follows:

- Industry would aggressively lease and explore the tracts offered.
- Economic conditions (particularly oil prices) would be high enough to support development in the Coastal Plain.
- Undiscovered oil deposits would be discovered in all potential areas (high, medium, and low).
- Industry groups would independently explore and develop new fields in the Coastal Plain.
- Operators would enter agreements to share road and pipeline infrastructure, where feasible.
- Discoveries could be announced any time during a 10-year period (primary lease term) following lease sale, or during a subsequent 10-year lease renewal period (per 43 CFR 3135.1-6).
- Up to three anchor fields, with a minimum of 400 million barrels of producible reserves in each, would be discovered.
- Future oil production would use existing North Slope infrastructure, including the Trans-Alaska Pipeline System (TAPS).
- If the Coastal Plain is connected to a future natural gas pipeline, the plant for compressing produced natural gas into liquid natural gas would be located outside of the Coastal Plain.
- Production wells would have horizontal wellbores, with the lateral portion coinciding with the target formation.
- All production would be accomplished by horizontal well bores and each producing well would be paired with an associated injection well.
- Across the action alternatives, directional drilling would be utilized to access subsurface resources to potentially increase recovery of the hydrocarbon resources.

- Once all wells are online for a field, the projected yield would be approximately 100,000 barrels of oil per day (peak production) for approximately 3 years, with an 8 percent annual production decline.[4]
- The maximum production range from CPF to satellite pads is an approximately 35-mile radius.
- Production activities would continue year-round for approximately 10 to 50 years, depending on field size and reservoir conditions.
- Production would end when the value of production cannot meet operating expenses.
- Fuel for equipment operation would be hauled overland.
- Gas would be re-injected into the formation to maintain reservoir pressure and enhance oil recovery.
- At least one seawater treatment plant to supply water for water flood recovery would be constructed, each plant would occupy approximately 15 acres. The plant(s) would be designed to process sufficient amounts of water for water flood recovery, the amounts would be based on reservoir characteristics which are not known at this time.

Gas would be flared or vented only in situations where an equipment failure prevents re-injection or there is danger of equipment becoming over-pressurized. Operators must use flaring over venting per 43 CFR 3179.6(b).

B.6.1 Surface Development Limitations

Section 1.9.1 of the EIS contains the BLM's interpretation of Section 20001(c)(3) of PL 115-97, which states the following:

> SURFACE DEVELOPMENT—In administering this section, the Secretary shall authorize up to 2,000 surface acres of Federal land on the Coastal Plain to be covered by production and support facilities (including airstrips and any area covered by gravel berms or piers for support of pipelines) during the term of the leases under the oil and gas program under this section.

For the purposes of impact analysis, BLM employs that interpretation as an assumption in each of the action alternatives analyzed in the EIS.

B.7 Hypothetical Unconstrained Scenario

This hypothetical unconstrained scenario projects an estimated projection of activity on federal lands in the Coastal Plain, assuming all potentially productive areas will be open to leasing, subject to standard terms and conditions. The exception is those areas designated as closed to leasing by law, regulation, or executive order. The activities and methods described in the hypothetical unconstrained scenario are based on the activities typically associated with oil and gas operations on the North Slope of Alaska.

For a further description of typical activities and methods in the North Slope, see Section 4.2.1.2 of the NPR-A Final Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) (BLM 2012).

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[4]The 100,000 barrels of oil per day represents the minimum for a CPF in the Coastal Plain based on Willow and Pikka Nanushuk on the North Slope, though for any particular development this number may be exceeded. Decline estimate is based on standard decline estimates from the State of Alaska and the estimates used in NPR-A analyses.

The hypothetical development scenario is meant to convey the most likely unconstrained development scenario, meaning the entire Coastal Plain would be offered for leasing under standard terms and conditions with no management restrictions, such as stipulations or required operating procedures, except those mandated by law. The hypothetical scenario provides the mechanism to analyze the effects that discretionary management decisions under the Leasing EIS alternatives would have on estimated future petroleum development activity.

Table B-3, below, describes the general time frames in which hypothetical exploration, development, and production might occur in the Coastal Plain. As described in *Method and Assumptions for Hypothetical Development Scenario Projections*, a time lag of at least 8 years is expected between the first lease sale and the beginning of production. As previously discussed, the time frames below represent an optimistic, aggressive hypothetical scenario. Activities projected to occur within 5 years after the first lease sale are considered short term; activities projected to occur more than 5 years after the first lease sale are considered long term.

Table B-3
Estimated Hypothetical Development Time Frames

Project Phase	Estimated Time Frames of Activities	Projected Activities
Initial three-dimensional (3D) seismic exploration	Within 2 years after lease sale	3D seismic exploration
Leasing	Within 1 year of ROD	Lease sale
Exploration	Within 2 years after lease sale or end of lease suspension	• First application for permit to drill submitted for exploration well • First exploration well drilled • Assumes discovery with first exploration well
Additional lease-level 3D seismic exploration and/or initial exploration wells	Within 3 years after lease sale (would occur during winter)	• Seismic exploration on lease block with discovery to locate future delineation exploration wells • Process seismic data and determine location of delineation wells to be drilled the following winter
Additional exploration wells	4 years after lease sale (winter)	Drill 3 to 5 additional wells to define the prospect and identify satellite pad locations
Master development plan	5 to 6 years after lease sale	• Conduct NEPA analysis on master development plan for anchor field • Continue drilling 2 to 3 exploration wells to identify CPF and satellite pad locations

Project Phase	Estimated Time Frames of Activities	Projected Activities
Development	7 years after lease sale	• Begin laying gravel for anchor pad, begin CPF construction • Construct oil transportation pipeline connection from anchor pad to existing infrastructure at Point Thompson • Continue drilling 2 to 3 exploration wells to identify satellite pad locations • Begin drilling production wells on anchor pad
Production begins	8 years after lease sale	• First production from anchor pad • Winter gravel and construction on satellite pads
Production increases	9 to 40 years after lease sale	• All wells completed on anchor pad • All wells completed on satellite pads
Development of additional fields	11 to 85 years after lease sale	• Construct facilities and drill wells in additional fields • Production continues for approximately 35 years after reaching peak production in each field
Abandonment and reclamation	19 to 85 or more years after lease sale	• Plug wells that are no longer economically productive • Remove retired equipment, remove vacant gravel pads and roads, and reclaim the area

B.7.1 Leasing

PL 115-97 mandates two lease sales: the first within 4 years and the second within 7 years. Under this hypothetical scenario, the assumption is that a lease sale would occur within a year of the publication of the ROD for the Supplemental EIS. It is also assumed that industry would lease areas offered and would follow up with a rapid exploration and development schedule.

B.7.2 Exploration

The completion of 3D seismic surveys would be the first step in the exploration process. After the lease sale, operators would likely conduct 3D seismic surveys on their lease blocks. This would require winter travel by vibroseis (seismic vibration) vehicles and smaller support vehicles. Vibroseis vehicles are mounted on rubber tracks to minimize ground pressure. No air-guns or dynamite are expected to be used as part of the seismic surveys. Multiple vehicles could be used simultaneously miles apart to conduct vibroseis exploration, or convoys of four to five trucks could travel in a line, which is less common.

It is assumed that cable-less geophone receivers (autonomous recording nodes) would be placed in lines perpendicular to source lines. Source and receiver lines could be 330 to 1,320 feet apart. Seismic operations would be accompanied by ski-mounted camp buildings towed by bulldozers or other tracked vehicles. There could be two to three strings with four to eight modular buildings in each string. Camps are assumed to move weekly. All seismic operations would be conducted in the winter to minimize impacts on the tundra

(BLM 2018). During the exploration phase, exploratory drilling would occur on lease, and geophysical exploration could occur both on and off lease. On lease seismic would occur to assist in the location of future delineation wells for hydrocarbon verification. Off lease seismic could occur in frontier areas to inform potential future prospects.

Following the completion of 3D seismic surveys, exploration wells would be drilled to confirm seismic findings and further explore the characteristics of the leased area. Exploration wells would be drilled in the winter, using an ice drill pad and an ice road to transport a drilling rig to minimize impacts. Exploration drilling rigs could also be flown in by helicopter in some cases which would remove the need to an ice road to the pad. These wells would target prospective geologic traps, indicated by seismic results. Initial exploration wells would likely be drilled vertically to the basement (approximately 13,000 feet, or deeper to the east) to define the entire stratigraphic column. Water needed for ice pad construction and drilling muds could be imported, taken from grounded ice in nearby lakes and rivers, or acquired by melting snow; water demand would vary based on the site geology, well depth, and the density of drilling mud required.

To protect the tundra, ice roads would be used for most exploration activities. Ice roads are constructed seasonally and are used to transport drill rigs, modular units, large or heavy equipment and other supplies. They are constructed by compacting snow using low-ground pressure vehicles (approximately 1 to 2 pounds per square inch). The compacted tracks would capture more snow blown by wind until they are compacted again after a week or two of accumulation.

Once accumulation is complete, larger tracked vehicles with higher ground pressure or wheeled vehicles, such as a water truck or front-end loader, would compact the snow to the desired road width. Water would then be dispersed on the compacted snow to create ice buildup. The rate of ice buildup in cold conditions is approximately 1.5 inches per day. Using ice chips shaved from frozen lakes can increase the buildup rate to 4.5 inches per day and can reduce the amount of water needed by approximately 75 percent. The minimum ice depth for use by full-size vehicles is 6 inches, and roads are typically 35 to 40 feet wide. A typical ice road requires 1 million to 1.5 million gallons of water per mile (North Slope Borough 2005). Crews can construct about 1 mile per day (BLM 2012).

Construction of ice roads for specific projects using traditional techniques may be limited by freshwater availability in the program area. Innovative techniques, including ice chipping, that minimize the use of freshwater or identify additional water sources could allow for additional construction of ice roads. Examples of alternative sources include naturally deep lakes, melting lake ice, trapping and melting snow, extracting water from gravel mine sumps, and desalinating marine water obtained beyond the barrier islands. Additional NEPA analysis at the site-specific level would assess water needs and measures to address water supply issues.

Snow trails could be used for smaller equipment, such as seismic trucks, camps, and maintenance vehicles. Low-ground pressure vehicles are used to pre-pack snow and groom trails if needed. Snow trails due not use ice as a construction medium and are typically thinner than ice roads and are wide enough for one vehicle only. If snow trail maintenance is necessary, a tracked vehicle would be used to tow a snow groomer to smooth out the trail and disperse snow to areas of the trail that need it.

A typical ice pad for exploration drilling is 1 to 2 feet thick and can require up to 5,000,000 gallons of water, depending on thickness and if ice chips are used (BLM 2012).

Current drilling technology is self-contained; reserve pits are not used. During initial exploration, drill cuttings would be transported out of the Coastal Plain for disposal. Once production pads and facilities have been established within the Coastal Plain, cuttings and muds from exploration wells may be transported to the nearest approved disposal well. Drilling an exploration well may take weeks or months, depending on depth, data collection program, and borehole conditions. Once the well is completed, additional down-hole testing and characterization can take up to a month (DOI 2005).

Following a promising discovery in an exploration well, delineation wells would be drilled to further characterize the discovery. These wells require similar resource commitments and require about the same time for drilling as an initial exploration well. After drilling, logging, and other downhole evaluation activities are complete, exploration and delineation wells may either be completed and suspended for future use or plugged and abandoned according to regulatory requirements, with all wastes removed from the site (DOI 2005).

B.7.3 Development

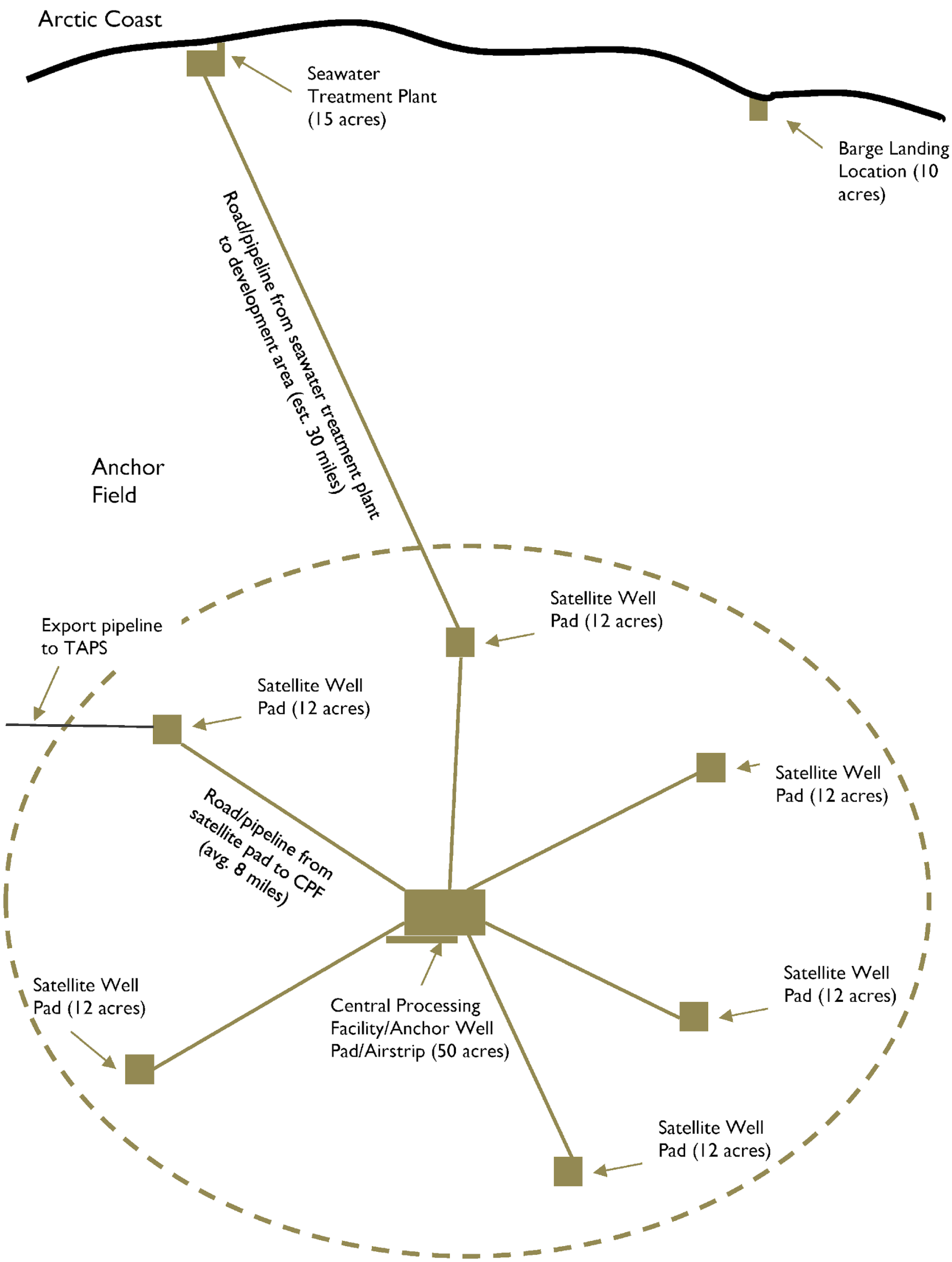
For the purposes of this hypothetical scenario, the assumption is that economic conditions would remain favorable to produce oil from the program area. Another assumption is that economically feasible oil accumulations would be discovered in all potential areas and that multiple anchor fields (each containing at least 400 million barrels of producible reserves) would be discovered. Further, the assumption is that several different operators would independently explore and develop new fields in the Coastal Plain. See **Figure B-1**, Conceptual Layout of a Stand-Alone Oil Development Facility, for a conceptual rendering of a hypothetical anchor field and associated facilities.

In caribou areas, roads would be built on north-south and east-west orientations to the extent possible, in order to promote immediate crossing and limit interference with caribou migration. BLM biologists have determined that caribou are more likely to cross roads that are close to perpendicular to their direction of travel. **Figure B-2**, Conceptual Layout of a Caribou Area Stand-alone Oil Development Facility, shows how the hypothetical layout could be adjusted for caribou mitigation if deemed appropriate by permitting agencies.

In this hypothetical scenario, development would start following the discovery of an anchor field. The first anchor field discovered is expected be in the western half of the Coastal Plain, most likely in the Topset play. Development would likely begin with the construction of a gravel pad for wells, CPF, airstrip, storage tanks, communications center, waste treatment unit, and a camp for workers. Typically, these facilities occupy a total of approximately 50 acres (BLM 2012).

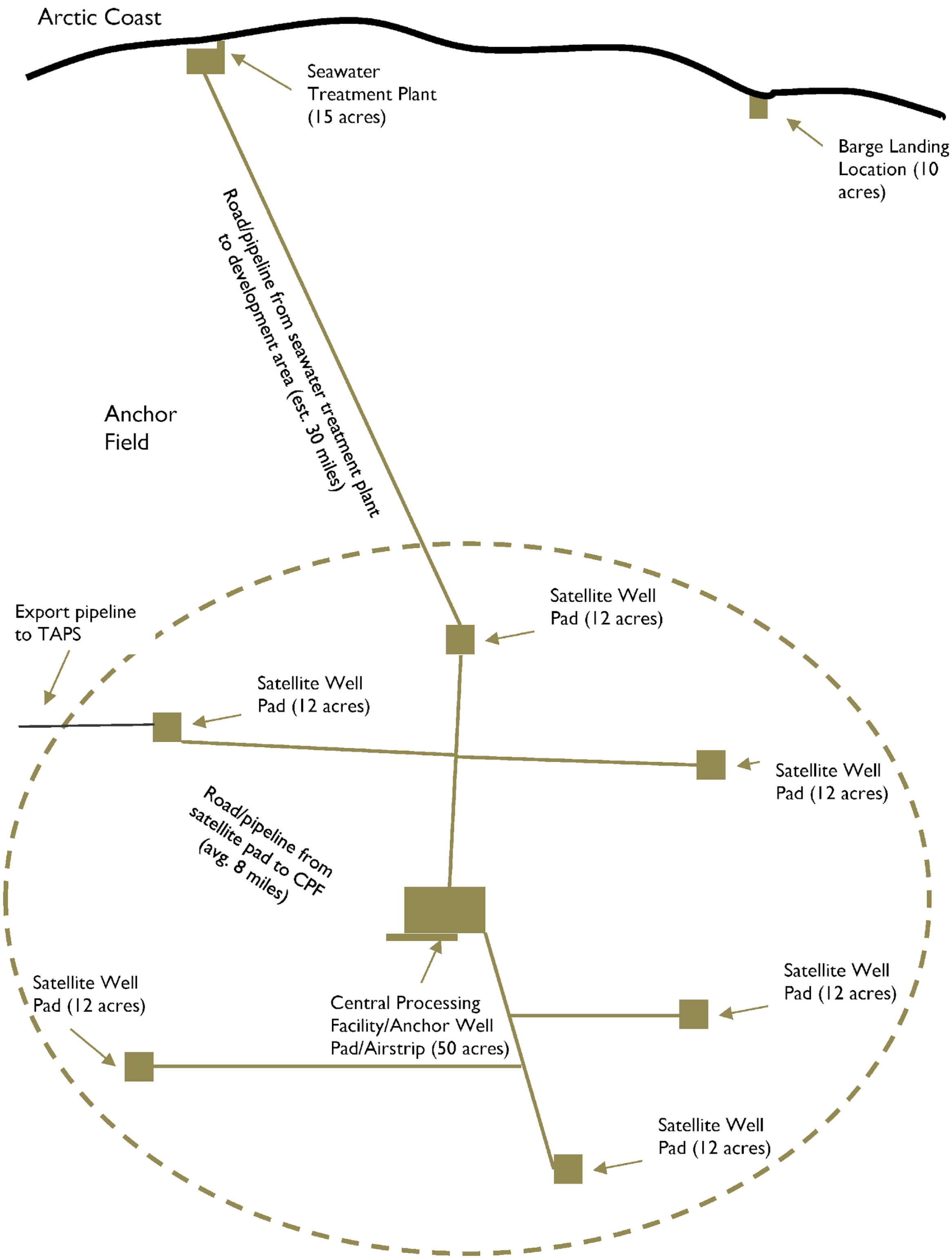
Large modular units and infrastructure too large for transport up the Dalton Highway and across existing North Slope routes to the Coastal Plain would be shipped by barge. Camden Bay has been identified as the most likely location for a barge landing (DOI 1987). If facilities were adequate and approval was given by the operator, Point Thomson is another option for barge landings. Barge trips are expected to begin in Dutch Harbor, Alaska, which is the first location within Alaskan water that materials could be shipped from to access the Coastal Plain. See **Map B-2**, Potential Marine Vessel Transportation Route. A barge landing and an associated staging pad, used to store equipment and modules until ice roads can be constructed, would disturb approximately 10 acres, including the landing area and a gravel staging pad. If dredging is required for a barge landing, it would be analyzed at the project level.

Figure B-1. Conceptual Layout of a Stand-Alone Oil Development Facility*



*Facility locations and sizes are conceptual and are not to scale

Figure B-2. Conceptual Layout of a Caribou Area Stand-alone Oil Development Facility*



*Facility locations and sizes are conceptual and are not to scale

Potential Marine Vessel Transportation Route

Potential marine vessel transportation route

Coastal Plain Supplemental EIS boundary

Data Source: BLM GIS 2022, USFWS GIS 2022
Print Date: 07/15/2023

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An average of two barge transports per year is anticipated; the number of transports would vary based on ice conditions and the large equipment needed for upcoming development phases. The barge landing would likely use a floating dock for support. The dock would likely consist of impermanent, industrial strength plastic, modular blocks that can be joined together.

A seawater treatment plant could also be constructed along the coast, if needed, to source saline water for waterflooding, reservoir pressure support, or other subsurface uses. Local lakes are typically the preferred water sources, due to the cost and maintenance requirements of a seawater desalination plant; however, with limited information about surface water resources in the Coastal Plain, those sources may not be sufficient to meet water needs. Thus, for the purpose of analysis, it is assumed that a seawater treatment plant would be required. Seawater treatment plants from other Arctic developments require approximately 15 acres of surface disturbance.[5] A road and seawater transport pipeline would be constructed from the seawater treatment plant to the CPF. Typical gravel roads in the Arctic require 7.5 acres of surface disturbance per mile (BLM 2012).

Following the construction of a gravel anchor pad for a CPF, airstrip, wells, and worker camp, facility construction and production drilling is expected to begin. A CPF is the long-term operational center for production activities in an anchor field. It generally contains equipment for processing oil, gas, and water, as follows:

- Separators for oil, gas, and water, with an output of sales-quality oil
- Filters for produced oil to extract solids
- Processors to remove water and natural gas liquids from associated gas, followed by gas compression and reinjection into the reservoir through gas injection wells
- Compressors for gas and pumps for water injection back into the reservoir

In addition to a CPF, it is expected that a generator, airstrip, storage tanks, a communications center, waste treatment units, and a maintenance shop would be constructed on the anchor pad. Living quarters and offices may or may not be constructed on an anchor pad with the rest of the facilities. Most buildings would be supported above ground on pilings to accommodate ground settling or frost heaving. Pile driving would be needed for the construction of these buildings. Some buildings like warehouses, shops, and material storage buildings may not be feasible to build on pilings, these could be built on a gravel pad with active and passive refrigeration to mitigate ground settling or frost heaving issues.

To minimize surface disturbance and increase recovery of oil directional extended reach horizontal wells would be used for production. Production wells would extend horizontally in the target formation and could take approximately 45 to 60 days to drill. Total horizontal distance could be up to 6 miles under favorable geologic conditions. This rate of drilling allows approximately eight wells to be drilled on the same pad per year. Depending on drill rig availability, drilling could take place on multiple well pads at the same time. Drilling and completing each well would require anywhere from 420,000 gallons of water for a typical exploration or other vertical well to up to 8 million gallons for a horizontal production well[6] (BLM 2012).

[5]The seawater treatment plant and gravel support pad at Prudhoe Bay measure 15 acres.
[6]Robert Brumbaugh, BLM-Alaska Oil and Gas Section Chief, meeting with Francis Craig, EMPSi geologist, on May 30, 2019, regarding water use for recent wells.

Current drilling technology is self-contained; reserve pits are not used and drilling muds are not placed on the ground. Using grind and inject technology, cuttings are now crushed and mixed with seawater in a ball mill to form slurry. Then it is combined with the remaining drilling muds and reinjected into confining rock formation at an approved depth, typically greater than 3,000 feet below surface. An Alaska Department of Environmental Conservation (ADEC)-approved injection well is used (DOI 2005). This reduces the environmental impacts of disposing of drill cuttings because it avoids the need to bury cuttings on-site or haul them to a landfill. Drilling muds and additives are reconditioned and recycled, to the extent possible.

The anchor pad or satellite pad may have a grind and inject, Class I or Class II disposal well, or both. These are used to dispose of industrial wastes and fluids associated with oil and gas production, respectively (EPA 2018). Disposal wells would need to be approved by the ADEC before use. Solid, unburnable waste would be disposed of in large trash receptacles or other approved containers and hauled to approved off-site landfills.

Wells are expected to be hydraulically fractured for initial stimulation; however, this process requires less water than the multi-stage hydraulic fracturing used in unconventional reservoirs, such as shale. The amount of seawater necessary to stimulate conventional reservoir sandstone would vary, depending on the length of the fracture desired in the horizontal section of the wellbore and the specific formation properties. The amount of stimulation can be gauged by poundage of proppant used (typically sand). As pressurized water opens up spacing between the formation particles, the proppant lodges itself into the spacing, keeping it open for hydrocarbons to flow more freely. A smaller scale stimulation may use 50,000 pounds of proppant and require approximately 21,000 gallons of water. A larger stimulation could use 400,000 pounds of proppant and 180,000 gallons of water.

Water flooding using parallel injection wells would occur to maintain reservoir pressure and to increase oil recovery by pushing oil toward producer wells. Water demand for maintaining reservoir pressure is proportional to the oil production from the field; a field with a daily production rate of 50,000 barrels of oil per day would require approximately 2 million gallons of water per day.

A production pipeline would be constructed to connect a CPF to the TAPS. Vertical support members (VSMs) are counted as ground disturbance at a rate of approximately 0.04 acres per mile (USACE 2017). Pipelines would also connect each satellite pad to the CPF. It is assumed that pipelines for water, gas, and electric cables to supply satellite pads would also be run on the same VSMs. A pipeline to transport future petroleum production from Native lands could be constructed across the northern Coastal Plain to connect to TAPS or other export infrastructure. If there is already a pipeline from other development in the Coastal Plain and if the distance is shorter, then the pipeline from Native lands could tie into that pipeline.

Following the completion of an anchor pad, development would begin on satellite pads around the anchor field. Development of individual pools reachable from an individual satellite pad may be delayed until the project is economical or additional geological data are collected. Satellite pads would consist of wells and the minimum amount of required production equipment. Production from these pads would be pumped via pipeline to the nearest CPF for processing.

Natural Gas Development

A gas line to Kaktovik is possible if gas is discovered nearby and it is considered economical to replace imported diesel or fuel oil as the primary source of power and heat to the village. In the longer term, gas could be exported to markets outside the North Slope; however, this is not likely to occur until other gas deposits closer to planned infrastructure have been produced. Given the large gas reserves around Prudhoe Bay, it could take a considerable amount of time before gas would be exported from the Coastal Plain.

Two pipeline systems, the Alaska Stand Alone Pipeline and the Alaska Liquid Natural Gas (LNG) Project, have been proposed to transport natural gas from the North Slope with southern Alaska where it would be exported using LNG tanker ships. At this time, the Alaska Stand Alone Pipeline has been put on hold and development focus has converged on the Alaska LNG Project (Alaska Gasline Development Corporation 2023). The timeline for the pipeline to come online is currently unknown. Gas transported through the pipeline is expected to come from established fields with proven reserves initially. If economically viable gas resources are discovered in the Coastal Plain, they could be connected to the pipeline to maintain capacity as the primary fields are depleted. Estimated possible natural gas production from the Coastal Plain ranges from 0 to 7 TCF of gas produced (Attanasi 2005). These production estimates do not include gas that would be reinjected into the formation to maintain reservoir pressure as part of the EOR process.

If natural gas resources were to be developed, the addition of gas compression pumping equipment to existing CPF pads in oil fields would result in an approximately 13 additional acres of ground disturbance per CPF. Gas pipelines would be installed on the same VSMs as oil pipelines, so no additional acres would be disturbed for gas pipelines.

Unconventional Development

No unconventional hydrocarbon development, such as hydraulic fracturing, is anticipated in the Coastal Plain for the period analyzed in this hypothetical development scenario. There is currently no unconventional oil and gas production on Alaska's North Slope; due to the high costs of and difficult operating conditions in the Arctic, the viability of hydraulic fracturing to produce from unconventional petroleum resources has not been proven from a technology or commercial viability standpoint (BLM 2012). Coal bed methane potential is low, and its production is unlikely, due to a lack of infrastructure to transport methane gas from northern Alaska to any significant market. Gas hydrates[7] (methane hydrates) are theorized to exist in the Coastal Plain, but no definitive discoveries have been published at this time. Commercial scale gas hydrate development is currently an unproven technology and is not likely to occur in the program area in the foreseeable future.

B.7.4 Production

Production is anticipated to peak at an estimated 100,000 barrels per day[8] from each field (not necessarily concurrently) after 3 years from initial production, though this number may be exceeded for any particular development. From that point onward, production from the field is estimated to decline at a rate of approximately 8 percent per year.[9] New production is expected to come online at various points during the decline but is not expected to bring production back to peak rates. Produced resources would be processed at a CPF to separate water and gas from salable oil and natural gas liquids. Water and gas would be reinjected into the formation to enhance oil recovery; oil and natural gas liquids would be shipped to market, likely via TAPS.

[7]A crystalline compound in which water molecules are chemically bound to another compound or to an element.
[8]Estimate based on production projections for Willow and Pikka Nanushuk developments on the North Slope.
[9]Estimate based on standard decline estimates from the State of Alaska and the estimates used in NPR-A analyses.

Field production can last from 10 to 50 years before abandonment (BLM 2012). In the Coastal Plain, assuming the 100,000 barrel-per-day peak production and the 8-percent decline per year, the assumption was made that it would take an estimated 35 years after reaching peak production to get to the point of abandoning a field. Reinjecting produced gas and water helps maintain oil reservoir energy and improve hydrocarbon recovery efficiency by pushing oil toward the production wells, increasing the ultimate oil recovery. Associated gas and water injection wells are needed where no gas sales line exists and where water disposal is not allowed at the surface (BLM 2012).

Depending on market forces, the size and number of fields discovered, and the timing of development, the projected ultimate recovery in the Coastal Plain is estimated to be anywhere from 1.5 BBO to 10 BBO (Attanasi and Freedman 2009). Given the limited data on the formations, reservoirs, and resources in the Coastal Plain exact locations, timing, layout, and total production of any development that might occur cannot be predicted.

B.7.5 Abandonment and Reclamation

Abandonment and reclamation occur once a well pad or field is no longer producing enough oil to cover costs. Typically, abandonment and reclamation take from 2 to 5 years following the termination of production (BLM 2012). Wells are plugged with cement to prevent fluid migration between formations; they are plugged at the surface to satisfy federal requirements. After plugging, the well casing is cut below the surface and buried. On-site equipment, facilities, and solid wastes are removed from the site. Gravel from pads and roads would be removed and reused in other areas. Gravel pits would have side slopes constructed and reclaimed as ponds. Pipelines and VSMs would be removed and scrapped or reused in other developments.

Once all satellite pads feeding to a CPF are no longer producing, or when the flow of produced oil is reduced to the point that operation is no longer economically viable, the CPF would be decommissioned and reclaimed.

B.8 Coastal Plain Oil and Gas Leasing Program EIS Alternatives Hypothetical Scenarios

B.8.1 Alternative A

Under Alternative A (the No Action Alternative), no federal minerals in the Coastal Plain would be offered for future oil and gas lease sales following the ROD for the Supplemental EIS. Alternative A would not fulfill the direction under PL 115-97 to establish and administer a competitive oil and gas program for leasing, developing, producing, and transporting oil and gas in and from the Coastal Plain in the Arctic Refuge. Under this alternative, management actions and resource trends as described in the Arctic National Wildlife Refuge Revised Comprehensive Conservation Plan (USFWS 2015), would continue. Alternative A is being considered to provide a baseline for the comparison of impacts under the action alternatives.

Because no leasing, exploration, or development would occur under this alternative, no production would occur, and no surface would be disturbed.

B.8.2 Alternative B

Due to limited restrictions and stipulations under this alternative, hypothetical development would be expected to occur in approximately the same manner as the hypothetical unconstrained scenario. In the long term, four CPFs are projected to be built. Hypothetically, this could include two CPFs in the high potential area, one CPF in the medium potential area south of Kaktovik, and one CPF in the low potential area. This hypothetical scenario includes the possibility that one or more CPFs could be located on state or Native lands. Approximately 14 satellite pads are projected to be developed in addition to the four anchor pads associated with the CPFs; an estimated 174 miles of gravel road would be needed to connect facilities. It is projected that one seawater treatment plant and at least one barge landing and storage pad would be needed under this hypothetical scenario.

It is possible that one or more of the CPF development clusters under any of the development scenarios would be roadless. This would entail an expanded airstrip at the CPF with the capacity to handle the larger cargo planes and increased air traffic. In a hypothetical roadless development scenario, it is expected that service roads would still connect satellite pads to the central CPF, so no airstrips would be required at satellites. An ice road would be constructed from a barge landing or supply area outside the Coastal Plain to the CPF each winter under a roadless hypothetical scenario in order to transport larger and heavier supply items required for the coming year. Any equipment or supplies not transported during the winter would be flown in. Additional flights would be needed, compared to a hypothetical development using roads. Roadless development would depend on sufficient water resources for the construction of ice roads each winter. Under the hypothetical development scenario for this alternative, it is expected that the 2,000-acre surface disturbance limit would be reached. See *Surface Disturbance Due to Oil and Gas*, below, for more details on the surface disturbance projected to be created under the hypothetical development scenario for this alternative.

B.8.3 Alternative C

Due to additional restrictions and stipulations under this alternative, including a 1,464-acre total limit on surface disturbance, development could be reduced, the potential locations for drill pads and CPFs could be limited, and pad configurations and locations could change. In the long term, two CPFs are projected to be built under a hypothetical scenario. This could include one in the high potential area and one in the medium potential area south of Kaktovik. The assumption is that approximately 9 satellite pads would be developed under this hypothetical scenario, in addition to the two production pads associated with the two CPFs. An estimated 135 miles of gravel road would be needed to connect facilities, and one seawater treatment plant and one barge landing and storage pad would be needed under a hypothetical scenario. Under the hypothetical development scenario for this alternative the 1,464-acre surface development limit is expected to be reached. See *Surface Disturbance Due to Oil and Gas*, below, for more details on the surface disturbance projected to be created under the hypothetical development scenario for this alternative. Under this alternative most areas with no surface occupancy (NSO) stipulations would be accessible by horizontal drilling from areas where surface occupancy is permitted or from adjacent state or Native lands. The area closed to leasing is predominantly low potential and is not likely to contain significant petroleum accumulations. The lower total disturbed acreage would result in a lower ultimate production total than under Alternative B but would likely not impact the level of production during the planning period.

B.8.4 Alternative D

Due to additional restrictions and stipulations under this alternative, limiting the leasable area to 765,800 acres and applying NSO stipulations to 726,300 acres of available area, the potential locations for drill pads and CPFs could be limited compared to the unconstrained scenario and Alternative B. Under the hypothetical development scenario for this alternative, 1,040 acres of surface disturbance is estimated to occur. See Surface Disturbance Due to Oil and Gas, below, for more details on the surface disturbance project to be created under the hypothetical development scenario for this alternative.

This new alternative incorporates more protective lease stipulations and ROPs than any alternative previously analyzed, has the most acres with NSO stipulations, and stresses protection of the four conservation-orientated statutory purposes of the Arctic Refuge. Infrastructure would be developed where surface occupancy could occur and would utilize directional horizontal extended reach drilling to increase recovery of the oil and gas resources.

In the long term, one CPS is expected to be built under a hypothetical scenario. Possible locations are the areas open for leasing under standard terms and conditions in the high and medium hydrocarbon potential areas. The assumption is that approximately 6 satellite pads could be developed, in addition to the production pad associated with the CPF. An estimated 100 miles of gravel road could be needed to connect facilities, and one seawater treatment plant and one barge landing and storage pad would be need under this hypothetical scenario. Under this scenario, it is possible that a CPF and satellite well pads could be placed on Native or state lands adjacent to the Coastal Plain with wells extending horizontally into leased NSO areas in order to access oil and gas resources while reducing the disturbance footprint within the Coastal Plain.

B.9 Surface Disturbance Due to Potential Future Oil Development

B.9.1 Production Facilities

A CPF is the operational center for long-term production. A typical pad for a CPF and associated facilities, which include an airstrip, workers camp, and production well pad, is approximately 50 acres (BLM 2012). Similar projects estimate gravel needs at 10,000 cubic yards per acre (BLM 2012), for a total of 500,000 cubic yards per 50-acre CPF.

A typical satellite well pad associated with potential future development in the Coastal Plain is projected to have approximately 30 wells and occupy approximately 12 acres. A well pad of this size would require approximately 120,000 cubic yards of gravel.[10] Pads would be constructed to a thickness sufficient to maintain a stable thermal regime. This hypothetical scenario assumes an approximately 5-foot thickness, based on data from Point Thomson (USACE 2012).

B.9.2 Support Facilities

A seawater treatment plant supplies water needed for drilling and water flooding. The total area for comparable Arctic seawater treatment plants and their required support pads is approximately 15 acres. A pad of this size would require approximately 150,000 cubic yards of gravel.

A barge landing and storage area with a floating dock or a module transfer island would likely be constructed in order to transport in CPF modules. Facilities, including camps, equipment and other infrastructure at other North Slope developments generally occupy approximately 10 acres.

B.9.3 Roads and Pipelines

Roads from similar oil and gas developments create a ground disturbance of approximately 7.5 acres per mile (BLM 2012). Roads are projected to be the greatest source of disturbance associated with future petroleum development in the Coastal Plain. Depending on the hypothetical development scenario for each alternative, anywhere from an estimated 750 to 1,500 acres of road could be built. Road disturbance requirements are somewhat elastic in that operators could route roads through Native or State lands in some

[10]Based on gravel need estimates from NPR-A IAP/EIS (BLM 2012).

areas or build some roadless developments, especially if there were a possibility of the total disturbance limits being exceeded.

Pipelines are hung on VSMs and would be used to transport oil to the CPFs and eventually to TAPS. Other pipelines are attached to the VSMs for water, gas, and electricity. The seawater line would connect from the coast to the CPF and associated satellite pads. The gas line would connect in the field and also would likely connect to other CPFs to provide gas to other reservoirs for EOR, fuel gas and lift gas. The electricity would be primarily used for pumping and operations on CPF and satellite pads.

Pipeline VSMs are counted toward the total disturbance limit, but spans are not. VSMs in the Arctic create approximately 0.04 acres of surface disturbance per pipeline mile (BLM 2012). The estimate is that approximately 120 to 220 miles of pipeline would be constructed in the Coastal Plain under the hypothetical development scenarios for each alternative, depending on field design; this would disturb approximately 5 to 9 acres of ground.

B.9.4 Gravel Mines

Gravel pits would be constructed to supply gravel needs for pads and roads related to future development. An estimated 6 million and 12 million cubic yards of gravel would be required to construct the following under the hypothetical development scenarios for each alternative:

- Roads, airstrips, and pads for wells
- CPFs
- The seawater treatment plant
- The barge landing pads and storage facilities, including camps, equipment and other infrastructure

Gravel could be sourced from hard rock or unconsolidated sand and gravel deposits, depending on what sources are available in the area surrounding development. Blasting could be required to produce gravel from hard rock or to loosen rock for extraction. Due to the number of outcrops and surface deposits in the Coastal Plain, pits are expected to be constructed next to facilities or roads used for satellite access. Minimal additional road construction is expected to be needed to access gravel mines.

In estimating potential gravel mine ground disturbance, the hypothetical development scenario used information from the gravel mine at Point Thomson, the closest oil and gas development to the Coastal Plain. In that case a 60-acre pit and an additional 11-acre pad for gravel storage and operational needs were constructed in order to provide approximately 2.65 million cubic yards of gravel for roads, pads, and an airstrip (Exxon Mobil Corporation 2009).

Gravel pits and associated storage pads are expected to be needed to supply oil exploration, development, and production in the Coastal Plain. This would encompass approximately 160 to 310 acres under all alternatives. The acreage required for gravel mining could increase or decrease, depending on local conditions. Gravel supply plans would be detailed in site-specific NEPA documentation for any future developments.

B.9.5 Surface Disturbance Estimates

Table B-4 and **Table B-5**, below, show surface disturbance estimates for the construction of oil and gas production facilities and infrastructure.

Table B-4
Estimated Surface Disturbance by Facility

Estimated Facility Sizes[11]	Acres of Estimated Surface Disturbance
CPF, airstrip, anchor well pad	50
Satellite pads	12
Gravel roads	7.5 per mile
Pipeline VSMs	0.04 per mile
Seawater treatment plant	15
Barge landing and equipment storage	10

Sources: BLM 2004, 2012; USACE 2017

Table B-5
Hypothetical Projected Facilities and Estimated Surface Disturbance by Alternative[1]

Facility Type	Alternative B		Alternative C		Alternative D	
	Number of Potential Facilities	Estimated Acres of Disturbance	Number of Potential Facilities	Estimated Acres of Disturbance	Number of Potential Facilities	Estimated Acres of Disturbance
CPF, airstrip, anchor well pad, and other associated service facilities	4	200	2	100	1	50
Satellite pads	14	168	9	108	6	72
Roads	172 miles	1,290	134 miles	1005	98 miles	735
VSMs (pipeline miles)	212 miles	8	175 miles	7	120 miles	5
Seawater treatment plant	1	15	1	15	1	15
Barge landing and storage	1	10	1	10	1	10
Gravel pits and stockpiles[2]	—	309	—	220	—	154
Total (approximate)	—	**2,000**	—	**1,464**	—	**1,040**

[1]All potential facility numbers and surface disturbance acreages are general hypothetical estimates and are not based on specific project proposals. Acreages are approximate and rounded to the nearest acre.
[2]The number of gravel pits is dependent on the locations of gravel resources in relation to project components and thus is unknown at this time.
— = not applicable

B.10 ECONOMIC IMPACTS

Issuance of an oil and gas lease under the directives of Section 20001(c)(1) of PL 115-97 has no direct impacts on the environment; however, it is a commitment of oil and gas resources for potential future exploration and development, subject to environmental review and permits, that would result in future indirect impacts from exploration and development activities. Indirect impacts because of a lease sale include direct and indirect impacts from post-lease activities, including seismic and drilling exploration, development, and transportation of oil and gas in and from the Coastal Plain. Therefore, an analysis is

[11]Estimated facility sizes were determined based on facility sizes from comparable North Slope projects, such as Alpine, and the professional expertise of the BLM and Alaska Department of Natural Resources staff.

provided of the potential direct and indirect impacts that may follow a leasing decision along with the potential cumulative impacts throughout the entire program area.

Following issuance of an oil and gas lease, subsequent possible future development of oil and gas resources in the Coastal Plain would have direct and indirect economic impacts on the economy. **Table B-6**, below, estimates the number of direct and indirect jobs that would be created because of potential future exploration, development, and production in the Coastal Plain.

Direct and indirect income projected to be created by potential future Coastal Plain development is shown in **Table B-7**, below.

Government revenues projected to be created by leasing and potential future Coastal Plain development are shown in **Table B-8**, below. These revenues represent estimates of the taxes and royalties that would be collected from leasing, developing, producing, and transporting oil and gas resources from the Coastal Plain. These estimates are based on the hypothetical unconstrained scenario detailed in **Section B.5**. Additionally, local governments could experience increased economic activity and revenues from an increase in hotel/bed tax collections.

Table B-6
Projected Employment Effects of the Hypothetical Unconstrained Post-Leasing Exploration, Development, and Production Activities

Effects	Jobs (average number of part-time and full-time jobs)	Annual Average	Peak
Direct	Exploration	250	650
	Development	2,260	3,300
	Production	770	1,200
Indirect	Exploration	130	390
	Development	1,720	2,500
	Production	1,020	1,600

Source: Northern Economics, Inc. 2023 estimates based on IMPLAN 2021 data year and assumptions listed in **Section 3.4.10 Economy** of the Supplemental EIS for the Coastal Plain Oil and Gas Leasing Program.
Notes:
Jobs during the exploration and development phases are seasonal and temporary.
"Direct effects" refer to the immediate economic consequences of the direct spending associated with the post-leasing activities (exploration, development, and production), and "indirect effects" refer to the secondary consequences that occur through the supply chain (i.e. jobs and income created by the businesses that supply goods and services to the oil and gas companies) as well as the induced effects that are generated when workers spend their income in the economy. In this SEIS, both the direct and indirect effects of post-leasing activities are considered indirect effects of leasing in the Coastal Plain.

Table B-7
Projected Labor Income Effects of the Hypothetical Unconstrained Post-Leasing Exploration, Development, and Production Activities

Effects	Labor Income (in Millions of 2017 Dollars)	Annual Average	Peak
Direct	Exploration	$26	$67
	Development	$233	$339
	Production	$133	$210
Indirect	Exploration	$8	$24
	Development	$106	$154
	Production	$64	$101

Sources: Northern Economics, Inc. 2023 estimates based on IMPLAN 2021 data year and assumptions listed in **Section 3.4.10 Economy** of the Supplemental EIS for the Coastal Plain Oil and Gas Leasing Program.
Note: "Direct effects" refer to the immediate economic consequences of the direct spending associated with the post-leasing activities (exploration, development, and production), and "indirect effects" refer to the secondary consequences that occur through the supply chain (i.e. jobs and income created by the businesses that supply goods and services to the oil and gas companies) as well as the induced effects that are generated when workers spend their income in the economy. In this SEIS, both the direct and indirect effects of post-leasing activities are considered indirect effects of leasing in the Coastal Plain.

Table B-8
Projected Government Revenues based on the Hypothetical Unconstrained Post-Leasing Activities

Government Revenues (in Millions of 2017 Dollars)	Annual Average	Total
North Slope Borough property taxes	$49	$1,119
State of Alaska royalties	$782	$15,648
State of Alaska taxes	$1,220	$24,425
Federal royalties	$782	$15,648
Federal taxes	$673	$13,459

Source: Northern Economics, Inc. 2023 estimate.

The management decisions and stipulations applied under Alternatives B, C, and D could result in unquantifiable diversions from the hypothetical unconstrained scenario presented above. The impacts associated with stipulations could result in additional consultations with stakeholders, studies for permitting, delays for timing limitations, and construction of additional facilities and infrastructure. Some of these actions could result in higher employment and income effects due to additional expenditures that would be necessary to comply with the required operating procedure, including additional spending on consultation and studies. Some of these actions could also delay exploration, development, and production and would therefore also delay potential employment and income effects and revenues that could accrue to the local, state, and federal governments.

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Appendix C

Traditional Knowledge

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Appendix C. Traditional Knowledge

C.1 Inclusion of Traditional Knowledge

Traditional knowledge is critical in the assessment of impacts in rural communities, particularly with regard to their subsistence practices and cultural concerns. Throughout the previous EIS NEPA process, testimony was provided and traditional knowledge was shared in a variety of forums to include public meetings, and government-to-government and ANCSA corporation consultations. This information was utilized during the development of action alternatives, and also to inform changes made in the Final EIS. The following representative comments identify specific areas or issues where commenters and stakeholders emphasized the importance of traditional knowledge during the draft and final EIS. Excerpts from public comment meetings, consultation meetings, and public comment submissions containing traditional knowledge relevant to these topic areas have been organized under these topic areas. Each excerpt has its origin identified as well. The information included in this appendix is direction from the FEIS and included so that it can be reviewed as part of the SEIS. Additional information may be incorporated into this appendix as a result of information received during the public review of the draft SEIS.

C.1.1 Cultural Resources

Iizhik Gwats'an Gwandaii Goodlit, "The Sacred Place Where Life Begins”

- Commenters requested the inclusion of traditional knowledge to address potential impacts on the Gwich'in people from industrial activities in "The Sacred Place Where Life Begins," which is considered a significant ethnographic cultural resource. “The Gwich'in people have relied upon the caribou for centuries, countless generations. They hold the coastal plain as a sacred place. Our subsistence way of life will be significantly impacted and restricted if the Porcupine Caribou herd and the migratory waterfowl migration habitat, food, and water resources and/or birthing grounds are impacted. All of the tribes rely upon migratory waterfowl as a critical resource in the spring.” –Ben Stevens, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- “The Gwich'in Nation, along with the majority of Alaskans and Americans have always opposed any development in Izhik Gwats’an Gwandaii Goodlit, the sacred place where life begins, due to the highly negative impact it would have on the Gwich'in as people, their culture and traditions, the language and overall health of their communities that lie on the migration route of the Porcupine herd. The Porcupine caribou rely on the coastal plain for their birthing grounds, to protect their young from the mosquitoes and other predators that otherwise would kill their newborns. But we must also keep in mind that the rich ecosystem houses more than just the 40,000 caribou calves born each spring. There are birds that migrate from all 50 states and six continents. The walrus, whales, seals and many other marine mammals and sea life make their way to the coastline to also nest and give birth.” –Adrienne Blatchford, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- “And there is more about our culture. And yesterday I was talking about what we are really talking about is it's like the (Speaking in Alaskan Native language). Iizhik Gwats'an Gwandaii Goodlit. Norma Kassi from Old Crow gave it the name, Iizhik Gwats'an Gwandaii Goodlit, Sacred Place Where the Life Begin. That means a birthplace. Like me, a woman, when I had -- when I was going to have my baby, I prepare to have my baby for nine months and then to deliver, and then nursing and then training. We did -- all the mother do that. All life do that Caribou do that. And that's the

place they want to do gas and oil development. (Speaking in Alaskan Native language.) It's a good place, a safe place, a healthy place to have caribou cow to have the calf. And they have done that for thousands of years. Each and every one of those caribou -- right now I think there is 250,000 Porcupine caribou herd, and each one born right there. It's been like that for thousands of years. Even when bow and arrow day, our people went through a lot of starvation before. It's not like -- they don't even bother with calving ground then. They let that thing process so they can live. And that's where they want to do gas and oil development." –Sarah James, Public Scoping Meeting, June 12, 2018, Venetie, AK

- "The closest thing that we have on this planet to the Garden of Eden is ANWR. And that's how we believe. I believe personally that it's -- it's -- you don't know what you are doing. You don't realize the implications of how devastating it's going to be to go up in that land and disturb that area. I mean, I'm telling you, I'm not joking." –Paul Shewfelt, DEIS Public Meeting, February 7, 2019, Fort Yukon, Alaska
- "But I'll tell you something: One time I went up to Arctic Village and I went to -- I stayed up there the summertime, and then I went to this family, and they said, 'Let's go up to Daa'chunla'. Oh, okay. Let's go. So, we went up there. And my grandma, she said, 'Do you know where you are going?' I said, 'No. I don't know where I'm going.' You are going where no man ever made footprint. There is not a footprint up there that belongs to anybody." –Belva Ansaknok, DEIS Public Meeting, February 7, 2019, Fort Yukon, Alaska

Broader Cultural Ties to the Coastal Plain

- Commenters requested that the BLM document the broader cultural ties to the Program Area for the Iñupiat and Gwich'in people. Ethnographic resources also require protections, including ethnographic landscapes, traditional cultural properties, Native American sacred sites, and intangible cultural resources (e.g., oral traditions, Indigenous knowledge, and traditional skills). "We have a creation story. In our creation story it's said that there was once a time when there were just animals. And in our story, the animals had human characteristics. They were like human beings. And then there was a split between the animal nation and us where we—where human beings were created. In our story it's said that we came from the caribou. Gwich'in came from the caribou. And at that time when that split happened, the caribou and the Gwich'in made an agreement that from that time on, the caribou would always retain a part of the Gwich'in heart, and the Gwich'in would always retain a part of the caribou heart. So, we are one and the same in a spiritual way with the caribou. …. We have a reciprocal relationship with the land since forever. The Creator gave us this place and this herd, which is why we're here today speaking to you. We follow Creator's laws. It's in our blood, natural law. The western value and system, the values and system of the western ways have forgotten the original laws of Creator. And now we see the threats to humankind itself." –Faith Gemmill-Fredson, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "You know, we have been -- from archeology findings, from 26,000 years that we have been finding in the headwaters on Canadian side, Old Crow River. Before it was hard to get information like that." –Edward Sam, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "If you want proof to know how long we have been here and to know how long we have lived off the caribou, there are caribou fences surrounding our villages and throughout our Gwich'in Nation. In Old Crow, Yukon, Canada researchers found arrowheads and caribou bone tools made by our people over 25,000 years ago. That's our proof that we lived on the caribou for thousands of years." –Jewels Gilbert, Public Scoping Meeting, May 24, 2018, Arctic Village, AK

- “That’s our feeding ground. That's our garden out here. … we have been environmentalists for 10,000 years. And look at it. We try to keep our land clean the way it is for a thousand years. We don't try to destroy it because we know it help us. In return, we take care of the land. In return, it takes care of us. That's the way we believe. …But when I was upriver and all that camping and getting harvest, spring -- like right now it's -- our young men is going out and getting those wonderful waterfowls. They are on their way to the calving grounds, calving grounds of the Porcupine caribou herd. And they are going to see some stuff they are never going to see. And it will change.” –Louie John, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- “Over 75 historical sites that were once used for subsistence usage areas are now restricted to access from my people who once hunted there. And that -- and to hear you can't hunt, that (Alaska indigenous word), you can't hunt at (Alaska indigenous word), that hurts me because my son won't ever, ever get the chance to ever hunt where my grandparents hunted, where I learned to hunt, also.” –Raymond Edward Igalook, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- “When the elders first got together, the main thing we were worried about was when the freshwater touches the saltwater, this is where the food chain in the Arctic begins. You cannot destroy that because if you do, you have broken the food chain of the Arctic Ocean. And when you look at from Point Barrow going out 200 miles to 168 miles west of Wrangell Island going out 200 miles, this turned out to be the last third of the world's … fish nursery. That's got to be protected. Remember when the Yukon River had no fish that one year? That occurred because the seismic was being done off of work—off of Wainwright all across. The fish that used to go down to the rivers in the southern part of Alaska, eastern part of Asia and northern part of Japan, those fish were chased into the Arctic Ocean.” –George Edwardson, DEIS Public Meeting, February 6, 2019, Utqiagvik, Alaska
- “The land is all we have left to survive. And believe it or not, we still use the land like always. We go on the land seasonal. Also, if we have to go any time and pretty much anywhere, we do it to hunt, trap and haul wood, just to pretty much go wherever we want. …. The caribou is like the land, our ancestors, our rich past and, most of all, the reason we all are here today right now. Put all these categories into one, and you have the Porcupine caribou herd. The caribou is our past, our history, our future.” –Chief Galen Gilbert, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska
- “And he told me that you get these little tundra tussocks, you put on the post. And from here to probably longer this whole airport, way out there, way out there, it goes a long way to the -- and I told him, how come we are doing this? He say caribou, they will see it and they will keep their distance from it, and they will just keep going right to where we are living in the tent. And that caribou, the bull caribou, we call them hasaii. This is pretty small. When I grew up, these are small. And my grandfather said, ‘Caribou will start coming in.’ And the caribou are right here from the corner of the house, right there, coming in, because the caribou, they see that long string of posts with the tundra tussock on there, and they keep their distance. And they keep their distance right to the tent. That’s when my grandfather got 30, 40. Shoot the caribou right there at the mouth of the tent. We don't have to pack. Right there we just butcher it up. And that's the way I grew up. ... Nowadays our way of life is changing lots, but we still—I go 30 miles, 40 miles just to harvest caribou now, at Bob Lake, halfway to Arctic.” –Macarthur Tritt, DEIS Public Meeting, February 9, 2019, Venetie, Alaska

C.1.2 Subsistence Use and Resources

General Traditional Knowledge on Subsistence Use

Some commenters provided general discussions on subsistence use, as seen below:

- "You know, that connection that we have for the land like that has gone to where we have got, like, moose and fish and things like that, but these people's strong connection to that food [Caribou] is very sacred. And when we think of sacred, to me growing up … living in a fish camp, fish, hunting, things like that, is when we prepare the meat to get all that blood all over your hands and on your body, you know, it's very sacred to us. It's a ceremonial thing. I know for a fact after when I'd be sleeping at night, I'd have strange dreams sometimes. It was just like I could feel that animal inside me. And when we ate, I'd be very strong, very healthy. And as you said, you know, this food is very sacred to us. ….You know, the way we -- we treat our land, it treats us. If we don't treat it right, it's not going to happen, you know." –Travis Cole, DEIS Public Meeting, February 4, 2019, Fairbanks, AK

Reliance on the Porcupine Caribou Herd and the Lack of Practical Alternatives

A number of commenters requested that the EIS in its analysis acknowledge that the Gwich'in people traditionally depend on caribou and that in some cases no other practical alternative to replace food supplies are available; in addition, there was a request to acknowledge that Old Crow has a unique dependence on Porcupine Caribou Herd, in addition to use of the herd by Kaktovik and Alaska.

- "And as you see, my people here, my family, they are all my brothers and sisters. We all came from the same generation. And we all live on caribou. We live on whitefish. We live on trouts. We live off our land. We don't go to the store. You buy steak, that's 15 bucks. One time a hunter came up to me and he said, 'I don't want to buy $15 steak. I want to buy $30 gun shells. I'll get more caribou with that.'" –Debbie Tritt-Kennedy, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "The prices of food there are extremely high. It's $20 for a can of coffee, $40 for a steak. Three bananas are $12. We take care of ourself, and that's what our food security does for us. What will your message be to my people when we no longer hunt for our food security? When an oil spill happens -- and mark my words it will -- the price of that is going to be more than we can endure. Our animals will be poisoned, our land contaminated." –Bernadette Dementieff, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- "The people living there, we are subsistence people. We hunt. We eat caribou, the birds, the way we eat off the ocean, and we have to make sure we protect our ability to feed ourselves. When you look at that 1002 area, it slopes into the ocean. You have got to keep that in mind. …over 60, 70 percent of us are subsistence hunters, and once you stop the migration routes, where are we going to eat? We were promised one time 12 pounds of beef if they had an accident, and that never came through. So what are you going to do for us if we can't feed ourselves? There is three communities that depend on that Porcupine herd." –George Edwardson, Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- "What will happen if we don't have any caribou? My kids and my people will be in danger. The high cost of food in our local stores are already high to get for our residents. The airfare and the freight also are high. This is my third scoping meeting I have attended, and it's not easy listening to all these comments and concerns. And I hope you take this into consideration and think how

important this issue is to us. Our livelihood is at stake.” Tiffany Yaltin, Public Scoping Meeting, June 12, 2018, Venetie, AK

- “… you go to the store here and buy a gallon of milk for, like, $20 and, you know, like if you are down there Anchorage, you buy a gallon of milk for, like, $5. Try buy a loaf of bread for $5 where you buy them for, like, a quarter, 75 cents to a dollar, but it's pretty spendy because the high price of Raven, it really takes a toll on our village because, you know, they are the only airlines that come into our village.” –Glen Solomon, Public Scoping Meeting, June 12, 2018, Kaktovik, AK
- “… we were very fortunate because if you go to the store, the little piece of meat costs $27.90. Times that by ten for 31 days, $270 times 31. I cannot afford this dinner alone. That does not include breakfast and lunch for my family, plus we have to pay for our own propane, which is $300 of propane, which lasts 42 days… 95 percent of our groceries comes from this land. ... Five percent of our groceries comes from Fairbanks. But if you include freight -- so if you are paying for a piece of meat or a box of meat, you are paying for groceries for $70 in Fairbanks, plus you still have to pay for it to get it here to Venetie, which the freight costs -- with the freight prices rising, it's very outrageous. So basically that box of meat could feed my family for maybe a week and a half, but we are paying almost $270. Right now yesterday we paid $350 for two boxes of meat, a thing of tissue, and pull-ups and diapers. That does not include the freight coming from Fairbanks.” –Crystal Sisto Druck, Public Scoping Meeting, June 12, 2018, Venetie, AK
- “And our traditional food back home, it's the same source of meat… the caribou. It's a main food source. Because if you buy a little chunk like this (indicating) almost as big as your hand, a chunk of meat in the village, it would probably be like about $50, almost. Why would you spend so much that money? It's survival, too, because you can't -- you can't survive on that little chunk of meat in the store. You rather get caribou, bring it home, butcher it, bless it. Part of our big thing is our religion. It's part of our religion because when the weather gets real cold, you know, the way the caribou acts, we even know how the weather is going to be, like if it's going to be cold or if it's going to be warm weather. … And all the beliefs come with that caribou. And the bones is our tools, you know. We use our regalia. Back in the day, we used it for knife. … caribou is very, very important to us. The trails are there for thousands of years, and they are still there. And you know, it's old ecosystem, like the geese, waterfowl, they all breed there, too. And those little, tiny shore birds, we call it dill. It's like dill pickle. They are -- dill are little shorebirds. And those are -- those used to be a lot, you know, around, but even that, this little bit cut back, we don't see it that much. But those are really born in the Arctic Refuge, too, because the water, waterfowl, geese, and those are important, too. Important, also.” –Kenneth Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- “As we all know, we depend on the Porcupine [sic] that goes up there and calve in the spring, which is right around the corner. That's our food security. We depend on this animal for our food, our basic needs. We also make clothing out of it. We use their bones to make tools and such things like that, that we are teaching our kids to do that because I believe in the future that we won't be able to go down to the store and buy food. We won't be able to go to the gas station.” –Mary Beth Solomon, DEIS Public Meeting, February 7, 2019, Fort Yukon, Alaska
- “It's caribou leg and boots. We use every part of the caribou. These boots is the warmest you can wear if you have caribou hair insole in it. 60-below you can survive with that. … Caribou is our dance. We do caribou dance. We do caribou skin hunt dance. We tell stories from way back. That's our history. What happened last week, men went out and got meat. Men came here and helped cut meat. … it's medicine for us. … We use caribou every day… we do need that medicine. And we

do live with it every day because our ancestor lived with it. And unborn going to live with it. Ancestor that's not here today with us live with it. … So it's still our shelter. That haven't gone away yet. It was our caribou skin hut. We dance caribou skin hut. So we haven't gone away from any one of these. And then it's our tool, just like what I said. It's 30,000 years. And clothing. We got boots we use every day and mitts -- and this one right here. And same goes when you're out camping. …. Caribou meat, it keep forever. It don't go stale. And this is caribou inside the stomach lining. And ch'ehtsihguu we call it. That means wrap around the stomach, the whole stomach. So this is our food and who we are." –Sarah James, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska

- "We are able to take that fall time caribou skin and make a sleeping mat, far better than what you can find at some outfitter store because it's warm. It's hollow hair. Or we can sew it and caribou leg skin boots. There's so much to a caribou that it's just awesome. But why take a chance of ruining that? Why? How can you say you have got these protocols that can work? Drilling machines and the contractors are going to do everything that's set in stone. You will have road construction crews. You will have flare tips burning off gases." –Macarthur Tritt, DEIS Public Meeting, February 9, 2019, Venetie, Alaska
- "Everything in the clothing we got off this caribou. We got boots. We got gloves. We got hats. Everything, drum, tools, from the horn to the toes. All those bones you see is from the caribou. There is our tools. That's how they lived a long time ago by using those caribou bones. That's how they got the tools. They make a sewing needle. They got skin on their backstrap for thread. Even from their leg you could make grease out of something, the marrow. That's your fat to cook your meat. That's how they provide us. That's how our animals provides us everything that we need. And we will fight for them. They come back and be nice to us and give us our food. But I'm just speaking up for these young kids to make it good for them, to make sure they got their -- like we have. And as our parents said, 'Fight for our rights.' And that's what I'm doing right now for our human beings' food, our resource. That's the main food that we have. And nobody can take it away." –Marie John Willoya, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska
- "I'm here to do a hearing and talk about the caribou that I got. And just this past week I have been down back and forth going down about 30 miles down, shooting, shooting, hunting caribou, and bringing it back. And we bring it all here into the community hall, and they cut it all up and they distribute it to the community. And it's just something that we all do to live off the caribou, you know. And I love doing it. I love providing for my family, the community, and other communities. And a lot of people, they -- they want caribou meat, you know. They -- it's their Native food. People living in Fairbanks are buying store-bought food. …There is going to be a big change if they disturb that area up there. …. we are already seeing animals that had contaminated meat, and we don't know where that came from." –James Martin, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska

Reliance on Migratory Birds, Fish, and other Marine Mammals, including Polar Bears

The following section compiles accounts of reliance on subsistence resources other than caribou that the tribes rely on within the Program Area.

- "And that's how healthy our people were. Everything was healthy. They couldn't even -- here right now springtime, sun is coming back up. In those days, they said it's so noisy that people have to yell at each other. It's so noisy that state bird, what you call it, ptarmigan, Alaska state ptarmigan was the most annoying one. …. And many, many birds come there. Many, many—150 different species of bird. I'm worried about that one little bird that lives there all year-round up there. There is a hot spring up there, and that bird lives in that hot spring. And once that oil get into that tundra, it will seep into the tundra. It will get to that little bird. So I'm worried about that. There is one from North Pole—I mean, South Pole. They fly from South Pole, Arctic tern. And that's pretty far. So we worry about all those things, and we got story on them just like we had—I'm just saying the raven story." –Sarah James, Public Scoping Meeting, May 24, 2018, Arctic Village, AK

- "You have heard a few people talk about the polar bears that are being threatened now. One of the only strongholds that they have has been Kaktovik because they have got the whaling -- the remains from their whaling and what they call the bone pile up there. And it's been reported that the polar bears are now cross breeding back to the grizzlies. They are saying that they originally evolved from grizzlies, and now they are devolving back into grizzlies. They have seen polar bears up here on the mountains following caribou. They have seen polar bears in Fort Yukon 150 miles south of here. And that's 500 miles from any coast. There has been other mammals. They are hunting other mammals out there, not just the caribous. You know, there's all kinds of ground squirrels and moose and things like that up there, too." –Lance Whitwell, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "Many of our people still depend heavily on the Chinook salmon, and we trade heavily with Arctic Village relatives. So the development in the coastal plain will affect all of our people. We fully believe that that development cannot be done in the -- I heard it like ten times today -- responsible manner. I'd like to see that. That would be nice." –Rhonda Pitka, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- "We not only use the ocean for the animals, like hunting them, but also we used it to make salt. On the west end of the island -- that would be towards Barrow -- we fished with nets, as well, both for the trout and (Inupiaq word), the whitefish. I'm not sure -- I forget what the -- what you would call it. It's a different kind of fish. Good fish. The island is also a nesting area for all the species of birds which we also gathered for food. A aahaliq -- 1 always forget the English name for aahaliq. It's a black and white bird which we call in Inupiaq aahaliq. …. We also have other species of edible fowl: geese, swans, and many kinds of birds. Some we cannot hunt as children. You see, we also killed the small brown birds for our elders since the smaller birds have softer meat. We used to have more elders living in our land in our village, but nowadays most of our elders no longer live long or live in the villages. We still take care of our elders, but they are -- there are facilities for them to live in and be cared for as a group. But if they still have family, they are cared for by them. We as a village also living by the Brooks Range to the south, we also have access to the Dall sheep, which is a delicacy for Christmas and Thanksgiving feasts we have as a village. Thanksgiving, Christmas, 4th of July and whaling season events." –Maryann Iqilan Nasoaluk Nageak Rexford, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- "I come from an island that was once populated up to an estimate of over 10,000 people. Upon the depletion of the whale population, 99 percent of our population was eradicated, over 9,000 human beings on one island killed for economic gain." –Panganga Pungowiyi, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska
- "My concern -- I also have many concerns, as others had mentioned, the whales and animals going by. Camden Bay is the gathering waters and extremely important area for bowhead whales. All the drainage from anything of that area is going to flow into there. …. a huge concern of mine is before we allow access to industry, we should allow access to our hunters from Nuiqsut and Kaktovik to

utilize ANWR as they should. They have restricted access. They are not allowed to use four-wheelers at certain times. They can only go in certain areas. They can't even get to somebody's camp that these folks talk about. And yet we want to go and drill, and we don't allow access for our hunters. So I hope that's looked into." —Qaiyaan Harcharek, Public Scoping Meeting, May 31, 2018, Utqiagvik, AK

- "[W]haling is hunting to provide our family for nutritional and dietary needs. So in the same way that caribou is a supplement to our diet, so funds have to be put aside for care…so that research impacts on wildlife can be already funded. …. the people have to be involved, just like the whaling captains are involved in the CAA, conflict avoidance agreement, for bowhead whaling so that each village have created a whaling subsistence zone in Kaktovik, Cross Island and now Barrow so that there is a cooperative arrangement with vessel traffic controls so that people have -- villages that have quota, they are provided quota." —Arnold Brower, Jr., Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- "Some of the ducks we never see them no more. Birds are same thing. That worries me. And we don't -- we don't say nothing, then we going to have more problems than 30 years ago." –Trimble Gilbert, Public Scoping Meeting, June 12, 2018, Venetie, AK
- "And I was talking to one of my friends last night, [indiscernible] and Jerry that testified earlier. I asked them, I said, 'How long does it -- when they come through, the ducks come through, how long does it last?' He said sometimes it lasts a whole week. Lasts a whole week. Several thousand a day. And you can imagine how many -- how many ducks in this little area down there, but cover the whole Yukon River. It's really massive, geese that go to the north. And fish do the same thing. And fish, they come up the river. They come up the river from where the mouth of the Yukon is. And they spawn in the clean water, clean water they spawn. And they do that year after year. They do that year after year. We all know that. The people that lives on the Yukon, they share fish. They share fish that comes up to the clean water to spawn. So like when spawning happens this year, it will come back in four to five years from now. And I was talking about the fish. Not only king salmon or chum salmon does that. Whitefish does that, too. They winter in the lakes and then they come out in the springtime and then they spawn. They spawn. They spawn during the summer. And then in July the little fish like this come up the creek, bunch of them. And we all know there is millions of creeks in Alaska. It happens the same way. So I'm talking about our way of life. It's really a way of life. We are guarding the fish, the animals that use the area up there." –Gideon James, Public Scoping Meeting, June 12, 2018, Venetie, AK
- "In addition to caribou, fish and waterfowl are important to the subsistence harvest of Gwich'in people, and impacts to these resources must be carefully evaluated. … In Arctic Village, for example, residents vary their activities between fishing, berry-picking, and harvesting waterfowl throughout the summer, to hunting migrating caribou in the fall into the winter, to ice fishing and fur trapping throughout the winter until spring. BLM must consider potential impacts to these subsistence resources themselves, as well as impacts to subsistence hunters, such as reduced access and availability, and impacts from the disturbance of traditional subsistence use areas. Oil and gas activities will negatively impact the many species of birds which use the Coastal Plain. …[I]n 2000, residents of Fort Yukon reported harvesting 3,615 birds. Collisions with infrastructure, spills of oil and other chemicals, noise from operations, and loss of habitat will lead to displacement, potential disruption in migration, and possible direct mortality of birds. BLM must clearly articulate how these important fish and bird populations will be monitored to detect short- and long-term negative

impacts to our subsistence resources." –Bernadette Demientieff, Gwich'in Steering Committee, Scoping Letter, June 19, 2018

- "Animals come and go during the winter and summer. The migratory birds come and go. Those have been our bread and butter for centuries, past centuries, past centuries. Now some of the major nesting ground areas are disrupted and destroyed or even practically reduced to a certain size. According to the way we live, we are harvesting people. We can smoke, sun dry and prepare food and store them for the winter use. But our capacities in terms of the kind of climate changes we are facing from the '50s and '60s to today are drastically changing quite a bit." –Johnnie Brower, DEIS Public Meeting, February 6, 2019, Utqiagvik, Alaska
- "[P]eople say not only the caribou will be impacted; the birds. This is one of the biggest places where the birds, the ducks come. And it's really big here in Venetie. People come here to hunt ducks. So that's going to be impacted, as well. So that's just as important." –Tonya Garnett, DEIS Public Meeting, February 9, 2019, Venetie, Alaska

C.1.3 Traditional Knowledge of the Caribou

Tribal Management of the Herd and Tribal Understanding of the Historic Migration Path

It was requested that the BLM discuss the role of the Gwich'in in the active management of the herd, in either a traditional or a contemporary, co-management context. Excerpts collected on this topic also seemed to reference traditional knowledge of the historical migration path of the Porcupine Caribou Herd, as well as any changes to the migration path.

- "We have been managing the moose in this area. We have been managing the fish, the wildlife, the waterfowl for as long as we have been here. Whenever our hunters decide to harvest, they are practicing active management. When they decide not to shoot the first leaders that come through, they are practicing active management. When they decide to take a bull and not a cow, they are practicing active management. And so I want to make that record clear because I think sometimes there is this notion that our management is not enough, that we are not qualified as biologists, that we always need these experts from western institutions to affirm our knowledge that we know based on many, many generations." –Charlene Stern, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "When I was growing up in this community, even from the time we were very young, every fall the caribou migrates back here to this mountain over here called Dachanlee. And we wait for them to come back from the calving grounds. Our people are waiting and watching. Over there we can watch and see when they start coming. And when they come, we have protocol, cultural protocol. The leaders have to come and pass. Once they pass, then it's our time to go up to the mountain. We all go up to the mountain, and there are campsites all over that mountain that are set up. And families are on the mountain and ready to start hunting caribou to support ourselves for the winter. It's a very sacred time, and it's a very important time for our people. It's one of the most important times of our community." –Faith Gemmill-Fredson, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "I hunt for caribou in Venetie all my life. We depend on caribou in Venetie, and please don't disturb the calving grounds in ANWR. Every year female caribou get pregnant, and thousands of thousands of females lay their beautiful babies, wet the caribou babies. They lay down and their mom lick it, the baby. After they have baby, they move forward again, baby caribou run with their mom, thousands and thousands and thousands. And baby caribou are strong enough to stay with their

mother. And they go across rivers, streams and plain country until caribou grow bigger and stronger. And they travel down to Arctic Village and Venetie, and another herd travels to Old Crow flats and another herd travels to Fort McPherson and another herd travels to Alkavik in Canada. Caribou, they stay whole winter long. And when spring comes, females get pregnant again, and caribou do that for thousands of years for generations and generations. Please don't disturb the calving grounds. And don't bother the calving grounds. And this caribou I'm talking about is -- we Gwich'in people are really strong. And I'm going to say in my language, Gwich'in. (Speaking in Gwich'in).” –Jeffrey John, Public Scoping Meeting, May 29, 2018, Fairbanks, AK

- “…. So that subsistence hunting, we know right now today it's not feasible to go get caribou because they are fawning. They are calving. This is an area that we don't have to go to look for caribou in this season. But those are the adherences that need to be done, however schedule that they can be done. So those require for collaborative effort to have funding already. …. The caribou, as we know, eats lichen. And lichen takes quite a while for it to reproduce. So that space is -- large space is needed for caribou to have adequate nutritional needs met, too. For those reasons I speak that there should be -- there must be funding allocated, set aside for wildlife research, wildlife monitoring and collaboratively co-managing perhaps these kinds of renewable resources.” — Arnold Brower, Jr., Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- “Okay. Well, so start off with, that's the path, the migratory path of the Porcupine herd, the caribou herd, and it's a very narrow route they have on the ocean side. And the slope of the land is if anything happens on land, it will be in the ocean. And what kind of protection do you have for the ocean? And also that's the migratory path of the birds, the ducks, the geese. When they migrate, that is their route, too. The snow geese used to be in the barrier islands around Prudhoe Bay area, but when the industry got out to the barrier islands, they chased them out of the islands and the snow geese went over into Canada. I was over there around 2000, and their Fish & Game was saying the snow geese had overpopulated and had destroyed their nesting areas. Now the snow geese are wandering around looking for a place to nest now. And just because the barrier islands were touched.” –George Edwardson, Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- “And lately we have been having concerns because of -- for various reasons -- I don't know all of the reasons -- the area biologists and stuff -- the fluctuation and major decline in caribou herds, the Western Arctic herd, Teshekpuk heard, Central herd. The only one that has maintained or is actively growing is the Porcupine herd that is in ANWR periodically. The point being, you know, that 10, 15 years ago at 490,000 animals in the Western Arctic herd and today at 220,000, that's maybe half the size of that herd, and 38 communities that that herd is feeding. And it graces 38 communities in its migratory path.” –Gordon Brower, Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- “Every part of the animal we get, we got a name for it. Yeah. Every little part we got, we eat them, down to the hooves. Yeah, we boil the hooves. We eat it. Every part, eyeball and all. Yeah. The caribou, they go up many miles. They go down to Beaver Mountain. They travel. They come home and go home to have their calves. That's many miles, rugged area. And when they make it, they make sure they have their calf very good and they come home and they come back to our village where we can be, you know, happy people. And these caribou, they are having a hard time right now with the mosquitoes and all that bother them. It's hard for them to keep up. And they can't speak. The caribou don't speak. So we got to fight for them.” –James John, Public Scoping Meeting, June 12, 2018, Venetie, AK
- “This herd used to go by Anaktuvuk Pass migration route, and they haven't seen them for six years now because they've been over here. ... This herd migrates more further than any other caribou herd

in the world. They estimate maybe 2,900 miles a year that this herd, Porcupine herd, migrate. That's a long way. Part of their migration route is always going through here or going up to the calving grounds or from the calving grounds coming back through here. It's always been like that. Nowadays with climate change now that their routes have changed and all that, but it seems like they always come back to this place here." –Carlie Swaney, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska

Tribal Understanding of Caribou Biology, Phenology, and Social Interactions

Commenters requested that any scientific study of the caribou needs to incorporate Indigenous knowledge in order to consider the full range of areas and habitats that are vital to caribou throughout the year.

- "And then we -- where we are talking about is windy and breezy all the time. That's where that vegetation come out. And that's the only safe place and healthy place and quiet place to have their calf. And that's why they go up there. And if we do gas and oil development, that's going to be gone. All the predators up there in the foothills raising their young. And caribou are on the coastal plain and I think -- they can't go up in the foothills. It's too cold and there are predators up there. And if they do go up high, it's too cold and there's no food." –Sarah James, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "So what I want to say is that when these people speak for the animals, it is very -- these are very intelligent animal. They travel thousands, thousands, thousands of miles to the feeding ground, into the calving ground. And when they travel, they got their own leaders. Any caribou don't lead, but they got special group within their herd that leads. I know that because I used to run them down with snowshoe, and I -- it's a hard time. It's hard to run it down with the group of leaders like that. And you can tell by the calluses in front of their legs. There is calluses right there. And the reason I bring this up because we are here to protect migrating animals and species. … There is new life that begins up there so everybody will stay healthy as in Gwich'in country." –Gideon James, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "There is a difference in vegetation between the uplands, the foothills on the other side of the Brooks Range here and the coastal plain. The coastal plain is rich in minerals, salts because of the salt air, and it's so windy that bushes and shrubs and trees and stuff can't grow. So there is a specialized ecosystem that grows specific types of vegetation that the caribou mothers need to eat after they give birth. It's high nutrition. It's the highest nutrition area that they can find, and that is one of the reasons why they give birth there. And you can't find those in any other areas. If you look at the map, if you look at the elevations on the map, the coastal plain is a low-lying area. If you get off of that plain, you go back into the foothills again, and it's a totally different kind of vegetation…..One of the elders was telling me one time that caribou have a scent gland in their foot, and as long as they are going good, they are putting off a scent that says it's fine, this is the trail, follow me. But if they get spooked or if they get startled or something like1 that, then it goes to an adrenaline type of a deal and they put off a different smell and the rest of the herd will not follow them. It doesn't take much to change the migration of the caribou herd. It doesn't take very much at all…. These river valleys right here that cut through the mountains, the caribou come through here because they are heavy. They are heavy with calves. They are pregnant. A caribou calf is 40, 50 pounds. And that mother caribou is maybe 150 pounds. Can you imagine that, trying to walk through three feet of snow over the mountains? But these river valleys, they go all the way through to the other side. That's why they come here. That's the easiest route for them to go over to

the Arctic refuge and the coastal plain. There is no other way. The only other way is for them to go 200 miles east and cut up right through all the flats, the Porcupine River flats. And I think the people here have shown you quite a bit that it's a lot more than just subsistence food that would be affected here. It's cultural, socioeconomics. And the hard part is that just nobody knows what they will do." –Lance Whitwell, Public Scoping Meeting, May 24, 2018, Arctic Village, AK

- "…caribou [have] to be free to move to the coast during insect relief periods. It's pretty obvious. So, I think like the worst thing you can probably do to caribou is restrict movement. If they move freely, they seem to do reasonably well, but they have to get to areas that -- you know, the important areas in different parts of their life history." –Craig George, Public Scoping Meeting, May 31, 2018, Utqiagvik, AK
- "We use every part of the caribou, even to the hooves, to the marrow, to the ligament." –Sarah James, Public Scoping Meeting, June 12, 2018, Venetie, AK
- "Same thing happens with the caribou when they – when they travel, they use only one route. And any caribou don't lead. There is a leader in that herd. There is a leader in the herd that does it. They call that the (Alaskan Native word.) That means leader. They lead the herd. And you can tell by the calluses on their arm right here. Yeah, thick calluses. Those are the leader." – Gideon James, Public Scoping Meeting, June 12, 2018, Venetie, AK
- [Re: the calving ground] "Those caribou chose that place for a reason, and they are smart. They know what works to protect their young. They know they need the wind that's there. They need that wide open plain so they can see predators. They need the wind to blow away the mosquitoes because mosquitoes will exsanguinate calves to death. They know why they calve there. To the east is mountains. You go over more mountains, and finally you come to a coastal plain on the Canada side that's similar, and sometimes they calve there. My fear is that they will go east because they will come back down the mountain, they will see out there, oh, there is roads, there is pumps, there is people, it stinks here, and they won't calve there. They will keep going. And the only way they can go is east. And what will that do to the path that they take when they pass by your villages here? What will it do when their migratory routes possibly shift to the east?"–Will Mayo, Public Scoping Meeting, June 12, 2018, Venetie, AK
- "But I go hunt up there in the Arctic Village for this rich caribou because each caribou, wherever it's from, it tastes different... It eats that lichens off the mountain. A lot of that plant grow up there. It eats that, and that's why it tastes real good…Like Arctic Wildlife Refuge is full of the caribou, their food. Also the reason they are surviving all these years, thousands of years, is because the caribou, it—when it calves there, the babies will survive. Or otherwise the mosquitoes will kill the babies. So as that's the only place it's been surviving for thousands of years." –Pete Peter, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- "…when we go out and we hunt caribou, we see the first bunch. They tell us not to bother it because those are the leaders. We let them go by and we wait for the ones behind, and we shoot those ones because we want those leaders to know that trail. And the ones that are following them are learning that trail. And if they—if they do anything to disturb that area out there and the leaders see that, they are not going to go back there. The leaders, they are just going to turn away. They try to avoid that stuff as much as they can, you know." –James Martin, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska
- "The calving ground is the only place where those young ones survive. They've got this little plant growing up there. For about two weeks they eat on that plant to keep up with their mom. The mom

is always on survival. Wolf is chasing it. Bears are chasing it. And we come along and we grab our share, you know. And it's really important that they don't drill up there. … it's the only place where those plants grow, and they eat that for two weeks to keep up with their mom. And if they don't, they fall to wolves, bears." –Bobby Tritt, DEIS Public Meeting, February 9, 2019, Venetie, Alaska

- "Recently, we have noticed that the herd is around our village for a very short time or sometimes not at all. They rarely venture on to the privately held lands around the village that we are able to access, and we notice that they mostly stay in the foothills of the Brooks Range. We have relied much more heavily on the Central Arctic herd in recent years.…. We have shared that we have difficulty hunting caribou in and around Kaktovik as we do not have access into the refuge in the summertime with motorized vehicles and because the caribou rarely, if ever, migrate to our village. We are only able to harvest caribou by traveling up the river corridors by boat. Mostly, caribou, even after calving, remain in the foothills of the Brooks Range and do not venture to the coast. We are concerned with the apparent absence of Traditional Knowledge in the DEIS.'" – M. Rexford, Native Village of Kaktovik, DEIS Letter, March 13, 2019

C.1.4 Sociocultural Resources

The Ethnographic Importance of the Porcupine Caribou Herd

Tribal members and commenters also requested that the BLM include in their analysis a discussion of the ethnographic cultural resources of the Indigenous Porcupine Caribou Herd subsistence users in the Northwest Territories and the potential impacts (direct, indirect, as well as cumulative) that the project may have on these ethnographic cultural resources, including the traditional use of the Porcupine Caribou Herd; the relation of the health and harvesting of the Porcupine Caribou Herd to spirituality and cosmology; and the importance of harvesting caribou to the identity, traditional skills, Indigenous knowledge, and way of life of the Indigenous peoples of the Northwest Territories.

- "The Porcupine caribou herd is vital to our cultural way of life. We use every part of the animal to meet our needs. In the past, even our homes were made from caribou hides. But now we still use bones to make cultural tools, and we still use the hides for many articles of clothing, cultural clothing. Hunting in itself is a cultural practice. At the time when the herd is in our territory, we practice many of our own spiritual beliefs that have been taught to us and handed down generation to generation from our ancestors; thereby, we are spiritually bound to the caribou, too. The herd also represents an important facet of the social fabric of our community…. Men, they are the providers of the community. They are our hunters. And some of them are taught from the time they are just small. They can't even hold a gun yet, but they are taught. They are taught how to respectfully take the animal, how to give proper respect for what they take, to only take what we need to feed our communities and to do it in a way that's respectful to the land and giving proper thanks. And we have all other -- many other teachings, but that's part of it. For the women, we take care of our homes, our families. We are the backbone of our families, the women. … There are some parts that young women are not supposed to eat. We teach our young women that. And once we put aside those parts, there is meat that's sent down to the community for families that need it. And then whatever is left in the camp, we cut it and we have drying racks and we dry and smoke our meat. And that's going to feed our family all winter. And at that time, a lot of teachings are being taught from the mothers and the grandmothers to the young women. So the caribou is not just our food. It's not just our culture. It's a part -- it's a vital component of the social fabric of our community. All these teachings are taught when we are out on the land. And then one of our young men spoke yesterday talking about how we can't afford to live without the caribou. You go to our store, look at the prices. You can't feed your family on that all year, unless you are a millionaire. And I don't see no millionaires in here. The caribou is essential to the economic well-being of our people. We have to have the caribou as our subsistence to feed our families because we can't afford what's sent up here from outside. We won't survive without it. …. We have to live our subsistence way of life to survive here. The prices that are added on just because of the cost of freight is too high for us to depend on anything else. So a critical part of our food security is at threat. How are you guys going to replace that? You can't replace that." –Faith Gemmill-Fredson, Public Scoping Meeting, May 24, 2018, Arctic Village, AK

- "But you know, we are all healthy, really healthy. We are not sick. We are all healthy because we eat caribou. And I don't see anybody that's sick, seriously, all these years that I work as a health aide because our iron is high, protein is high and everything…. I don't want to buy caribou on the farm. No way. I'd rather hunt for it. I'd rather teach my kids. I'd rather teach my grandchildren. I sew. I sew caribou skin. I make a lot of stuff with it. I make living with it. I put food on the table. That's what we do, all of us. And why are they disturbing our caribou? That's our life. I grew up with it. They grew up with it. That's all we know. We learn. We go out in the world. I came back to it. Some of us went out in the world, and they came back. They'd rather stay here. And one of you should try it. Try stay here one year with us and maybe you will change your mind." –Bertha Ross, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "We are not separate. We are together. What happens to them happens to us. It happens to you. It happens to all of us. If they lose their food source, we will lose our food source, too. … It's a cycle. And we give ourselves to the land, and the land gives itself back to the caribou. You cannot break that cycle. You break that cycle, you will break our way of life, all of us. If it happens to us, it will happen to you." –Diloola Erickson, Public Scoping Meeting, May 29, 2018, Fairbanks, AK
- "For all the trauma, through everything that my people have been through, we have had something to gather and celebrate, and that is our traditional food. As a young woman, I have seen what has happened to my people. I have seen spiritual, mental, and physical sickness ravish. My mother took me out of the village very young. She wanted to give me what she thought would be a better life. But being forced to move from my village, I lost my language, I lost my culture, and I lost my identity. For many years growing up, I filled those voids with unhealthy things. I have been through so much in my journey to speak my language, which I still struggle with. I see that we have gone from 98 percent speaking to 11 percent. This is what happens when you take away our food security, when you take away our health. This is not just something that we eat. It is for our spiritual and our mental and our physical well-being." –Sikanik Maupin, Public Scoping Meeting, May 29, 2018, Fairbanks, AK
- "My sister is a community health aide in the rural villages, and she was a health aide in Arctic Village for many years. One year a few years back, the caribou didn't come through Arctic Village. … What we saw medically was very alarming to us. Our elders had no food, no traditional food, so they had to rely on hot dogs, Spam, macaroni and cheese, expensive food that is completely useless to us. And that winter my sister had to treat the majority of those elders for many gestational [sic] issues. They were vomiting. They had the runs because they didn't have their traditional food. They were sick. And that's what we are -- we will be facing in Arctic Village, in Venetie, and in Fort Yukon and Birch Creek. This is very real." –Kathy Tritt, DEIS Public Meeting, February 4, 2019, Fairbanks, AK

- “And every part of the caribou is like a medicine to us. It works like a medicine. It's our medicine. We can't live without all that.” –Sarah James, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- “And some of the best time for us as Gwich'in people is when we bring home -- the food home to our family, but especially our elders. And I'll never forget my son carrying the caribou head -- because don't waste anything. He carried the caribou head to one of our elders, grandma to my kids, and brought that to her. And she opened the door, and there is my little boy, 12-year-old boy, standing there with this caribou head for her. And she cried and just kissed on my son. And that's a part of his healing. That's a part of him becoming a man and learning how to respect in both ways and having that relationship that Shawna was talking about. And also that relationship with our elders and importance that has been passed down for millennia to take care of each other, but especially our elders.” –Jody Potts, DEIS Public Meeting, February 4, 2019, Fairbanks, AK

The Ability to Pass on Traditional Knowledge to Descendant Communities

Tribal members and commenters noted that the initial reduction of traditional use areas will limit the ability to pass on traditional knowledge to younger generations and traditional use and knowledge of the use areas will be lost; accordingly, they suggested that the EIS measure this impact as long-term or permanent and consider the loss of knowledge as a significant subsistence impact. The following excerpts also discuss this topic.

- “In my current research, I co-conduct numerous research projects on what brings wellness for Alaska Native communities, and again it's been shown it's tribal governance, as well as the land, animals, but most of all the culture, the culture built on this timeless relationship with the land and the animals. Culture that is passed down from father to son, from mother to daughter, from auntie to niece, uncle to nephew, year after year, decades after decades, centuries after centuries. This culture is also rooted in important values, such as sharing, caring for elders, language and, again, respect. This sharing respectful culture extends to people we meet, people like you. When you visit our communities, we open our homes, we feed you, and we treat you with respect despite any differences that lie between us. As I know, many of you were treated like family by the Gwich'in during your recent trip to Arctic Village.” –Jessica Black, Public Scoping Meeting, May 29, 2018, Fairbanks, AK
- “We have ancestral knowledge that has taught us how important it is to defend our sacred land, animals, and waters, and we have done that. The land, the animals, the water are part of an intricate beautiful culture, the Gwich'in culture, a culture that ensures the land, animal and water relatives are taken care of, too, a balance, a relationship that is built on respect. …. It’s been shown that it's tribal governance, as well as the land, animals, but most of all the culture, the culture built on this timeless relationship with the land and the animals. Culture that is passed down from father to son, from mother to daughter, from auntie to niece, uncle to nephew, year after year, decades after decades, centuries after centuries. This culture is also rooted in important values, such as sharing, caring for elders, language and, again, respect. This sharing respectful culture extends to people we meet, people like you. When you visit our communities, we open our homes, we feed you, and we treat you with respect despite any differences that lie between us. As I know, many of you were treated like family by the Gwich'in during your recent trip to Arctic Village.” –Jessica Black, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska

- “I just have a strong feeling that it [the project] would destroy our culture because it's already on the base of being lost because our language is used only by people that are in their late 40s now on up. And the kids, they don't—they don't use Gwich'in anymore. They are speaking English, which is not—which is not very appropriate for them to speak English because it's not their language and it's not—it's not what they understand. And I think if they interfere with the caribou, that will destroy their language, their way of talking because everything that they use on caribou is used in Gwich'in. And so every single piece of the caribou has a Gwich'in name. …. So caribou has a lot of meaning in Gwich'in, in the language because they tell you where they live, or they tell you where to go. They tell you all this stuff about caribou, which the Gwich'in people can talk about in their language. So I think the language is a major concern for me and the caribou that the elders live on. We hardly got any elders, but there is still elders up there that really live on caribou, and they don't really care about store meat.” –Caroline Tritt-Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- “I just want to say a little comment I learned from my grandfather. Our ancestors said that -- they told us this word about (speaking in Gwich'in). It means not to get away from their guideline of survival. They said don't forget their name, don't forget their way. And it's a good message for us and not to forget them. And in the past…the way they learn about caribou was one of them, was one of the guidelines. They learned the way of the caribou. The caribou is the one that taught them how to survive. And the caribou taught them how to use whatever is on those caribou. And they gave us all the stories and the knowledge and everything to the people. … And from that they learned a lot from the caribou how to—you know, how to use whatever is being used on the caribou, like the skin, the meat, and the intestine… And then they taught us to—how to take care of them. They taught us how to—not to disrespect the caribou. They taught us not to neglect the caribou or, you know, to do wrong to them. It's a good message that our people had. So, with that, you know, we use every part of the caribou for survival. And so that's how we survive from way back. So I think it's a good message. And some of our people, you know, we still hang onto these stories so we can bring that to our generation for our people, for our kids to depend on the caribou.” –Kenneth Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- “He said our ancestor, and they said that let's not stray away from their guideline, their survival, and their life. And they were with the caribou, and the caribou taught them how to survive in early days. And then one of the men, he became a caribou and the caribou taught them everything about what you use on the caribou and how to survive. In return, the caribou told the human to defend him into the future for our generation, our grandchildren, and all that. So that's what that message is all about. And you know, this is a caribou message that I'm giving you. You know, it's kind of a long story with our spirituality, but I think I'm going to end it here because it's -- with that (speaking in Gwich'in.)” –Kenneth Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK
- “And in an educational system, the caribou is mostly used a lot with language. And the western education is interfering with our cultural values, and it's destroying the way that our young people stays on the language.” –Caroline Tritt-Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK

C.1.5 Climate Change

Commenters requested that the EIS include traditional knowledge on past and present climate change, effects on the Porcupine Caribou Herd as well as their habitats and migration behavior. The BLM received information on many topics that informed the development of the EIS. Examples of issues that were identified through public testimony and included in the EIS for further analysis are described below:

- "This is the bow and arrow day location for Gwich'in people where the caribou travel, and that's where all the village was colonized into village because our parents got forced to build a village and put it where we can survive. Arctic Village was one place that they put Arctic Village here because the treeline was here [indicating]. And now the treeline is all the way to Brooks Range. And that's due to more climate change, which is caused by fossil fuel burning." –Sarah James, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "The taiga, this kind of forest that you see right here is called the taiga. And it's like the farthest north timber, the farthest north trees. But that's not being the case anymore. There has been more and more spruce trees, willows, shrubs all moving north. They're migrating north as the climate changes. And you know, caribou eat lichen. Here we call it caribou moss. It's lichen, and it grows about one inch every hundred years. And when you have shrubs and other kinds of trees that start growing, it shades out that moss, and that moss cannot grow. It will not regrow once the caribou have eaten it. The sea level rising we heard some people mention. It's not only the erosion problem that it's causing along the coast. The flooding that's been occurring on the coastal plains on the low-lying areas, I believe this is the third year in a row that Deadhorse has been flooding. The pipeline haul road has been shut down three times because the last three years it's been flooded out. That's climate changing. We have been seeing a lot of strange insects, new insects that we have never seen before. Especially when the caribou go more southerly, there have been incidences of ticks, big, huge ticks that get infested on them, and they can actually suck a caribou's blood until they are dead. They suck all the blood out of them." –Lance Whitwell, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "Things that are changing with the climate, of course, we have mentioned the weather getting warmer. It rains in the winter. When it rains in the winter, it forms a hard crust on the top of the snow. And as Gideon was saying, you could see -- if you are following the trails you will see the scarring on the caribous' legs because they have to push through that hard crust of ice that's on top of the snow. And as the water, the rainwater goes down into the snow to the ground layer and then refreezes as ice, the caribou can't dig through the ice to get to their food. And many of them starve. There has been many natural occurrences to where almost half of the caribou herd has died in one year, in one event. And it is still happening." –Lance Whitwell, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- "The bears are coming ashore because of climate change. It's not the problems that they are getting used to us being around them. It's they don't have a habitat. They are coming ashore, and that's directly related to the oil situation. The fact that we have climate change, the oil is open -- the ocean is open, and the bears have to come to shore. So you know -- and some of it could be mitigated by the whaling captains. They took a lot of the blubber this year and threw in the ocean. That could have been food for the bears. They could have been eating on it rather than come to town." –Robert Thompson, DEIS Public Meeting, February 5, 2019, Kaktovik, AK
- "So, the impact of the plants by the global warming… we have less snow covering on the tundra, but how much impact has that occurred? … So, each season we have less snow than last year, but

this year we have hardly any snow. ... it impacts the food source of the animals, the caribou, all the way to the lemming. So that will impact tremendously. And those type of studies are not occurring." –Robert Suvlu, DEIS Public Meeting, February 6, 2019, Utqiagvik, Alaska

- "Polar bear has been a problem. One went as far as Fort Yukon before, and then just recently here. That's not normal. Wolf was a problem two days ago, a day ago, hearing a lot of desperate cry. They are hungry. Snow is too deep. They can't get food. They have to team up in order to get food. So that's a threat to us, to our kids that go to school, walk to school." –Sarah James, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska
- "Back when I was about five, six, seven years old, you can even hear people talking, so much noise with geese there. Now I go there, I got tears in my eyes. Barely see geese. We are losing. We are losing ducks, caribou, and less and less. Moose is getting less. Fish is pretty scary." –Macarthur Tritt, DEIS Public Meeting, February 9, 2019, Venetie, Alaska
- "As someone else had said previously, we can see the changes that are happening with our own eyes. It is more dangerous today to hunt for our traditional food than it has ever been. Our old ice has melted. When we pull a whale up after hunting, it is cracking the ice and people are falling in and dying. Our way of life I'm seeing before my eyes is changing, and I truly don't know if my children when they grow up are going to enjoy the same foods as I did growing up. I don't even know if they're going to be able to go back to Utqiagvik because it's falling into the water." –Siginiq Maupin, DEIS Public Meeting, February 11, 2019, Anchorage, AK
- "… you can see with your own eyes that the climate is changing around us. And you can see with your own eyes that we have to do something to protect access to lands, to protect the air that we breathe, to protect the salmon runs. My family has gone to the Copper River near the Canadian border every year of my life to get our salmon limit, and we weren't able to go this year because the entire salmon system was shut down. Because of the warming oceans, because of inaction on behalf of us as a society, as well as on our government to deal with this crisis that we are living in. There were not enough salmon to let people go and get the food that they -- that sustains us throughout the year." –Laura Herman, DEIS Public Meeting, February 11, 2019, Anchorage, AK

C.1.6 Cumulative Effects

A number of commenters and tribal members stated that the Draft EIS failed to address cumulative effects of climate change and oil and gas on cultural resources, including on unknown traditional land use sites/archeological sites in the Coastal Plain and the broader region of cultural landscapes significant to the Vuntut Gwich'in relationship with the Porcupine Caribou Herd. The following excerpts echo this and provide specific examples of such effects.

- "Historical trauma to our people has been alluded to time and time again as systemic issues; yet the judicial system is occupied with disproportionate numbers of Alaska Natives. Missing and murdered Indigenous women are at the highest where development occurs, with no database and continued disregard to their cases. And the majority of offenders are nontribal members. Alcohol and drug abuse plague our small communities. Our children fill the systems, from private and State facilities to foster care. This is the war we already face from being forced to settle time and time again for the government deals which only benefit the one percent. That's what brings me here today to talk about the attack on the Arctic coastal plain, better known as area 1002 in the Arctic National Wildlife Refuge. …. Yet there are shareholders that have already seen what they have given up for compensation checks and a promise of good health and wealth. The land that's been developed in the NPR-A will never go back to its original state. The industrial footprint left behind and the health issues that the Indigenous people are left with, no money can fix.” –Adrienne Blatchford, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska

- “There is harmony. We could all be in harmony, all four directions coming together to stand for water, stand for life and for that food out there that grows the land and goes through the waters that sustain our lives. They are being killed due to the oil, the gas, the coal. And we are not even able to have a good diet because we are being so driven out by your way. You bring your food to us, and that is what we have to eat. You bring us your clothing. There is no room for our traditional ways when it comes to your governments and your corporations. And I get the feeling -- you know, I wouldn't doubt there is a lot of these people getting paid for your vote. I wouldn't doubt it was one of you.” –George Pletnikoff, Public Scoping Meeting, May 30, 2018, Anchorage, Alaska

C.1.7 Public Health and Safety

Finally, a number of written and oral comments expressed concerns that the Draft EIS failed to adequately consider impacts of the program on public health and safety and provided accounts of such impacts within the tribes.

- “The other thing I want to talk about is the community and public health. I used to work up north for, like, four years working in the clinic. As itinerary travel from village to village, I see a lot of health issues, the health issues that we don't even have in our community. I see patients with respiration problem. I see people with mental health problem that we don't have. I asked that question to one of the elders up there. She said before the oil company came, we had a healthy life, but now look around. As far as you could see, it's just all you could see is oil rigs everywhere. And she said, this is what happened. My husband died of cancer. And my kids, my grandkids have mental health problems. And she said, all these are created when the oil company came.” –Myra Thumma, Public Scoping Meeting, May 24, 2018, Arctic Village, AK
- “Like many others, I have experienced severe health issues without the access to regular balanced traditional diet. Science again proves that our DNA demands high protein and high-fat foods to sustain our bodies that keep us in these harsh conditions. For the Gwich'in, 60 percent of their diet is the caribou. Development in this coastal plain would not only cause cultural genocide, but also elimination of food security.” –Ben Stevens, Public Scoping Meeting, May 29, 2018, Fairbanks, AK
- “You know, since the Air Force has been here, I mean, for the last, what, 70 years or so, I mean, we have seen an uprise in cancer. And you know, I mean, they dumped drums and stuff. We have no idea what they are. And on our beaches, on our shores, they displaced our village numerous times, no apologies, no, you know, I'm sorry, no reparations. But we live with that. We have thrived through that.” –Charles Lampe, Public Scoping Meeting, June 12, 2018, Kaktovik, AK
- “…. I thought we going to have better life, but in the last 30 years, you should see the graveyard in every community. It's bigger and bigger because of the alcohol, drugs and alcohol, something that's not good for the Athabascan people, not only here, but all over Alaska, Native people, more crimes, and all that. A lot of them been lost with alcohol. Some of the village we losing that populations near the pipeline, like down Stevens Village and all that. I hope they come home someday to have a good life.” –Trimble Gilbert, Public Scoping Meeting, June 12, 2018, Venetie, AK
- “And during my period of 58 years living in Alaska, during my younger years, I barely seen any sickness. But from the start -- from beginning of the pipeline, more sickness came into our

community. And it's unstoppable because everything came to our village that's made out of oil. Also the animal. I see animal that are -- they are not healthy anymore. And the animal numbers are going down. And continually I'm stuck in the middle of everything, in between both cultures. And with the oil—with the big oil company, all the disease came with it. Like alcohol, drugs. All those -- of that came from Lower 48 when the oil companies started the big oil boom back in the '70s. In the '70s, everything came with it." –Ricky Frank, DEIS Public Meeting, February 4, 2019, Fairbanks, AK

- "I don't know if you gentlemen are aware that we now have the highest rates of suicide, highest ever. I know a 14-year-old boy that just committed suicide in St. Michaels. To me it's -- we are going down the wrong path. …we have been marked needing immediate relocation. The Army Corps of Engineers have -- we are highly vulnerable now more than ever because our -- one more storm like we had in 1964, and the water -- our drinking water will be contaminated." –Sara Thomas, DEIS Public Meeting, February 6, 2019, Utqiagvik, Alaska
- "Ever since 1977, July of 1977 when the first oil flow, they were pumping 2.5 million gallons or barrels a day for 30 years. And it's been 32 years since we have our gathering to oppose oil development. And I still stand by our tribe member and our tribe member in Canada. They oppose oil development. The elders that have been deceased, that's why I come standing here. I still support my leaders in the past. They oppose oil development, and I still do. The main vegetation in the winter is the lichen. The main vegetation that the caribou eat during the wintertime, the lichen, is the one that the nuclear particles -- radioisotope, they call it, it detects -- the lichen detect the radioactive material, and it goes down the food chain. I hate to tell my people that, but it's very, very, very dangerous. Just like a half-life of 28 years on plutonium 360. Strontium 90, they give you half-life of 28 years. Our people in the past from Old Crow, our next community down, I see people die from it. But I'm just one person. I'm trying to understand what's going on. And it really don't look good." –Edward Sam, DEIS Public Meeting, February 9, 2019, Arctic Village, Alaska
- In my village, we are surrounded and engulfed by methane flaring, something that is heavily restricted in the Lower 48, but not as restricted here. We have had a 50 percent and higher amount of respiratory illnesses grow in Nuiqsut since the oil fields have been built. The air is so dirty there that people are forced to move out and move to Anchorage and Fairbanks because they literally can't breathe. We have children with asthma. We have had two children in a 500-population town diagnosed with leukemia. We have cancer clusters growing everywhere." –Siginiq Maupin, DEIS Public Meeting, February 11, 2019, Anchorage, AK
- "I stand here today in honor of those missing and murdered Indigenous women whose lives were cut short because of all of this that has come into our land. I stand here today to all of the -- to honor all of the people that have died of cancer and autoimmune diseases inflicted upon them because of this desecration of our land." –Adrienne Aakaluk Titus, DEIS Public Meeting, February 11, 2019, Anchorage, AK
- "All right. What I'm trying to tell you is that suicide rate has a lot to do with confidence. And in order for you guys to help us build confidence, take a step back and let some Natives get in these positions that you are sitting in. I promise you that. One thing -- yeah, Anchorage -- there is one thing that is very highlighted about Anchorage. It's diverse. We are always, yeah Anchorage is so diverse. It's not in the political realm. It's not diverse where people are making decisions. You see that?... So I'm just letting you know what you are doing here today does perpetuate suicide. It does. You are sitting in here making decisions for us. You see that? Making decisions for Indigenous people. I'm not -- I'm not okay with that. I'm glad my daughters aren't here today. I'm glad they are

not in this building right now because I wouldn't want them to see this. I want them to have some confidence in themself. I want them to see some Alaska Natives up there on the stage with you guys, but it's not. Everybody see that? There are no Alaska Natives on the stage right now talking about Indigenous land.” –Samuel H. Johns, DEIS Public Meeting, February 11, 2019, Anchorage, AK

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Appendix D

Laws and Regulations

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ACRONYMS AND ABBREVIATIONS — Full Phrase

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ANILCA	Alaska National Interest Lands Conservation Act of 1980
ANS	Aquatic Nuisance Species
APDES	Alaska Pollutant Discharge Elimination System
Arctic Refuge	Arctic National Wildlife Refuge
AS	Alaska Statute
BLM	Bureau of Land Management
CAA	Clean Air Act
CFR	Code of Federal Regulations
Coastal Plain	Public Law 115-97 Coastal Plain
CWA	Clean Water Act
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EO	Executive Order
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency
ESA	Endangered Species Act
I-I Agreement	Inuvialuit-Iñupiat Polar Bear Management Agreement
Leasing EIS	Coastal Plain Oil and Gas Leasing Program Environmental Impact Statement
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NISA	National Invasive Species Act
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
PCH	Porcupine Caribou Herd
PL	Public Law
SHPO	State Historic Preservation Officer
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service

Appendix D. Laws and Regulations

Requirements of international agreements, federal, state, and local laws and regulations, and executive orders associated with future development in the Coastal Plain are provided below.

D.1 International Agreements

D.1.1 International Porcupine Caribou Herd Agreement

In 1987, the United States (US) and Canadian governments signed the Agreement between the Government of the United States of America and the Government of Canada on the Conservation of the Porcupine Caribou Herd. This bilateral agreement recognizes that the Porcupine Caribou Herd regularly migrates across the international boundary between Canada and the United States. It further recognizes that the herd should be conserved according to ecological principles that emphasize the importance of conserving habitat, including calving, post-calving, migrating, wintering, and seeking insect relief habitat.

The main objectives of the agreement are to conserve the Porcupine Caribou Herd and its habitat through international cooperation and coordination so that the risk of irreversible damage or long-term adverse effects, including cumulative effects, as a result of use of caribou or their habitat is minimized. It also ensures opportunities for customary and traditional uses of the Porcupine Caribou Herd. The agreement set up the International Porcupine Caribou Board, composed of representatives from both countries, who give advice and recommendations to the countries on the conservation and management of the herd. The International Porcupine Caribou Board, in turn, set up the Porcupine Caribou Technical Committee, composed of biologists from each country, to advise them in their recommendations. This agreement was signed by the US on July 17, 1987, in Ottawa, Canada, and entered into force in this country at that time.

D.1.2 Agreement on the Conservation of Polar Bears (Range States Agreement)

This is an agreement between the governments of Canada, Denmark, Norway, the former Union of Soviet Socialist Republics, and the US. It recognizes the responsibilities of circumpolar countries for coordinating actions to protect polar bears. The agreement prohibits hunting, killing, and capturing polar bears, except for bona fide scientific and conservation purposes, preventing serious disturbance to the management of other living resources, and by local people under traditional rights. This multilateral agreement also commits each associated country to adhere to sound conservation practices by protecting the ecosystem of polar bears. Special attention is given to denning areas, feeding sites, and migration corridors, based on best available science through coordinated research. The agreement was signed by the US on November 15, 1973, in Oslo, Norway; it was ratified on September 30, 1976, and went into force in this country on November 1, 1976.

D.1.3 Inuvialuit-Iñupiat Polar Bear Management Agreement (I–I Agreement)

Signed in 1988 and reaffirmed in 2000 by the Inuvialuit Game Council and the North Slope Borough (NSB) Fish and Game Management Committee, the I–I Agreement is a voluntary user-to-user agreement between Inuvialuit (in Canada) and Iñupiat (in Alaska) hunters. It provides for annual quotas, hunting seasons, protection of polar bears in or during construction of dens, females accompanied by cubs-of-the-year and yearlings, collection of information and specimens to monitor harvest composition, and annual meetings to exchange information on the harvest, research, and management. The I-I also establishes a joint commission to implement the I-I Agreement, and a technical advisory committee, consisting of biologists from agencies in the US and Canada involved in research and management. Their function is to collect and evaluate scientific data and make recommendations to the joint commission.

D.1.4 Memorandum of Understanding for the Conservation and Management of Shared Polar Bear Populations

In 2008, the US and Canada signed a Memorandum of Understanding (MOU) to facilitate and enhance coordination, cooperation, and development of partnerships around the conservation and management of polar bears. The two countries share management responsibilities for the Southern Beaufort Sea polar bear population, and Indigenous peoples from both countries have harvesting rights. The agreement provides a framework for the development and implementation of mutually agreeable immediate, intermediate, and long-term actions that focus on specific components of polar bear conservation. The MOU established a Bilateral Oversight Group whose function is to achieve enhanced, collaborative action on polar bear management and conservation.

D.2 Federal Laws and Regulations

The following summarizes federal laws and regulations relevant to the oil and gas leasing program in the Coastal Plain. Some obligations would be placed directly on the applicant. Others would be required of federal agencies before they would grant authorizations to oil and gas companies.

D.2.1 Bureau of Land Management (BLM)

- The National Environmental Policy Act of 1969 (NEPA) sets out policy and provides the means by which the federal government, including the BLM and the federal cooperating agencies, examines major federal actions that may have significant impacts on the environment. Examples are the oil and gas leasing and development contemplated in this Environmental Impact Statement (EIS) (42 United States Code [USC] 4321 et seq.).
- Section 28 of the Mineral Leasing Act of 1920 (30 USC 185; 43 Code of Federal Regulations [CFR] 2880), provides the BLM with the authority to issue right-of-way grants for oil and natural gas pipelines and related facilities (not authorized by appropriate leases).
- Section 810 of the Alaska National Interest Lands Conservation Act (ANILCA) establishes procedures for federal land management agencies to evaluate the effect of federal actions on subsistence uses and needs, the availability of other lands for the purposes sought to be achieved, and other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes (16 USC 3120).
- The Tax Cuts and Jobs Act of 2017 (Section 20001(c)(1) of Public Law [PL] 115-97, December 22, 2017) directs the Secretary of the Interior, acting through the BLM, to establish and administer a competitive oil and gas program for the leasing, development, production, and transportation of oil and gas in and from the Coastal Plain in the Arctic National Wildlife Refuge (Arctic Refuge). PL 115-97 amends ANILCA Section 1003 to authorize oil and gas leasing in the Coastal Plain and authorizes the BLM to issue rights-of-way or easements across the Coastal Plain for the exploration, development, production, or transportation necessary to carry out the oil and gas leasing program.
- The BLM issues geophysical permits to conduct seismic activities, as described in 43 CFR 3150.
- Applications for transportation and utility systems in conservation system units are processed under ANILCA Title XI.

- The BLM reviews and approves applications for permit to drill (including drilling plans and surface-use plans of operations) and subsequent well operations, as prescribed in 43 CFR 3160, for development and production on federal leases.
- As described in 43 CFR 3130 and 3180, the BLM approves lease administration requirements, including unit agreements and plans of development, drilling agreements, and participating area determinations for exploring for and developing oil and gas leases.
- Section 106 of the National Historic Preservation Act (54 USC 300301 et seq.) and its implementing regulations (36 CFR 800) require the BLM to consider the effects of federal undertakings on historic properties. Other relevant federal cultural resource protection laws include the Antiquities Act of 1906 (54 USC 320301 et seq.), the American Indian Religious Freedom Act (42 USC 1996), the Archaeological Resources Protection Act (ARPA) (16 USC 470aa et seq.), the Abandoned Shipwreck Act of 1987 (43 USC 2101 et seq.), and Executive Order 13007 (Indian Sacred Sites).
- Under the Endangered Species Act the BLM consults with the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) regarding the effects of its actions on threatened and endangered species and designated critical habitat, and conferences on species proposed for listing.
- Under the Magnuson-Stevens Fishery Conservation and Management Act, the BLM conducts an essential fish habitat consultation with NMFS regarding authorized, funded, or undertaken actions that may adversely affect essential fish habitat.
- The BLM would ensure that all identified archaeological resources are protected, consistent with the ARPA to ensure there is no "[u]nauthorized excavation, removal, damage, alteration, or defacement of archaeological resources."
- The BLM disposes of mineral materials pursuant to the Materials Act of 1947 and 43 CFR 3600.
- The Energy Policy Act of 2005 (EPAct) (Public Law 109-58) includes (but is not limited to): energy efficiency, renewable energy, oil and gas, and Tribal energy. EPAct 2005 calls for the development of grant programs, demonstration and testing initiatives, and tax incentives that promote alternative fuels and advanced vehicles production and use.

D.2.2 US Fish and Wildlife Service

- The USFWS manages the Arctic Refuge (established in Public Land Order 2214), as defined under Section 303(2) of ANILCA, which establishes the Arctic Refuge and additions as part of the National Wildlife Refuge System. The purposes for which the Arctic Refuge is established and is managed are as follows: (i) to conserve fish and wildlife populations and habitats; (ii) to fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats; (iii) to provide, in a manner consistent with the purposes set forth above in (i) and (ii), the opportunity for continued subsistence uses by local residents; and (iv) to ensure, to the maximum extent practicable and in a manner consistent with the purposes set forth in (i), water quality and necessary water quantity within the refuge. PL 115-97 amended Section 303(2)(B) of ANILCA to add as a purpose of the Arctic Refuge "to provide for an oil and gas program on the Coastal Plain."
- The mission of the National Wildlife Refuge System Administration Act, as amended through the National Wildlife Refuge Improvement Act, is "to administer a network of lands and waters for the conservation, management and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations

of Americans." Under the National Wildlife Refuge System Administration Act, each refuge shall adhere to the mission of the National Wildlife Refuge System. The USFWS is required to monitor the status and trends of fish, wildlife, and plants in each refuge.

- The Endangered Species Act (ESA) (Section 7(a)(I)) "requires federal agencies, in consultation with and with the assistance of the Secretary, to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of endangered and threatened species." All federal agencies shall, in consultation with and with the assistance of the Secretary of the Interior or Commerce (Secretary), ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species. Furthermore, an agency's action shall not destroy or adversely modify the habitat of such species that the Secretary determines to be critical. Section 9 (16 USC 1538) of the ESA identifies prohibited acts related to endangered species and prohibits all persons, including all federal, state, and local government employees, from taking listed species of fish and wildlife, except as specified under provisions for exemption (16 USC 1535(g)(2) and 1539). Generally, the USFWS manages land and freshwater species, while NMFS manages marine species, including anadromous salmon. However, the USFWS is responsible for some marine animals, such as nesting sea turtles, walrus, polar bears, sea otters, and manatees.
- The National Invasive Species Act (Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (as amended through the National Invasive Species Act [NISA])—The NISA mandates the USFWS to lead national efforts to prevent the spread of aquatic invasive species. The NISA furthered Aquatic Nuisance Species (ANS) activities by calling for ballast water regulations, the development of state management plans and regional panels to combat the spread of ANS, and additional ANS outreach and research. Section 1204 of the NISA authorizes the ANS Task Force to provide funding to states that have an ANS management plan. It established the ANS Task Force to coordinate nationwide ANS activities.
- All marine mammals are protected under the Marine Mammal Protection Act of 1972 (MMPA) (16 USC 1361 et seq.). Jurisdiction of the MMPA is shared by NMFS and the USFWS, depending on the species being considered. Under the MMPA, the taking of marine mammals without a permit or exception is prohibited. "Take" under the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." The MMPA defines harassment as "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment]." The USFWS may authorize the incidental take of small numbers of marine mammals of a species or stock only if such take would have a negligible impact on a species or stock and would not have an unmitigable adverse impact on the availability of such species or stock for subsistence purposes.
- The Migratory Bird Treaty Act (16 USC 703-712) makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird, except under the terms of a valid permit issued under federal regulations. The migratory bird species protected by the act are listed in 50 CFR 10.13
- The Bald and Golden Eagle Protection Act prohibits taking eagles, including their parts, nests, or eggs. The act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." "Disturb" means to agitate or bother a bald or golden eagle to a degree that

causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. If a project may result in take, and after avoidance and minimization measures are established, the USFWS may issue an eagle take permit.

- The Fish and Wildlife Coordination Act provides one of the basic legal authorities for assessing the impacts on fish and wildlife resources at water resource development projects. Under the act, any public or private agency under federal permit or license to modify or control for any purpose any stream or other water body is required to consult with the USFWS to conserve wildlife resources by preventing loss of and damage to such resources. "Wildlife resources" is explicitly defined to include birds, fishes, mammals, and all other classes of wild animals and types of aquatic and land vegetation that wildlife depend on. Further, the act states that reports that determine the possible damage to wildlife resources and estimates wildlife loss "shall be made an integral part of any report prepared or submitted by any agency with the authority to authorize" water projects (16 USC 662 (b)(0)).
- Native American Graves Protection and Repatriation Act (25 USC 3001-3013) requires the USFWS to plan for and facilitate the return of human remains, funerary objects, sacred objects, and objects of cultural patrimony to lineal descendants and culturally affiliated Alaska Native tribes.
- John D. Dingell, Jr. Conservation, Management, and Recreation Act (2019) consists of more than 100 individual bills that were introduced by 50 Senators and several House members. Specific to Alaska, the program provides the opportunity for eligible Vietnam-era veterans or their heirs to select 2.5 to 160 acres of Federal Land in Alaska and removes the requirement for personal use or occupancy mandated under previous laws.

D.2.3 Environmental Protection Agency (EPA)

The EPA's authority to regulate oil and gas development is contained in the Clean Water Act of 1972 (CWA) (33 USC 1251 et seq.), Clean Air Act of 1963 (CAA) (42 USC 7401 et seq.), and the Safe Drinking Water Act of 1974 (42 USC 300f et seq.). These authorities are discussed below.

- Under Section 402 of the CWA (33 USC 1342), the EPA has delegated authority to the State of Alaska to issue permits for discharging pollutants from a point source into waters of the US for facilities, including oil and gas, operating within state jurisdiction. Point-source discharges that require an Alaska Pollutant Discharge Elimination System (APDES) permit include sanitary and domestic wastewater, gravel pit and construction dewatering, hydrostatic test water, and stormwater discharges (40 CFR 122).

  The EPA co-administers the CWA Section 404 program with the US Army Corps of Engineers (USACE). The EPA develops and interprets policy, guidance, and the Section 404(b)(1) Guidelines, which are the environmental criteria used in evaluating permit applications. The EPA also determines the scope of geographic jurisdiction and the applicability of statutory exemptions to the permit requirements. It approves and oversees state and tribal assumption of Section 404 permitting authority, reviews permit applications for compliance with the guidelines, and provides comments to the USACE. The EPA can elevate specific permit cases or policy issues pursuant to Section 404(q), under which it has the authority to prohibit, deny, or restrict the use of any defined area as a disposal site. Lastly, the EPA has independent authority to enforce Section 404 provisions.

Under the Safe Drinking Water Act (42 USC 300f et seq.), the EPA's responsibilities are to manage the underground injection control program and the direct implementation of Class I and Class V injection wells in Alaska. These wells cover injection of nonhazardous and hazardous waste through a permitting process for fluids that are recovered from down hole. Also covered are municipal waste, stormwater, and other fluids that did not come up from down hole (40 CFR 124A, 144, and 146). The EPA oversees the Class II program delegated to the State of Alaska and managed by the Alaska Oil and Gas Conservation Commission, which includes Class II enhanced oil recovery, storage, and disposal wells that may receive nonhazardous produced fluids originating from down hole, including muds and cuttings (40 CFR 147).

- Under Section 311 of the CWA, as amended (33 USC 1321, 40 CFR 112), the EPA requires a "spill prevention containment and countermeasure plan" for storage of over 660 gallons of fuel in a single container or over 1,320 gallons in aggregate aboveground tanks.
- Under the CWA, as amended (Oil Pollution Act; 33 USC 40; FRP Rule; 40 CFR 112, Subpart D, Sections 112.20–112.21) the EPA requires a "facility response plan" to identify and ensure the availability of sufficient response resources for the worst case discharge of oil to the maximum extent practicable, "…generally for facilities that transfer over water to or from vessels, and maintaining a capacity greater than 42,000 gallons, or any facility with a capacity of over one million gallons."
- Under Sections 165 (42 USC 7475) and 502 of the CAA (42 USC 7661a), the State of Alaska is authorized to issue air quality permits for facilities operating within state jurisdiction for the Title V operating permit (40 CFR 70) and the "prevention of significant deterioration" permit (40 CFR 52.21) to address air pollution emissions. The EPA maintains oversight authority of the State's program.
- Under Section 309 of the CAA (42 USC 7609), the EPA requires a review and evaluation of the draft and final EIS for compliance with Council on Environmental Quality guidelines.
- The EPA retains oversight authority over the APDES program.

D.2.4 National Marine Fisheries Service

NMFS is responsible for the stewardship of national marine resources. The agency conserves and manages fisheries to promote sustainability and prevent lost economic potential associated with overfishing, declining species, and degraded habitats.

- Provides consultation under the ESA, Section 7(a)(2) on the effects on threatened or endangered species.
- Provides consultation under the Fish and Wildlife Coordination Act on the effects on fish and wildlife resources.
- Provides consultation under the MMPA on the effects on marine mammals; issues Incidental Harassment Authorization under the MMPA for incidental takes of protected marine mammals (bowhead whales and ringed seals).
- Provides consultation under the Magnuson-Stevens Fishery Conservation and Management Act for effects on Essential Fish Habitat; the act requires federal agencies to consult with the Secretary of Commerce on any action authorized, funded, or undertaken or proposed to be authorized, funded, or undertaken by such agency that may adversely affect essential fish habitat identified under the act.

D.2.5 US Army Corps of Engineers

The USACE has the authority to issue or deny permits for placing dredge or fill material in the waters of the US, including wetlands, and for work or structures in, on, over, or under navigable waters of the US. These USACE authorities are set forth as follows.

- Under Section 404 of the CWA (33 USC 1251 et seq.), the USACE regulates discharges of dredge and fill material in waters of the US, including wetlands.
- Under Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403), the USACE has regulatory authority for work and structures performed in, on, over, or under navigable waters of the US.
- Under Section 103 of the Marine Protection Research and Sanctuaries Act of 1972 (33 USC 1413), the USACE issues Section 103 ocean dumping permits for transport of dredged material for ocean disposal.

D.2.6 Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management provided subject matter expertise in the drafting and review of this NEPA document as part of the BLM Interdisciplinary Team. The Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska, established under Executive Order (EO) 13580, adopted the concept of integrated Arctic management to ensure that decisions on development and conservation made in the Arctic are driven by science, stakeholder engagement, and government coordination.

D.3 EXECUTIVE ORDERS

In addition to the statutory authorities described above, a number of Executive Orders (Eos) may apply, as follows: EOs 13783 (promoting energy independence and economic growth), 11988 (floodplain management), 11990 (protection of wetlands), 13158 (Marine Protected Areas), 12898 (environmental justice), 13007 (Indian sacred sites), 13175 (tribal consultation), 13112 (invasive species control), and 13751 (safeguarding against invasive species), 13990 (social costs of GHG emissions), 14008 (Paris Agreement).

D.4 STATE OF ALASKA

The State issues several permits associated with oil and gas activities. The Alaska Department of Natural Resources issues temporary water use and water rights permits, permits for cultural resource surveys, cultural resource concurrences, and other authorizations for activities associated with oil and gas development. The Alaska Department of Fish and Game issues fish habitat permits. The Alaska Department of Environmental Conservation issues prevention of significant deterioration and other air quality permits as part of implementation plans. The Alaska Department of Environmental Conservation is responsible for issuing several permits and plan approvals for oil and gas exploration and development, including the storage and transport of oil and cleanup of oil spills. The Alaska Oil and Gas Conservation Commission issues drilling permits and approves production, injection, and disposal plan for exploration and development. Additional State authorities are presented below.

D.4.1 Alaska Department of Natural Resources

- Issues rights-of-way and land use permits for use of State land, ice road construction on State land, and State freshwater bodies under Alaska Statute (AS) 38.05.850.

- Issues "temporary water use and water rights" permits under AS 46.15 for water use necessary for construction and operations.
- Issues Alaska cultural resource permits for surveys under the Alaska Historic Preservation Act (AS 41.35.080).
- Issues cultural resources concurrences for development on State land (but not on federally managed land) that may affect historic or archaeological sites under the National Historic Preservation Act of 1966 (54 USC 300301 et seq.), and the Alaska Historic Preservation Act (AS 41.35.010 through .240).
- Adjudicates instream flow reservations and other applications for reserved water rights under AS 46.15.145, Reservation of Water; permissible in-stream uses are protection of fish and wildlife habitat, migration, and propagation; recreation and parks; navigation and transportation; and sanitation and water quality.
- The Office of History and Archaeology identifies and protects historic properties in Alaska and is led by the State Historic Preservation Officer (SHPO). Section 106 of the National Historic Preservation Act requires federal agencies to avoid or minimize impacts on properties listed on or eligible for listing on the National Historic Preservation Act by requiring federal agencies to identify sites that may be affected and determine their eligibility to be listed. This consultation is done through the SHPO.

D.4.2 Alaska Department of Environmental Conservation

- Issues an APDES "wastewater discharge permit" for wastewater disposal into all State waters under a transfer of authority from the EPA National Pollutant Discharge Elimination System Program under Section 402 of the CWA, as amended (33 USC 1342); AS 46.03.020, .100, .110, .120, and .710; 18 Alaska Administrative Code (AAC) Chapters 15 and 70, and Section 72.500; these permits may include a mixing zone approval where appropriate; in addition to developing, issuing, modifying, and renewing permits, the APDES program includes the Storm Water Program, Compliance and Enforcement, Federal Facilities, and the Pretreatment Program.
- Issues a certificate of reasonable assurance for permits issued by the USACE under Section 404 of the CWA; these permits may include discharge of dredge and fill material into Waters of the US.
- Issues a Class I well wastewater disposal permit for underground injection of non-domestic wastewater under AS 46.03.020, .050, and .100.
- Reviews and approves all public water systems, including plans, monitoring programs, and operator certifications under AS 46.03.020, .050, .070, and .720, 18 AAC, Section 80.005.
- Approves domestic wastewater collection, treatment, and disposal plans for domestic wastewaters (18 AAC, Chapter 72).
- Approves financial responsibility for cleanup of oil spills (18 AAC, Chapter 75).
- Reviews and approves the "oil discharge prevention and contingency plan" under the Oil Pollution Act of 1990 and the "certificate of financial responsibility" for storage or transport of oil under AS 46.04.030 and 18 AAC, Chapter 75; The State review applies to oil exploration and production facilities, crude oil pipelines, oil terminals, tank vessels and barges, and certain non-tank vessels.
- Issues Title V operating permits and prevention of significant deterioration permits under CAA Amendments (Title V) for air pollutant emissions from construction and operation (18 AAC Chapter 50).

- Issues solid waste disposal permits for State lands under AS 46.03.010, .020, .100, and .110; AS 46.06.080; 18 AAC Section 60.005; and .200.
- Reviews and approves solid waste processing and temporary storage facilities plans for handling and temporarily storing solid waste on federal and State lands under AS 46.03.005, .010, and .020 and 18 AAC, Section 60.430.
- Approves the siting of hazardous waste management facilities.

D.4.3 Alaska Department of Fish and Game

- AS 16.05.841—The Fishway Act, deals exclusively with fish passage; applies to streams with documented resident fish use and without documented use by anadromous fish.
- AS 16.05.871—The Anadromous Fish Act, applies to streams specified in the Anadromous Waters Catalog as important for the spawning, rearing, or migration of anadromous fishes; AS 16.05.871 is a broader authority than AS 16.05.841 and extends to anadromous fish habitat.
- AS 16.05.841 and AS 16.05.871—Issues "fish habitat permits" for activities in streams used by fish that the agency determines could represent impediments to fish passage or for travel in, excavation of, or culverting of anadromous fish streams.
- Issues public safety permit for nonlethal hazing of wild animals that are creating a nuisance or a threat to public safety.
- Evaluates potential impacts on fish, wildlife, and fish and wildlife users and presents any related recommendations to the Alaska Department of Natural Resource or, via the Fish and Wildlife Coordination Act, to federal permitting agencies.

D.4.4 Alaska Oil and Gas Conservation Commission

- Issues permits to drill under 20 AAC Section 25.05.
- Issues approval for annular disposal of drilling waste (20 AAC Section 25.080).
- Authorizes plugging, abandonment, and location clearance (20 AAC Section 25.105 through 25.172).
- Authorizes production practices (20 AAC Section 25.200–25.245)
- Authorizes Class II waste disposal and storage (20 AAC Section 25.252).
- Approves workover operations (20 AAC Section 25.280).
- Requires information and documentation as requested by the Commissioner (20 AAC Section 25.300–25.320).
- Authorizes enhanced recovery operations under 20 AAC Section 25.402–460.

D.4.5 Alaska Department of Public Safety

- Fire marshal approval.

D.5 NORTH SLOPE BOROUGH

The NSB, as a Home Rule Borough, issues development permits and other authorizations for oil and gas activities under the terms of its ordinances (NSB Municipal Code Title 19). The Iñupiat History, Language, and Culture Division is responsible for traditional land use inventory clearance.

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Appendix E

ANILCA Section 810 Preliminary Evaluation

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Appendix E. ANILCA Section 810 Preliminary Evaluation

E.1 Subsistence Evaluation Factors

Section 810(a) of the Alaska National Interest Lands Conservation Act (ANILCA), 16 United States Code (USC) 3120(a), requires that an evaluation of subsistence uses and needs be completed for any federal determination to "withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands." As such, an evaluation of potential impacts on subsistence under ANILCA Section 810(a) must be completed for the Coastal Plain Oil and Gas Leasing Program Supplemental Environmental Impact Statement (Leasing SEIS or SEIS). ANILCA requires that this evaluation include findings on three specific issues, as follows:

- The effect of use, occupancy, or disposition of public lands on subsistence uses and needs
- The availability of other lands for the purposes sought to be achieved
- Other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes

In this analysis, three factors are considered when determining if a significant restriction of subsistence uses and needs may result from the proposed action, alternatives, or in the cumulative case, as follows:

- Reduction in the *abundance* of harvestable resources used for subsistence purposes
- Reduction in the *availability* of resources used for subsistence caused by alteration of their distribution, migration patterns, or location
- Legal or physical limitations on *access* of subsistence users to harvestable resources

Each alternative will be analyzed according to these criteria. ANILCA Section 810 also requires that cumulative impacts be analyzed. This approach helps the reader separate subsistence restrictions that could be caused by activities proposed under the four alternatives from those that could be caused by past, present, or future activities that have occurred or could occur in the surrounding area.

An alternative would be considered to significantly restrict subsistence uses if, after consideration of protection measures, such as lease stipulations or required operating procedures, it can be expected to substantially reduce the opportunity to use subsistence resources. Substantial reductions are generally caused by large reductions in resource abundance, a major redistribution of resources, extensive interference with access, or major increases in the use of those resources by non-subsistence users.

If the analysis determines that the proposed action, alternatives, or the cumulative case may significantly restrict subsistence uses, the BLM is required to notify the State of Alaska and appropriate regional and local subsistence committees. It also must conduct ANILCA Section 810 hearings in potentially affected communities.

It is possible that the finding may be revised to "will not significantly restrict subsistence uses" based on changes to alternatives, new information, or new mitigation measures resulting from the hearings. If the significant restriction remains, the BLM may prohibit the action or finalize the evaluation by making the following determinations:

- A significant restriction of subsistence uses would be necessary, consistent with sound management principles for the use of public lands
- The proposed activity would involve the minimal amount of public land necessary to accomplish the purpose of the use, occupancy, or other disposition
- Reasonable steps would be taken to minimize adverse effects on subsistence uses and resources resulting from such actions (Section 810(a)(3))

The BLM can then authorize use of the public lands.

E.2 ANILCA Section 810(a) Evaluations and Findings for All Alternatives and the Cumulative Case

This ANILCA Section 810 evaluation relies primarily on the information contained in the Leasing SEIS. **Chapter 3** describes areas and resources important for subsistence, and specific communities' degree of dependence on various fish and wildlife resources. It also describes the environmental consequences anticipated under each alternative, which the BLM uses to determine whether each alternative and the cumulative case would cause a significant restriction to subsistence uses. Consistent with NEPA and Council on Environmental Quality (CEQ) guidance, this evaluation does not analyze or present impacts under a worst-case scenario. Rather, it discusses impacts under each alternative based on the assumptions and discussion in the hypothetical development scenario (**Appendix B**).

Issuance of oil and gas leases under the directives of Section 20001(c)(1) of Public Law (PL) 115-97 would have no direct impacts on the environment because by itself a lease does not authorize any on the ground oil and gas activities; however, a lease does grant the lessee certain rights to drill for and extract oil and gas subject to further environmental review and reasonable regulation, including applicable laws, terms, conditions, and stipulations of the lease. The impacts of such future exploration and development activities that may occur because of the issuance of leases are considered potential indirect impacts of leasing. Such post-lease activities could include seismic and drilling exploration, development, and transportation of oil and gas in and from the Coastal Plain. Therefore, the analysis in Chapter 3 is of potential direct, indirect, and cumulative impacts from on-the-ground post-lease activities.

The Leasing SEIS uses a hypothetical development scenario (see **Appendix B**) to inform the impact analysis for each alternative; however, additional National Environmental Policy Act (NEPA) and ANILCA Section 810 analyses would occur with future project-specific proposals. The regulations governing leasing and development provide for multiple decision stages prior to any ground-disturbing activities being authorized and require further compliance with applicable laws, including NEPA, during post-leasing decision stages. Until the BLM receives and evaluates an application for an exploration permit, permit to drill, or other authorization that includes site-specific information about a particular project, impacts of actual exploration and development that might follow lease issuance are speculative, as so much is unknown as to location, scope, scale, and timing of that exploration and development. At each decision stage, the BLM retains the authority to approve, deny, or reasonably condition any proposed on the ground-disturbing activity based on compliance with applicable laws and policies. Therefore, the analysis of effects of exploration and development in the Leasing SEIS, including this ANILCA 810 evaluation, necessarily reflects a more general, programmatic approach than could occur at the post-lease project-specific stage.

The SEIS summarizes the relevant subsistence activities of communities that use the program area or the resources that migrate through the program area and are harvested elsewhere. Consistent with the SEIS, this evaluation focuses on subsistence impacts to four communities: Kaktovik, Nuiqsut, Arctic Village, and Venetie. They are the closest to the program area and have subsistence uses in or near the program area or rely heavily on resources that use the program area.

In addition, because of the importance of the program area to caribou-particularly the Porcupine Caribou Herd and Central Arctic Herd – relevant data on subsistence uses of caribou by 22 Alaskan communities, including the four subsistence study communities listed above is also included in the SEIS.

The SEIS recognizes that the Inuvialuit, Gwich'in people, and other user groups in Canada have cultural, historical, and subsistence ties to the Arctic Refuge or the Porcupine Caribou Herd or both; however, Section 810 of ANILCA only applies to subsistence uses by rural Alaska residents, per the definition of "subsistence uses" in Section 803 of ANILCA. More information regarding subsistence impacts affecting Canadian communities and user groups can be found in **Section 3.4.3**, Subsistence Uses and Resources.

The Gwich'in People, who live both in Alaska and Canada, have a unique cultural connection to the program area, as they consider the Arctic Refuge to be sacred ground and "the place where life began." Because of their high reliance on the Porcupine Caribou Herd and their identity as the "Caribou People," the Gwich'in view protection of the Arctic Refuge, home to the Porcupine Caribou Herd calving grounds, to be of the utmost importance to their cultural survival. These broader cultural impacts to the Gwich'in are discussed in the SEIS; however, this Section 810 focuses its analysis on impacts to resource abundance, availability, and subsistence access (see **Section E.1**., Subsistence Evaluation Factors).

Kaktovik and Nuiqsut engage in subsistence activities in and around the program area. Kaktovik uses the program area to procure most of the resources they harvest (**Map 3-46** through **Map 3-63** in **Appendix A**). Nuiqsut's marine mammal and furbearer use areas overlap the program area (**Map 3-58** through **Map 3-61** in **Appendix A**). Arctic Village and Venetie subsistence use areas do not overlap the program area, but these communities rely heavily on resources that use the program area, specifically caribou from the Porcupine Caribou Herd (**Map 3-39** in **Appendix A**).

While the SEIS describes potential impacts to subsistence use of all resources, this evaluation focuses on impacts to subsistence use of fish, marine mammals (bowhead and beluga whales, bearded and ringed seals), and caribou. Other resources such as waterfowl, polar bears, and furbearers are culturally important to residents of these communities, but they do not comprise the majority of the wild foods consumed by residents of Kaktovik, Nuiqsut, Arctic Village, or Venetie (**Section 3.4.3**, Subsistence Uses and Resources). Residents of Kaktovik and Nuiqsut rely most heavily on fish, marine mammals, and caribou. Combined, these resources make up 98 percent of the harvest for Kaktovik and 97 percent of the harvest for Nuiqsut (**Tables 3-45** and **3-46** in **Chapter 3**). Fish and large mammals (caribou and moose) make up 86 percent of the harvest for Venetie (**Table 3-48** in **Chapter 3**). Nineteen percent of Venetie's annual harvest is caribou, although they receive appreciably more through sharing with other communities (Van Lanen et al. 2012; Kofinas et al. 2016). Detailed harvest data for Arctic Village is not available but it is likely similar to the harvest documented for Venetie.

In addition to Kaktovik, Nuiqsut, Arctic Village, and Venetie, 18 communities have positive customary and traditional use determinations for the Porcupine Caribou Herd and/or the Central Arctic Herd (**Map 3-45**, Coastal Plain EIS Subsistence Study Communities, in **Appendix A**). These 22 communities, referred to in the SEIS as the caribou study communities, could be affected by impacts on caribou abundance and availability, and were therefore included in **Chapter 3**. Those communities with the greatest reliance (where caribou accounts for greater than 10 percent of the annual subsistence harvest, and on average over 50 percent of households use caribou) include Alatna, Anaktuvuk Pass, Bettles, Coldfoot, Eagle, Kaktovik, Nuiqsut, Point Lay, Utqiagvik, Venetie, Wainwright, Wiseman, and likely Arctic Village (although detailed harvest data is not available for this community). Alatna, Bettles, Point Lay, Utqiagvik and Wainwright harvest caribou primarily from the Western Arctic Herd, and Eagle harvests caribou primarily from the Fortymile Herd. These herds would not be impacted by development in the program area. Coldfoot, and Wiseman harvest primarily Central Arctic Herd caribou. The majority of Nuiqsut's harvest consists of Teshekpuk Lake Caribou Herd animals, although Nuiqsut also harvests caribou from the Central Arctic Herd. Anaktuvuk Pass harvests a combination of Western Arctic, Teshekpuk Lake, and Central Arctic Herd caribou. Teshekpuk Lake caribou would not be impacted by future oil and gas exploration, development, and production activities in the program area, and potential impacts on Central Arctic Herd caribou are expected to be low for Alternatives B, C, and D. Kaktovik, Arctic Village and Venetie rely heavily on Porcupine Caribou Herd. Therefore, Kaktovik, Arctic Village, and Venetie are the communities most likely to be appreciably affected by changes in the abundance or availability of Porcupine Caribou Herd, although other communities may experience indirect impacts through impacts on sharing networks. For these reasons, Porcupine Caribou Herd-related discussion in this evaluation focuses exclusively on impacts on the Porcupine Caribou Herd from future on-the-ground activities and consequent impacts on subsistence use of them by these three communities.

E.2.1 Evaluation and Finding for Alternative A: No Action

Alternative A would not comply with the directive in Section 20001 of PL 115-97 to establish and administer a competitive oil and gas program for leasing, developing, producing, and transporting oil and gas in and from the Arctic Refuge Coastal Plain. There would be no oil and gas lease sales in the program area. Current management actions and resource trends would continue in the program area, as described in the Arctic Refuge Revised Comprehensive Conservation Plan (CCP) (USFWS 2015). Existing impacts on subsistence uses and resources, described in **Section 3.4.3**, Subsistence Uses and Resources, would continue along current trends.

E.2.1.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

The United States (US) Fish and Wildlife Service (USFWS) determined that the alternative selected in the Record of Decision (ROD) for the Arctic Refuge Revised CCP (USFWS 2015) and subsequent cumulative effects would not significantly restrict subsistence use of resources in the program area.

E.2.1.2 Evaluation of the Availability of Other Lands for the Purpose Sought to be Achieved

Alternative A does not propose the disposition or use of public lands with regard to the proposed action; therefore, evaluating the availability of other lands is not applicable.

E.2.1.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence

Alternative A would eliminate the use of public lands needed for subsistence purposes, but it does not meet the purpose of the proposed action, nor does it comply with PL 115-97.

E.2.1.4 Findings

Alternative A will not result in a significant restriction in subsistence uses. A positive determination pursuant to ANILCA Section 810 is not required.

E.2.2 Evaluation and Finding for Alternative B

Section B.8.2, Alternative B in **Appendix B**, assumes that up to four central processing facilities (CPFs) would be built under Alternative B: two CPFs would be built in the high potential area, one CPF would be built in the medium potential area on State or native lands, or just south of Kaktovik, and one CPF would be built in the low potential area. Under this scenario it is estimated that four CPFs and associated airstrips, 14 satellite pads, 174 miles of road, a seawater treatment plant, and at least one barge landing and storage pad would be built. The 2,000-acre surface disturbance limit would be reached under Alternative B.

The hypothetical development scenario anticipates that future development would occur in the same manner as the baseline scenario described in **Appendix B** under Alternative B. The entire Coastal Plain would be offered for lease sale. Compared to the other action alternatives, this alternative has the largest amount of acres where only Required Operating Procedures (ROPs) would apply (**Table 2-1** in **Chapter 2**). Approximately 358,100 acres would be subject to a no surface occupancy (NSO) stipulation to protect caribou calving habitat, fish and hydrologic resources, and subsistence activities adjacent to major rivers. There would be zero acres subject to controlled surface use (CSU), and 585,400 acres would be subject to timing limitations (TLs). While the 46 ROPs apply to the entire program area, approximately 620,000 acres would be subject to ROPs only. **Map 2-1**, Alternative B and **Map 2-2**, Alternative B, Lease Stipulations (**Appendix A**) illustrate where NSO and TLs would be adopted.

E.2.2.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

This evaluation summarizes potential impacts on major subsistence resources (fish, marine mammals, and caribou) for residents of Kaktovik, Nuiqsut, Arctic Village, and Venetie before a discussion of other issues, such as impacts on resource access anticipated under Alternative B. **Table E-2** classifies each impact as minor, moderate, or major, based on the discussion in the SEIS. **Table E-3** summarizes the extent to which impacts on access would affect subsistence users.

Abundance and Availability

<u>Fish</u>

Section 3.3.2, Fish and Aquatic Species, describes potential impacts on non-salmon fish, including Dolly Varden and Arctic cisco which are important subsistence resources for residents of Kaktovik and Nuiqsut (**Table 3-45**). Impacts to fish are not likely to extend beyond Kaktovik harvesting areas, unless there is a large-scale contamination event. In this event, it is possible that Nuiqsut harvesters could experience impacts to resource availability of Arctic cisco, which migrate past the program area on their way to the Colville River Delta. It is unlikely that impacts to fishing would extend to the other study communities of Arctic Village and Venetie, as they do not harvest from waterways connected to the program area. Dolly Varden is the primary fish resource harvested within the rivers and streams of the program area.

Impacts from future oil and gas exploration, development, and production that may affect the availability or abundance of non-salmon fish are as follows:

- Habitat loss or alteration
- Disturbance or displacement
- Injury or mortality due to noise, entrainment, or contaminants

Infrastructure could result in habitat loss, increased turbidity and sedimentation, obstructions to fish passage, and changes in water quantity, affecting availability to Kaktovik subsistence users in nearshore waters and along rivers. Noise and traffic associated with future oil and gas exploration and development could potentially disturb or displace fish, causing temporary changes in harvesting success for Kaktovik harvesters. Vehicle traffic associated with seismic surveys could alter flows, and underwater shock waves could disturb, kill, or insure fish in the winter when Kaktovik residents fish through ice at inland locations. Residents in other North Slope communities have reported decreased fishing success as a result of seismic activities (SRB&A 2009). Most of these impacts would be temporary and would not have population-level effects on fish.

Spills would have the greatest potential for lasting effects to fish abundance and availability, as spills can cause direct mortality in addition to changes in egg survival and fish health. Small spills would be likely to occur throughout post-lease oil and gas activities. Although uncommon, the risk of large or very large crude oil spills would be greatest during the exploratory drilling phase of each project. Such spills pose substantial risks to fish and their habitats, depending on location and timing, and would likely affect subsistence resource availability for Kaktovik and possibly Nuiqsut harvesters. Even in the absence of large-scale spills, accumulation of small spills over time could add to the perception, particularly by Kaktovik harvesters, that species near development activities or infrastructure are contaminated or unsafe to eat. Avoiding subsistence foods due to contamination concerns is well documented (see **Section 3.4.3,** Subsistence Uses and Resources).

Ten rivers and creeks, listed in **Chapter 2,** would have 0.5- to 1-mile setbacks for surface development under Alternative B; all other fish-bearing streams would have a 500-foot setback. Bridges, roads, and pipelines could still be built in the setbacks. All of the nearshore marine, lagoon, and barrier island habitats of the Southern Beaufort Sea (within the boundary of the Arctic Refuge) would be subject to NSO. In addition, an impact and conflict avoidance and monitoring plan to assess, minimize and mitigate the effects of infrastructure on coastal habitats would be required. Numerous mitigation measures would be implemented to address impacts on fish and fish habitat, namely Lease Stipulations 1, 3, 4, and 9, and ROPs 3, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 22, 24, 40, and 41. While potential impacts on fish would be most pronounced under this alternative, it is likely that the proposed mitigation measures would effectively reduce impacts on fish that are important to residents of Kaktovik. Dolly Varden or Arctic cisco abundance or availability would not likely be affected to the extent that subsistence use of these fish would be significantly impaired.

Marine Mammals

Section 3.3.5, Marine Mammals, describes potential impacts on bowhead whales and ringed/bearded seals, which are important subsistence resources for residents of Kaktovik and Nuiqsut (**Tables 3-45** and **3-46**). Impacts from future oil and gas exploration, development, and production that may affect the abundance or availability of marine mammals are mortality or injury due to vessel strikes and disturbance or displacement due to vessel traffic or noise and activity associated with onshore infrastructure.

Whales and seals could be injured or killed by vessel strikes, although such events would be highly unlikely. Collisions with whales are rare for slow-moving vessels such as barges, and ringed/bearded seals are able to avoid oncoming vessels (George et al. 1994; Laist et al. 2001). There is no indication that vessel strikes would be a major source of mortality for whales or bearded/ringed seals during marine transport associated with future on-the-ground activities in the program area.

Large vessel traffic in the vicinity of Kaktovik could temporarily disturb or displace whales or bearded/ringed seals. These animals demonstrate habituation to noise and activity associated with vessel traffic and onshore infrastructure when disturbance does not result in physical injury, discomfort, or social stress (NRC 2003). This impact would not have population-level effects, and ROP 46 is designed to minimize impacts on marine mammals from vessel traffic. While these impacts may not have population-level effects, displacement or behavioral changes in marine mammals could affect resource availability for whaling crews and marine mammal hunters in Kaktovik and Nuiqsut. Kaktovik whaling crews and seal hunters hunt offshore from the program area, and Nuiqsut whaling crews hunt to the west of the program area from Cross Island, when bowhead whales migrate from east to west during their fall migration. Whaling crews have reported skittish behavior in whales and other marine mammals during seismic activity as well as during times of heavy air and vessel traffic. In recent years, conflict avoidance agreements (CAAs) have been effective in reducing such impacts to whaling (see **Section 3.4.3,** Subsistence Uses and Resources). CAAs are generally limited to the whaling season, and therefore some impacts to seal hunting may still occur outside the whaling season as a result of program-related barge and vessel traffic due to skittish behavior.

Potential impacts on marine mammals important for subsistence would be minor or effectively mitigated under Alternative B. Specifically, Lease Stipulation 4 would require NSO in nearshore marine, lagoon and barrier island habitats and would require that lessees implement a conflict avoidance and monitoring plan for coastal areas. In addition, ROPs that would apply under Alternative B would sufficiently mitigate residual impacts to subsistence use of bowhead whales and seals by residents of Kaktovik and Nuiqsut.

Caribou

Table 3-36 lists potential impacts on terrestrial mammals, including caribou. Impacts from future oil and gas exploration, development, and production that may affect the abundance or availability of caribou to subsistence users include:

- Displacement of maternal caribou during calving
- Habitat loss or alteration
- Mortality or injury due to vehicle collisions
- Altered movement patterns due to linear infrastructure
- Altered caribou behavior due to aircraft traffic and development activities

Displacement of maternal caribou during calving was one of the primary issues raised during scoping and in comments on the draft SEIS. Oil and gas development on the Coastal Plain of the Arctic Refuge and its potential impact on the Porcupine Caribou Herd calving grounds has been the subject of much discussion for decades. As a result, Porcupine Caribou Herd habitat, movement, and population dynamics have been well studied. Studies on the Central Arctic Herd and others have shown that maternal caribou tend to avoid infrastructure by as far as 1.25 to 3.11 miles (Dau and Cameron 1986; Cameron et al. 1992; Lawhead et al. 2004). A level of displacement of approximately 2.49-3.11 miles would be expected in the program area (**Section 3.3.4,** Terrestrial Mammals), with additional displacement if subsistence hunting occurs from industry roads. . The literature generally suggests that calving would most likely shift to the east or southeast if displacement of maternal caribou occurs during the calving season (Griffith et al. 2002). This could result in reduced calf survival, as areas east of the program area are characterized by suboptimal forage and, as a result, higher calf mortality and lower pregnancy rates (Russell et al. 1996). These areas also have higher predation rates, which contributes to higher calf mortality (Young et al. 2002).

The likelihood or extent to which impacts to Porcupine Caribou Herd abundance could occur depends largely on the extent of surface development associated with future on-the-ground activities happening within important calving grounds. Although calving can occur throughout the program area, the SEIS defines the most important calving grounds as the high-use Porcupine Caribou Herd calving area (area used in greater than 40 percent of years). This area spans 2,745,109 acres across northeastern Alaska and Canada (Yukon Environmental GIS 2018, Map C-1). Of the 1,563,500 acres in the program area, 728,200 acres (46.5 percent) are in the high use calving area (area used in greater than 40 percent of years). During the 2012-2018 time period, 76,700 acres in the program area overlapped with the Porcupine Caribou Herd calving area, and 589,100 acres overlapped with the post-calving area. Calving grounds vary annually based on spring weather conditions and available vegetation, and it is important that the Porcupine Caribou Herd have a large area from which to select calving grounds each year (**Section 3.3.4**, Terrestrial Mammals). More surface development within the high-use Porcupine Caribou Herd calving area could result in greater displacement of maternal caribou during calving, and thus could contribute to lower pregnancy rates and lower calf survival rates (Griffith et al. 2002; Russell and Gunn 2019). Alternatively, less or no surface development in this area, and the calving grounds in general, would result in less, negligible, or no displacement.

Direct habitat loss associated with future on-the-ground activities could occur on 2,000 acres in the program area. Additional habitat in the vicinity of infrastructure would be affected by dust deposition, gravel spray, thermokarst, flow alteration, and impoundments. Direct habitat loss would reduce forage availability for caribou. Aside from concentrations of the high-quality tussock tundra and moist sedge-willow tundra vegetation types, which are a critical feature of the Porcupine Caribou Herd primary calving grounds, foraging habitat is abundant across the program area. Using the hypothetical scenario provided in **Appendix B** and assuming displacement of calving caribou within 3.11 miles, the BLM estimated the total acres of potential disturbance and displacement under Alternative B at 803,000 acres (**Section 3.3.4**, Terrestrial Mammals). This number would vary depending on different road and pad scenarios.

Development in the Porcupine Caribou Herd calving grounds may have behavioral effects on maternal caribou which could affect population size (described below); nevertheless, it is not likely that development on 2,000 acres in the calving grounds, insect relief habitat, or general summer habitat would reduce forage enough through direct habitat loss to affect caribou health or body fat reserves on a large scale. Caribou would be displaced from areas that no longer have suitable forage, but displacement due to direct habitat loss is not expected to be widespread (Truett and Johnson 2000). Caribou abundance or availability and the subsistence use thereof would not likely be affected as a result of direct habitat loss.

Small numbers of Porcupine Caribou Herd could be killed or injured due to vehicle collisions associated with future oil and gas exploration, development, and production in the program area during construction, drilling, and operations. Collision risk would be highest during periods of oestrid fly harassment, when caribou move erratically and often seek relief on gravel pads, roads, and airstrips. Alternative B proposes a number of mitigation measures to reduce vehicle collisions with caribou. ROP 23 would require that lessees design and implement a traffic management and vehicle use plan, and ROP 42 would prohibit chasing wildlife (specifically caribou) with vehicles. These measures would minimize vehicle-related mortality risk to caribou on the North Slope (Truett and Johnson 2000). Residual mortality would likely be very low and would not significantly affect the abundance of caribou for subsistence use.

Movement patterns could be altered due to future development activities and linear infrastructure under Alternative B. Caribou movements can be delayed or deflected by roads or pipelines. Roads with vehicle traffic elicit the greatest responses from caribou (**Section 3.3.4**, Terrestrial Mammals). Traffic volumes greater than 15 vehicles per hour have been shown to increase the probability of delays or deflections during road crossings (Curatolo and Murphy 1986; Cronin et al. 1994). Caribou crossing success would vary by season, behavioral motivation, level of habituation, and activity levels. Movements in response to insect harassment between late June and mid-August would be most likely to be affected. In addition to roads and vehicle traffic, caribou also elicit strong reactions to humans on foot (Curatolo and Murphy 1986; Lawhead et al. 1993; Cronin et al. 1994). Overall, caribou show greater displacement in areas with consistently high levels of activity.

Caribou are highly motivated to seek relief in coastal areas during insect harassment (Cronin et al. 1994; Murphy and Lawhead 2000). Thus, they are less likely to be affected by roads and vehicle traffic from mid- to late summer if appropriate mitigation measures, such as vehicle management plans, elevated pipelines and road-pipeline separations are used. Some deflection or movement delays will likely occur, but these impacts are not expected to be of extended duration. Most impacts related to noise and traffic would be local, occurring in areas where Kaktovik subsistence use areas overlap with action areas. Even small changes in resource migration or distribution, from a biological perspective, can have larger impacts on subsistence users if resources are not in traditional use areas at expected times of the year. The mitigation measures proposed under Alternative B (Lease Stipulations 3, 4, 7 and 9, and ROPs 23 and 42) should be adequate to maintain caribou passage to coastal areas but may not prevent delays or deflections of caribou altogether. These stipulations would affect both Porcupine Caribou Herd and Central Arctic Herd caribou during midsummer.

Porcupine Caribou Herd caribou would likely still be available to subsistence hunters along the coast during traditional timeframes, but some uncertainty regarding impacts to availability exists due to three factors that differ from the experience with the Central Arctic Herd: 1) Porcupine Caribou Herd post-calving aggregations can be greater than 100,0000 animals (Russell and Gunn 2019) and the Central Arctic Herd does not provide any data on how well groups of this size navigate oilfields; 2) hunting along roads in the program area could increase the probability of delays or deflections; and 3) the Porcupine Caribou Herd uses both coastal areas and inland ridges for mosquito-relief habitat (Walsh et al. 1992) thus caribou could use inland areas more frequently in response to coastal development. The Porcupine Caribou Herd may increase their use of mountain ridges for insect relief as a result of development, which would decrease their availability to Kaktovik hunters (see **Section 3.3.4**, Terrestrial Mammals). In recent years, caribou hunters have observed that caribou are remaining inland and not venturing to the coast; the lack of caribou along the coast, in combination with restrictions on off-road vehicle access for Kaktovik residents into the

Arctic Refuge, has resulted in caribou not being available to residents. Additional obstructions to caribou movement toward the coast would likely exacerbate these recent issues. Thus, it is likely that some deflections or delays in caribou movement would occur as a result of development, potentially reducing harvest success for Kaktovik hunters, particularly along the coast.

A CPF or one or more satellite pads could be located south of Kaktovik in the area bounded by the Hulahula and Jago Rivers. This is an important subsistence use area for residents of Kaktovik (**Map 3-46**, Kaktovik Subsistence Use Areas in **Appendix A**). The majority of Kaktovik's subsistence use area that is bounded by the Hulahula and Jago Rivers would be subject to NSOs or TLs. Still, a substantial portion of use areas with high overlapping use occur in areas that are subject only to standard terms and conditions, and infrastructure could occur in a larger area which is not subject to NSO. It is likely that the community of Kaktovik would experience impacts to resource availability, resulting in reduced harvest success for individual hunters. However, it is less likely that these activities would affect resource availability such that they reduce overall harvest amounts for the community.

In addition to impacts from infrastructure, roads, and road traffic, caribou behavior could also be altered from aircraft traffic (see **Section 3.3.4**, Terrestrial Mammals). Responses vary depending on the season, degree of habituation, aircraft type, altitude, flight patterns, weather conditions, frequency of overflights, and the sex and age composition of caribou groups. Low-level flights or maneuvering in the presence of unhabituated caribou can elicit increased speed and abrupt direction change. Alternatively, caribou can become habituated to aircraft, particularly when aircraft pilots maintain altitudes greater than 500 feet above ground level and do not haze or harass the caribou (Valkenburg and Davis 1985). The SEIS describes potential impacts of aircraft associated with future on-the-ground activities on caribou and caribou behavior in detail.

Although short-lived, caribou responses to aircraft can affect subsistence hunters. Residents of Nuiqsut consistently highlight aircraft disturbance of caribou as a concern and state that aircraft activity makes animals more wary and harvest more difficult (Stinchcomb 2017). Such impacts could occur for Kaktovik harvesters as they travel along the coast by boat or four-wheeler or inland by snowmachine looking for caribou. The extent of this potential impact is highly contingent on the location of frequently used flight paths, which would depend on the locations of airstrips, CPFs, and other major facilities. Air traffic in the vicinity of Kaktovik associated with future oil and gas activities would increase under Alternative B, and could increase further if one or more CPF development clusters were roadless, as is described in **Appendix B**. If a CPF development cluster is either along the coast or in the area bounded by the Hulahula and Jago Rivers (**Map 3-47**, Kaktovik Caribou Subsistence Use Areas, in **Appendix A**), which would be permissible under Alternative B, caribou could be more difficult to harvest. Arctic Village and Venetie would likely not be affected by these short-term impacts; however, this could affect the availability of caribou for residents of Kaktovik.

Impacts on caribou availability resulting from infrastructure, human activity, and vehicle and air traffic would be most likely during the peak of the caribou hunting season for Kaktovik, in July and August (SRB&A 2010). While Porcupine Caribou Herd use of the program area during July and August varies annually, the Central Arctic Herd regularly uses the program area during the July and August insect relief season; therefore, impacts on resource availability for Kaktovik hunters may be more likely for the Central Arctic Herd in some years but could occur for both herds (**Section 3.4.3**, Subsistence Uses and Resources).

ROPs 34, 36 and 40 would require lessees to follow numerous mitigation measures to ensure that the effects of aircraft on caribou and caribou hunting would be minimized. These strict operating procedures are used on BLM-administered lands in the National Petroleum Reserve-Alaska (NPR-A) and are generally successful in reducing impacts. ROP 36 would require that lessees, operators, and contractors work closely with residents of Kaktovik during all phases of project application, design, and implementation. If done effectively, this consultation would assist permittees in the design and orientation of facilities, including airstrips, such that frequent, low-level traffic in caribou subsistence use areas would be considered minor to moderate (**Table E-2**). While mitigation measures can help reduce impacts on subsistence users, they cannot eliminate them (**Section 3.4.3**, Subsistence). Mitigation measures may be less effective if not adequately enforced, communicated to local residents, or developed in consultation with local subsistence users. However, if mitigation measures are implemented effectively and in coordination with local subsistence users, it is likely that residual impacts associated with future on-the-ground activities would not significantly affect caribou availability for residents of Kaktovik.

A total of 22 percent of the high-use calving area (592,800 of the 2,745,109 acres) could be leased and subject to surface occupancy under Alternative B (**Table J-22** in **Appendix J**; **Table E-1**). Development on all of the acres subject to surface occupancy within the high-use calving area is not possible given the 2,000-acre surface disturbance limit mandated by PL 115-97. Using a 2,000-acre maximum footprint, the total potential disturbance and displacement is 803,000 acres; however, this number would vary with different road and pad scenarios, and some portion of this area could be overlapping the buffer from other development, outside of the program area, or in the ocean. All of the areas available for lease within the high use calving area would be subject to TLs. Lower activity levels resulting from TLs result in lower levels of disturbance to caribou, but they do not effectively mitigate the displacement of maternal caribou during calving. Thus, maternal caribou could still be displaced within areas subject to TLs.

Under Alternative B, two CPFs and associated well pads and roads could potentially be located within the medium and low hydrocarbon potential areas, with one CPF potentially sited on private lands and one within or partially within the high-use Porcupine Caribou Herd calving area. Surface disturbance associated with one CPF in the high use Porcupine Caribou Herd calving area could total up to 488 acres based on Figures B1 and B2 in **Appendix B**. These facilities do not include coastal facilities and access roads to coastal facilities that would be located outside of the high-use Porcupine Caribou Herd calving area. Depending on the configuration of the oil field, displacement of maternal caribou around 488 acres of surface disturbance could total up to 118,500 acres (4 percent) of the high use calving area based on 3.11 miles of observed displacement around infrastructure on the North Slope during calving. However, the precise location of infrastructure, and thus the extent of overlap between surface disturbance and the high-use Porcupine Caribou Herd calving area, is unknown. It is possible there would be very little surface disturbance within the high-use Porcupine Caribou Herd calving area, given that the hypothetical development scenario suggests that future development would move from west to east, would be concentrated along the coast, and that lessees would attempt to minimize lengthy travel from coastal and existing infrastructure, and between CPFs. Some additional displacement would occur for individual caribou calving west of the high-use Porcupine Caribou Herd calving area and in some years when high density calving occurs in areas to the west that have been used less than 40 percent of years. The calving distribution may move farther west in years with warmer springs as discussed in **Section 3.3.4**, Terrestrial Mammals.

Griffith et al. (2002) modeled changes in calf survival under development scenarios outlined by Tussing and Haley (1999). Similarly, Russell and Gunn (2019) estimated calf survival between calving areas within and outside the program area. The 2,000-acre surface disturbance limit was not used in these models. Griffith et al. (2002) predicted an 8.2 percent decline in annual calf survival if the full development scenario described by Tussing and Haley (1999) occurred. Griffith updated the 2002 analysis in 2018, and recalculated an average 6.2 percent decline in calf survival under the full development scenario described by Tussing and Haley (1999) using data from 1985-2017, but Russell and Gunn (2019) used different methods and estimated a 10 percent decline in calf survival if calving is displaced from the program area. The full development described by Tussing and Haley (1999) and used in Griffith et al. (2002) and the development scenario described by Russell and Gunn (2019), would not occur under Alternative B.

Russell and Gunn (2019) used models of caribou movement, energy and protein intake, and demography to model the impact of potential development on population size based on changes in caribou activity budgets in the project area. The models predicted population change under each alternative for two starting populations (218,000 and 100,000 caribou), and under three climate conditions ("poor," "average," and "good"). As summarized in **Section 3.3.4**, Terrestrial Mammals, these models assumed that changes in behavior (e.g. time spent foraging; time spent moving) as a result of disturbance would result in changes in body condition and consequently, would affect calf survival and cows' probability of pregnancy. Russell and Gunn (2019) modelled the worst-case scenario with respect to 1002 development, making the assumption that any area within the program area could be developed. Further, in this worst-case scenario they did not account for mitigation measures (e.g., lease stipulations and required operating procedures), that could limit development under the action alternatives, including Alternative B (see Russell and Gunn 2019, page 52). See **Section 3.3.4**, Terrestrial Mammals, for further discussion.

While these modelling results suggest that Porcupine Caribou Herd population size will be impacted under multiple population and climate scenarios to the extent that subsistence hunting will be impacted, the lack of support for specific model assumptions in the literature limit the utility of these models when determining whether impacts to subsistence will be significant. Specific changes in feeding behavior and duration assumed for areas under NSO, CSU, and TLs are not supported by the literature. As a result, anticipated changes to body condition and consequent cow pregnancy rates and calf survival are difficult to compare among alternatives. They did not specify a zone of influence for these impacts, stating that they, "modeled the worst-case scenario with respect to [program area] development, making the assumption that any area in the [program area] would be potentially developed in the future." They add that, "any day a caribou spends in [the program area] would potentially cause it to be disturbed." Given the 2,000 acres of estimated surface disturbance, approximately 57 percent of the total project area could approximately 3.11 miles from roads, pads, or gravel mines, and based on the hypothetical development scenario, much of the development would be outside of the high-use Porcupine Caribou Herd calving area; thus, the model assumes changes to caribou behavior extend beyond this distance from infrastructure, the distance of reported displacement around infrastructure on the North Slope during calving (Dau and Cameron 1986; Cameron et al. 1992; Lawhead et al. 2004) and much of the program area would be outside of the 1.9 mile distance reported for changes in time spent feeding and resting near a large open pit mine (BHP 2004; Golder 2011). In addition, maternal caribou may respond to infrastructure by moving away as described above, rather than changing their activity budget. According to **Section 3.3.4**, Terrestrial Mammals, future oil and gas infrastructure in the program area could cause a shift in calving distribution in certain years, which would likely reduce calf survival and halt herd growth in those years.

According to the Gwich'in's knowledge, any development in the program area would have devastating effects on the population of the Porcupine Caribou Herd and other resources, such as migratory birds, that have key habitat in the Arctic Coastal Plain. In addition, there are those among the Iñupiat who report similar knowledge regarding the effects of Arctic Coastal Plain development (see **Section 3.4.3**, Subsistence Use and Resources). These concerns are based on Alaska Native observations of the sensitivity of resources to development and change, in addition to traditional knowledge that has been passed on through generations.

While the Porcupine Caribou Herd population size would continue to fluctuate, based on the hypothetical development scenario, potential impacts to herd size as a result of displacement of maternal caribou are still anticipated to be negligible. Potential impacts to herd size as a result of behavior, feeding, and body condition changes are not anticipated to impact population size. Thus, caribou abundance for Kaktovik, Arctic Village, and Venetie would not be significantly impacted.

Subsistence Access

Kaktovik and Nuiqsut are the only communities whose subsistence use areas overlap the program area. Thus, they are the only communities that could be legally or physically prohibited from accessing these areas. Nuiqsut subsistence uses occur primarily to the west of and offshore from the program area, with some direct overlap associated with nearshore marine mammal hunting and isolated overland furbearer harvesting areas. Thus, direct impacts to subsistence access resulting from infrastructure or legal or regulatory barriers are relatively unlikely for this community.

Potential impacts on subsistence access from future oil and gas exploration, development, and production are as follows:

- Loss of subsistence use areas due to direct overlap with infrastructure
- Physical obstruction of subsistence users or activities by infrastructure
- Legal or regulatory barriers

For Kaktovik, areas of high overlapping subsistence use occur in areas of high, medium, and low hydrocarbon potential. If future development extends into areas of medium and low potential for oil and gas development, as may occur under Alternative B (see **Appendix B)**, associated oil and gas infrastructure could occur in areas of high overlapping use for the community of Kaktovik and create direct loss of subsistence use areas in addition to physical obstructions between the community and highly used inland areas for caribou, fish, and other inland subsistence resources. Infrastructure would pose physical obstructions to subsistence users if it is not designed to account for overland travel; ROPs 18, 20, 21, and 23 would minimize but likely not eliminate potential direct obstructions to subsistence users.

Infrastructure parallel to the coast could affect Kaktovik hunters, who frequently travel to the west and east of the community by boat to search for caribou as they congregate along the coastline, in addition to hunting for other resources such as seals in nearshore areas. Residents may experience physical obstructions if they are traveling inland from the coast by four-wheeler, or their ability to shoot their targeted resources could be hampered by the presence of pipelines or other infrastructure and hunter concerns about shooting toward areas of development.

The use of future program roads for subsistence activities would bring impacts and benefits to subsistence users in Kaktovik. It is likely that some residents would use roads to access subsistence harvest areas, particularly when overland snowmachine travel is not possible, or if they do not have access to overland forms of transportation (for example, snowmachines and off-highway vehicles). Roads can provide easy access to harvesting areas and can provide access to resources when they are unavailable closer to the community. Roads can also facilitate increased competition among hunters. Use of roads would be less frequent if the roads are not connected to the community of Kaktovik.

Exploration and development of the program area would result in some legal and regulatory barriers, including restrictions on access and firearm discharge near oil and gas facilities. Depending on the parameters of these restrictions, subsistence users may have difficulty hunting in certain areas such as along roads in areas with higher density of infrastructure, and in areas where pipelines or roads parallel the coast. Miscommunication regarding policies about hunting near oil and gas facilities may dissuade certain residents from hunting near development, constituting an impact on subsistence access. Under Alternative B, numerous lease stipulations and ROPs would ensure that impacts to Kaktovik subsistence access would be minimized. These include Lease Stipulations 1, 3, 4, 7, 9, and 11 and ROPs 23, 34, 36, 37, 39, 40, 41, and 42. Legal and physical access to subsistence resources may be altered, depending on the locations of CPFs and industry-established safety areas; however, it is likely that large-scale access to subsistence resources would be maintained.

E.2.2.2 Evaluation of the Availability of Other Lands for the Purpose Sought to be Achieved

Section 1003 of ANILCA, 16 USC 3143, deferred the decision to conduct leasing in the program area until authorized by Congress. PL 115-97 provides that decision, and requires the Secretary of the Interior, acting through the BLM, to conduct leasing in the program area. The purpose of the SEIS is to inform the BLM's implementation of PL 115-97; Alternative B would fulfill this purpose. Lands outside the program area are not subject to PL 115-97 and would therefore not fulfill this purpose.

E.2.2.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence

Alternatives that would reduce or eliminate the use of public lands needed for subsistence are those that make more land in the program area unavailable for oil and gas leasing or those that would not allow oil and gas activity. Alternatives C and D would make more land in the program area unavailable for oil and gas leasing than Alternative B. Alternative A would not allow oil and gas leasing to occur.

E.2.2.4 Findings

Alternative B will not result in a significant restriction to subsistence uses. Potential impacts on subsistence resources and access from future oil and gas exploration, development, and production would be minimal or would be adequately mitigated by stipulations or ROPs under which lessees must operate. Porcupine Caribou Herd abundance may be affected due to minor displacement of maternal caribou, but large-scale displacement and consequent large decreases in the abundance of Porcupine Caribou Herd available for subsistence use is unlikely. A positive determination pursuant to ANILCA Section 810 is not required.

E.2.3 Evaluation and Finding for Alternative C

Section B.8.3, Alternative C in **Appendix B** anticipates that two CPFs would be built: one CPF would be built in the high potential area and one in the medium potential area south of Kaktovik. This scenario estimates that two CPFs and associated airstrips, 16 satellite pads, and 135 miles of road, a seawater treatment plant, and one barge landing and storage pad would be built. An estimated 1,464 acres of surface disturbance would occur in the high and medium potential areas. Most areas with NSO stipulations would be accessible by horizontal drilling from areas where surface occupancy is permitted or from adjacent state or Native lands.

Approximately 526,300 acres would be closed to leasing to protect caribou calving habitat under Alternative C (**Table 2-1** in **Chapter 2**). Of the remaining 1,037,200 acres available for leasing, 708,200 would be subject to NSO, 123,900 would be subject to CSU, 0 would be subject to TLs, and 205,100 would be subject to ROPs only. **Map 2-3**, Alternative C and **Map 2-4**, Alternative C, Lease Stipulations, in **Appendix A** illustrate where NSO, CSU, and areas subject to only standard terms and conditions would be adopted.

E.2.4.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Abundance and Availability

Fish

The types of potential impacts on subsistence fish species would be similar to those described under Alternative B, although future facility locations may differ due to the lands available for lease and surface occupancy. Under Alternative C, more extensive mitigation measures would be used, a 0.5- to 4-mile setback for surface development would apply on all streams and waterbodies, and NSO would apply along the coast. While minor impacts on fish could still occur from future oil and gas exploration, development, and production, they are not anticipated to affect fish availability or abundance for residents of Kaktovik or Nuiqsut.

Marine Mammals

Disturbance and displacement of marine mammals, such as bowhead whales and bearded and ringed seals, associated with future on-the-ground activities would be similar to that described under Alternative B, although future facility locations may differ due to the lands available for lease and surface occupancy. These potential minor impacts are not anticipated to affect bowhead whale or bearded/ringed seal availability or abundance.

Caribou

Direct habitat loss or alteration from future oil and gas exploration, development, and production would be smaller than that described under Alternative B, as an estimated 1,464 acres of surface disturbance would occur in the program area. Direct habitat loss or alteration from future on-the-ground activities would not affect the availability or abundance of caribou for subsistence use.

Mortality or injuries due to vehicle strikes associated with future oil and gas development in the Coastal Plain would be similar to that described under Alternative B. ROP 23 would apply under Alternative C as well and would sufficiently address collision risk. Low-incidence mortality would not significantly affect the abundance of caribou for subsistence use.

Altered movement patterns due to roads and pipelines associated with future oil and gas development in the Coastal Plain would be similar to what is expected to occur under Alternative B, but the extent of this impact would be lessened. This is because the areas important for caribou movement would be largely subject to NSO, TLs, or would not be offered for lease sale. This would apply to spring migration and movements to and from the coast in response to insect harassment, and potentially to fall migration. Although some delays and deflections while crossing roads and pipelines are expected, Porcupine Caribou Herd and Central Arctic Herd caribou movements would be relatively undisturbed and would not significantly affect the availability of caribou for subsistence use by residents of Kaktovik.

A total of 14,300 acres (0.5 percent) of the high-use calving area could be leased and subject to surface occupancy under Alternative C (**Table J-22** in **Appendix J**; **Table E-1**). 5,400 acres (0.2 percent) would be subject to CSU and 8,900 acres (0.3 percent) would be subject to standard lease terms and conditions only. Caribou could be displaced within these areas. Alternative C would not allow CPFs in the Porcupine Caribou Herd post-calving area and would limit total infrastructure density in this area (Lease Stipulation 8).

One CPF and associated well pads and roads could potentially be located within the medium hydrocarbon potential area under Alternative C. This CPF would likely be sited on private lands. Displacement of maternal caribou could occur on up to 26,648 acres (less than 1 percent) of the high use calving area if one to two well pads were constructed in this area. Based on these assumptions, potential impacts to herd size as a result of displacement of maternal caribou from future on-the-ground activities would be small or negligible. Alternative C would be less likely to affect calf survival and overall herd numbers compared to Alternative B. Caribou abundance for Kaktovik, Arctic Village, and Venetie would not be significantly impacted.

Subsistence Access

The types of impacts to subsistence access would be similar to those described under Alternative B; however, the intensity of these impacts would be substantially less under Alternative C due to the decrease in expected development infrastructure and limits on the density of development. Under Alternative C, there would be a larger area of high overlapping subsistence use for Kaktovik which would subject to NSO stipulations. The area south of Kaktovik between the Okpilak and Jago rivers, an area of high overlapping use for caribou and furbearers, would continue to be available for lease sale and subject to standard terms and conditions. In addition, an area of moderate overlapping use near the Sadlerochit River would also be subject to standard terms and conditions under Alternative C. Therefore, impacts to subsistence access would likely occur under Alternative C but at a lower intensity than under Alternative B.

E.2.4.2 Evaluation of the Availability of Other Lands for the Purpose Sought to be Achieved

Evaluation of the availability of other lands would be similar to Alternative B (see **Section E.2.2.2,** above).

E.2.4.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence

Alternative D would make more land in the program area unavailable for oil and gas leasing than Alternative C. Alternative A would not allow oil and gas leasing to occur.

E.2.4.4 Findings

Alternative C will not result in a significant restriction in subsistence uses. Potential impacts on subsistence resources and access from future oil and gas exploration, development, and production would be minimal or would be adequately mitigated by stipulations or ROPs under which lessees must operate. A positive determination pursuant to ANILCA Section 810 is not required.

E.2.4 Evaluation and Finding for Alternative D

Section B.8.5, Alternative D in **Appendix B** anticipates that one CPF would be built under Alternative D in either a high potential area near the Tamayarick or Katakturuk rivers, or in the medium potential area south of Kaktovik. This scenario estimates that one CPF and associated airstrips, six satellite pads, and 100 miles of road, a seawater treatment plant, and one barge landing and storage pad would be built. An estimated 1,040 acres of surface disturbance would occur in the high and medium potential areas.

Approximately 797,700 acres would be closed to leasing under Alternative D (**Table 2-1** in **Chapter 2**). Of the remaining 765,800 acres available for leasing, 726,300 would be subject to NSO, 15,900 would be subject to CSU, 1,800 would be subject to TLs, and 21,800 would be subject to standard terms and conditions only. **Map 2-5**, Alternative D, and **Map 2-6**, Alternative D, Lease Stipulations, in **Appendix A** illustrate where NSO, CSU, TLs, and areas subject to only to standard terms and conditions would be adopted.

E.2.5.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Abundance and Availability

<u>Fish</u>

The types of potential impacts on fish would be similar to those described under Alternative C, although future facility locations may differ due to the lands available for lease and surface occupancy. Lease stipulations under Alternative D would provide more protection for fish habitat compared to Alternatives B and C. While minor impacts on fish could still occur from future oil and gas exploration, development, and production, they are not anticipated to affect fish availability or abundance for residents of Kaktovik.

<u>Marine Mammals</u>

The types of potential impacts on marine mammals such as whales and seals would be similar to those described under Alternative B, although future facility locations may differ due to the lands available for lease and surface occupancy. Under Alternative D, oil and gas exploration operations, including seismic activity, would not be permitted during the open water season (May 15 through November 1), thus reducing impacts on resource availability for marine mammal hunters. While minor impacts on marine mammals could still occur from future oil and gas exploration, development, and production, they are not anticipated to affect marine mammal availability or abundance.

<u>Caribou</u>

Direct habitat loss or alteration from future oil and gas exploration, development, and production would be lowest under Alternative D, as an estimated 1,040 acres of surface disturbance would occur in the program area. Alternative D would also require Master Development Plans for each field development, which would have the effect of reducing development footprints and encouraging joint use of infrastructure between alternatives. Alternative D would have the fewest acres available for leasing and the largest number of acres subject to NSOs. As a result, Alternative D would have the lowest impacts on caribou of any action alternative. Direct habitat loss or alteration from future activities in the Coastal Plain would not affect the availability or abundance of caribou for subsistence use.

Mortality or injuries due to vehicle strikes associated with future oil and gas development in the Coastal Plain would be similar to those described under Alternatives B and C. ROP 23 would apply under Alternative D and would require additional measures regarding monitoring and consultation. Lease Stipulation 6 would be adopted as part of a suite of mitigation measures. These measures would sufficiently address collision risk and impacts to caribou during calving, post-calving, and insect-relief periods. Low-incidence mortality from future activities would not significantly affect the abundance of caribou for subsistence use.

Alteration of movement patterns associated with future oil and gas development in the Coastal Plain would be similar to that expected under C. It is likely that roads will cross areas with NSO restrictions in order to access leased areas, and these roads would likely cause some deflection and displacement of caribou. Under Alternative D, lease sales or surface occupancy would be prohibited in areas more frequently used by the Central Arctic Herd during the summer season, thus lessening the potential for impacts to Nuiqsut hunters along the Colville River Delta. Impacts to caribou movement under Alternative D would not significantly affect the availability of caribou for subsistence use by Kaktovik residents.

Under Alternative D, no leasing would be allowed within the Porcupine Caribou Herd comprehensive calving habitat area, which includes all current Porcupine Caribou Herd calving habitat (Lease Stipulation 6). In addition, no CPFs would be allowed in the Porcupine Caribou Herd comprehensive post-calving habitat area and other infrastructure would be limited to 510 acres total. Only 100 acres of current and predicted future Porcupine Caribou Herd calving areas would be available for leasing under standard terms and conditions. Displacement of maternal caribou associated with future oil and gas development in the Coastal Plain would be similar to that expected under Alternative C, although the extent of potential displacement would be less given that less area would be offered for lease sale. Potential impacts to caribou abundance as a result of maternal caribou displacement would be small or negligible. Caribou abundance for Kaktovik, Arctic Village, and Venetie would not be significantly impacted.

Subsistence Access

The types of impacts to subsistence access would be similar to those described under Alternative B; however, the intensity of these impacts would be substantially less under Alternative D due to the decrease in expected development infrastructure and limits on the density of development. Alternative D would include the least amount of areas of high overlapping subsistence use for Kaktovik with areas that would allow surface occupancy. Several areas to the west of the community along the coast would continue to be available for lease and subject only to standard terms and conditions, including an area at Brownlow Point which is an important coastal caribou hunting and fishing area. Thus, impacts to subsistence access may still occur but would be greatly reduced under this alternative when compared with Alternatives B and C.

E.2.5.2 Evaluation of the Availability of Other Lands for the Purpose Sought to be Achieved

Evaluation of the availability of other lands would be similar to that described under Alternative B (see **Section E.2.2.2**, above).

E.2.5.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence

Of the action alternatives analyzed in the SEIS, Alternative D offers the fewest amount of public lands for leasing, representing the minimum leasing acreage allowable under PL 115-97. Alternative A, the No Action Alternative, would not allow oil and gas leasing to occur.

E.2.5.4 Findings

Alternative D will not result in a significant restriction in subsistence uses. Potential impacts on subsistence resources and access from future oil and gas exploration, development, and production would be minimal, or they would be adequately mitigated by stipulations or ROPs under which lessees must operate. A positive determination pursuant to ANILCA Section 810 is not required.

E.2.5 Evaluation and Finding for the Cumulative Case

The goal of the cumulative case analysis presented in **Chapter 3** is to evaluate the incremental impact of the actions considered in the SEIS, in conjunction with all past, present, and reasonably foreseeable future activities in or near the Coastal Plain, specifically, in the Kaktovik, Nuiqsut, Arctic Village, and Venetie subsistence use areas.

Actions included in the cumulative case analysis are listed in **Section F.3.2** in **Appendix F**. Past and present actions that have affected subsistence uses and resources are as follows:

- Oil and gas exploration, development, and production on the North Slope
- Transportation
- Subsistence activities
- Recreation and tourism
- Scientific research
- Community development
- Climate change

Reasonably foreseeable future actions include the following:

- Expansion of the CD5, Nuna, GMT1, and GMT2 developments in the Colville River Region
- Development of the Willow and Nanushuk Projects in the Colville River Region
- Development of a natural gas pipeline from the North Slope to Cook Inlet (Alaska LNG Pipeline)
- Infrastructure projects including those developed through the Arctic Strategic Transportation and Resources (ASTAR) program
- Continued and increased marine vessel traffic and air traffic
- Ongoing impacts of climate change

E.2.6.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Actions included in the cumulative case analysis are listed in **Section F.2.2** in **Appendix F**. These actions fall into six broad categories: oil and gas exploration and development, transportation, subsistence activities, recreation and tourism, scientific research, and community development. Additionally, climate change is considered a variable that could contribute to potential cumulative effects of the proposed alternatives and reasonably foreseeable future actions. This section describes the potential impacts each of these categories could have to Kaktovik, Nuiqsut, Arctic Village, and Venetie subsistence uses.

Oil and Gas Exploration, Development, and Production

Oil and gas exploration, development, and production is ongoing and planned within the onshore North Slope, State and Federal waters in the Beaufort Sea, and in the Western Canadian Arctic. These activities include exploration work, infrastructure development, construction, and maintenance, gravel mining, and production associated with existing wells. These activities are expected to continue under all alternatives.

Section 3.4.3, Subsistence Uses and Resources, identifies cumulative infrastructure development on the North Slope as a major impact to subsistence activities. This is corroborated by other analyses and 810 evaluations. In the NPR-A Integrated Activity Plan/EIS, the BLM (2012) indicated that, irrespective of the alternative selected, cumulative activity on the North Slope had the potential to significantly restrict subsistence access for a number of communities. Increased infrastructure has contributed to a feeling of being “boxed in” by development in and around Nuiqsut. Impacts to Nuiqsut’s ability to access subsistence resources, according to previous EISs, would be significant.

Similar to issues associated with development around Nuiqsut, ongoing and proposed oil and gas activities associated with Point Thomson, together with Coastal Plain oil and gas activities, would impact lands in the vicinity of Kaktovik, and would potentially restrict subsistence activities and access to subsistence resources within their subsistence use area. Past, present, and future development would not mirror the scenario observed for Alpine-associated development and Nuiqsut. Future development within the program area beyond the surface disturbance limit of 2,000 acres would require additional action by Congress, and is not included in the hypothetical development scenario (**Appendix B**). Future development associated with the Leasing SEIS would not surround Kaktovik, but residents may still feel surrounded if there is development to the west, south, and east of their traditional hunting areas[1]. This could occur under Alternatives B and C. Future development associated with oil and gas activities could occur along the coast, where multiple ports or seawater treatment plants could be constructed, and within the important subsistence use area bounded by the Hulahula and Jago rivers. It could also occur under Alternatives C and D, as future on-the-ground development could occur on corporation lands directly south of Kaktovik.

Numerous measures would be adopted to mitigate potential impacts to subsistence access. Under all alternatives, Lease Stipulation 1 would implement NSO along rivers that are important for subsistence use by residents of Kaktovik. Lease Stipulation 9 would require lessees to develop and implement an impact and conflict avoidance and monitoring plan to assess, minimize, and mitigate the effects of the infrastructure and its use on subsistence users. ROPs 18, 20, and 23 would require that roads and other infrastructure be designed to avoid or minimize impacts to subsistence access to traditional hunting and fishing areas. ROPs 36-40 would require that lessees participate in extensive consultation with subsistence communities and would prohibit hunting, trapping, and fishing by lessees, operators, and contractors when on work status. Lessees would be required to coordinate directly with Kaktovik and seek input from local advisory councils such as the North Slope and Eastern Interior Subsistence Regional Advisory Council. They would be required to develop a plan to prevent unreasonable conflicts with subsistence activities, and to develop a

[1]S. Braund, [Stephen R. Braund and Associates Senior Scientist], personal communication with E. Julianus [BLM Wildlife Biologist], EMPSi, [08 September 2018].

subsistence access plan prior to beginning exploration or development. All future development plans would be subject to the BLM review prior to approval.

Public testimony indicates that residents believe conflict avoidance and subsistence access plans help to mitigate potential impacts to subsistence. However, residents also report ongoing residual impacts, particularly when mitigation is perceived to be implemented in an ineffective way (SRB&A 2013). Access patterns have changed in response to development on the North Slope, and residents still report feeling “boxed in” by existing development (SRB&A 2018). Potential impacts to subsistence access would likely be mitigated but not eliminated under Alternatives B, C, and D. However, cumulative impacts associated with Point Thomson, Liberty, and other projects could result in extensive interference[2] of the ability of Kaktovik harvesters to reach and use active subsistence harvest sites. Therefore, cumulative impacts of oil and gas exploration, development, and construction could significantly impact Kaktovik’s ability to access subsistence resources.

The BLM (2012) found that caribou availability for residents of Nuiqsut could be significantly impacted as a result of development in the vicinity of Alpine. Impacts to Porcupine Caribou Herd availability would not affect Nuiqsut, as their caribou subsistence use area does not overlap with the Porcupine Caribou Herd range nor is there documented harvest of Porcupine Caribou Herd by Nuiqsut, although Nuiqsut harvesters have reported some harvesting from this herd in the past. Cumulative impacts to Porcupine Caribou Herd would not significantly impact residents of Nuiqsut under all alternatives.

Ongoing and future actions along the coast may contribute to some impacts to caribou availability. Availability impacts may result from changes in caribou distribution, movement, and behavior resulting from development infrastructure and activities. Impacts to caribou availability for Kaktovik resulting from aircraft and vehicle disturbance are described below in *Transportation*. Displacement of caribou around roads and other infrastructure could affect availability to Kaktovik hunters. While roads may cause deflection, Kaktovik hunters may also use the roads to access areas where caribou are located, thus providing a mitigative effect. Road use may affect overall subsistence patterns for the community, resulting in a concentration of hunting activities along the road system while also reducing opportunities to transmit traditional knowledge about traditional harvesting practices and locations.

Direct habitat loss for the Porcupine Caribou Herd is most likely to occur under Alternative B, as are impacts to calf survival and overall herd abundance. If oil and gas activities, in combination with climate change and other reasonably foreseeable actions, result in a decline in Porcupine Caribou Herd abundance, then residents of Kaktovik, Arctic Village, Venetie could experience declines in Porcupine Caribou Herd harvest success and harvest amounts. In addition, other Gwich’in communities who receive Porcupine Caribou Herd caribou through sharing networks could also experience indirect impacts through a decline in sharing. A decline in caribou for the Gwich’in, who refer to themselves as the “Caribou People” and view the Arctic Refuge as sacred ground, could have larger cultural and spiritual impacts.

Potential impacts from future oil and gas exploration, development, and production to Central Arctic Herd and Porcupine Caribou Herd abundance for residents of Kaktovik, Arctic Village, and Venetie under Alternatives B, C, and D, are expected to be minor due to the lease stipulations and ROPs. Ongoing or future development in combination with development of the program area are not expected to impact

[2]Significance threshold defined on page 7 of BLM Instruction No. AK-2011-008.

caribou abundance. Therefore, the cumulative impact, in conjunction with Alternatives B, C, and D, would not significantly restrict subsistence uses of Porcupine Caribou Herd.

Transportation

Surface, air, and marine transportation within Kaktovik and Nuiqsut's subsistence use areas would continue under all alternatives. This includes roads and vehicular traffic, shipping and barging, and aircraft traffic. Increased activity associated with future oil and gas developments would result in higher levels of vessel, ground, and air traffic. This increased activity is likely under Alternatives B, C, and D. Under each alternative, NSOs, TLs, and ROPs would be sufficient to mitigate but not eliminate potential impacts of transportation associated with future on-the-ground oil and gas activities on subsistence resources. Potential impacts to subsistence resource abundance and availability for Kaktovik would not be significant under all alternatives. Roads and transportation activities would contribute to the potentially extensive interference of the ability of Kaktovik harvesters to reach and use subsistence harvest sites. Impacts to caribou availability due to development in the vicinity of Nuiqsut were found to be potentially significant for Nuiqsut. However, potential impacts to caribou from future oil and gas activities associated with all alternatives would not contribute to cumulative effects on Nuiqsut's resource availability.

Subsistence Activities

Subsistence activities on the North Slope would continue under all alternatives. Although subsistence practices are somewhat fluid and subject to annual variation, current and past hunting, gathering, fishing, and trapping activities would be similar in the types of activities and areas used by the communities in the program area in the foreseeable future. Subsistence activities would not vary by alternative and would not contribute to adverse effects on the abundance or availability of subsistence resources, nor would they impact subsistence users' ability to access subsistence resources.

Recreation and Tourism

Recreation and tourism would continue under all alternatives. Recreation and tourism activities would occur independent of development activities proposed under each of the proposed alternatives, and thus are not expected to vary by alternative. Although these activities occur across the North Slope, recreation and tourism are most concentrated in the Arctic Refuge and Kaktovik, where polar bear viewing is a popular activity. Recreation and tourism do have the potential to adversely affect the availability of subsistence resources if these resources are disturbed by aircraft conducting flightseeing tours. Such activities are carefully managed to avoid impacts to subsistence (USFWS 2015) and would not significantly affect the availability of subsistence resources. If roads, such as the Dalton Highway, connect to a road system within the program area and facilitate access by non-local hunters, then residents could experience increased competition from non-local hunters harvesting caribou and other resources in traditional hunting areas. However, there is a low likelihood of industrial roads in the program area becoming open to public use. The abundance of subsistence resources would not be affected by recreation and tourism. Subsistence users' ability to access subsistence resources would not be affected.

Scientific Research

Scientific research is ongoing in the program area and within Kaktovik, Nuiqsut, Arctic Village, and Venetie's subsistence use areas. It is likely that scientific research would increase under Alternatives B, C, and D, particularly if mitigation measures are adopted that require companies to fund research documenting and monitoring impacts on specific resources, such has been done elsewhere (BLM 2012). Research activities typically involve vessel, air, and overland transport of researchers and equipment, and could contribute to cumulative effects. Research activities could affect the availability of subsistence resources under Alternatives B, C, and D. Caribou could be disturbed during aerial surveys, but impacts would be short-lived. Frequent disturbances during peak hunting times could cause larger impacts to harvester success on an annual basis. The availability of subsistence resources would not be significantly impacted by research activities under the cumulative case if Alternatives B, C, or D are adopted, nor would the abundance of or access to subsistence resources be significantly impacted.

Community Development

Community development projects would occur under all alternatives. The type and size of development projects could vary by alternative. Kaktovik would likely undertake community development projects if Alternatives B, C, or D are selected. Comparatively more projects may occur in or near Kaktovik if Alternatives C or Dare selected than under Alternative B. NSOs would be in place along the majority of the coast under these alternatives, creating a situation where seawater treatment plants or port and airport infrastructure may be more likely to be constructed or expanded in or near Kaktovik. Community development projects would not contribute to adverse impacts on the abundance or availability of subsistence resources, nor would they impact subsistence users' ability to access subsistence resources.

Climate Change

Climate change is an ongoing factor considered in cumulative effects analyses on the North Slope. Climate change could affect the habitat, behavior, distribution, and populations of fish and wildlife within the program area. It could also impact access to these resources. Specifically, impacts of oil and gas exploration and development on user access to subsistence harvesting areas would be compounded by climate change impacts on access, including melting permafrost and decreased snow and ice cover which affect snowmachine travel. Climate change, in combination with development of the program area and other reasonably foreseeable developments, could result in greater impacts to subsistence access and greater risks to harvester safety as residents travel farther to access subsistence resources. Impacts on resource abundance from development of the program area, particularly under Alternative B which would open up greater amounts of calving grounds to leasing and development, would also be compounded by climate change effects on resources. Changes in the timing and location of resource migrations due to warmer temperatures would be compounded by oil and gas development if infrastructure further deflects or delays caribou and other resource migrations. The trends in climate change that were described in the BLM 2018 are expected to continue.

E.2.6.2 Evaluation of the Availability of Other Lands for the Purpose Sought to be Achieved

Evaluation of the availability of other lands is identical to that described under Alternative B (see **Section C.2.2.2**, above).

E.2.6.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence

Evaluation of other alternatives is identical to that described under Alternative B (see **Section E.2.2.2**, above).

E.2.6.4 Findings

The cumulative case, when taken in conjunction with Alternatives B, C, and D will not result in a significant restriction to subsistence uses for the communities of Nuiqsut, Arctic Village, and Venetie.

The cumulative case, when taken in conjunction with Alternatives B, C, and D, may result in a significant restriction to subsistence uses for the community of Kaktovik due to potential decrease in access to fish, marine mammals, and caribou. A positive determination pursuant to ANILCA Section 810 is required.

E.3 NOTICE AND HEARINGS

ANILCA Section 810(a) provides that there shall be no "withdrawal, reservation, lease, permit, or other use, occupancy, or disposition of the public lands which would significantly restrict subsistence uses," until the federal agency gives the required notice and holds a hearing in accordance with ANILCA Section 810(a)(1) and (2). The BLM will provide notice in the *Federal Register* that it made a positive finding pursuant to ANILCA Section 810 that the cumulative case presented in the SEIS met the "may significantly restrict" threshold. As a result, a public hearing will be held in the potentially affected community of Kaktovik. Notice of this hearing will be provided in the *Federal Register* and in local media with coverage to all villages on the North Slope. The hearing date and time will be posted on BLM's website at https://eplanning.blm.gov/eplanning-ui/project/2015144/510.

E.4 SUBSISTENCE DETERMINATIONS UNDER THE ANILCA SECTION 810(A)(3)(A), (B), AND (C)

ANILCA Section 810(a) provides that there would be no "withdrawal, reservation, lease, permit, or other use, occupancy or disposition of the public lands which would significantly restrict subsistence uses," until the federal agency gives the required notice and holds a hearing, in accordance with ANILCA Section 810(a)(1) and (2), and makes the following three determinations required by ANILCA Section 810(a)(3)(A), (B), and (C): 1) that such a significant restriction of subsistence use is necessary, consistent with sound management principles for the use of the public lands; 2) that the proposed activity would involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other such disposition; and 3) that reasonable steps would be taken to minimize adverse impacts on subsistence uses and resources resulting from such actions (16 USC 3120(a)(3)(A), (B), and (C)).

The BLM has found in this preliminary evaluation that the cumulative case considered in this Leasing SEIS may significantly restrict subsistence uses. The BLM will undertake the notice and hearing procedures required by ANILCA Section 810 (a)(1) and (2), in conjunction with releasing the draft SEIS in order to solicit public comment from the potentially affected community of Kaktovik.

The determination that the requirements of the ANILCA Section 810(a)(3)(A), (B), and (C) have been met will be analyzed in the Final ANILCA Section 810 Evaluation. The Final Evaluation will integrate input voiced during the hearing by the residents of Kaktovik, and will be published as part of the Final SEIS.

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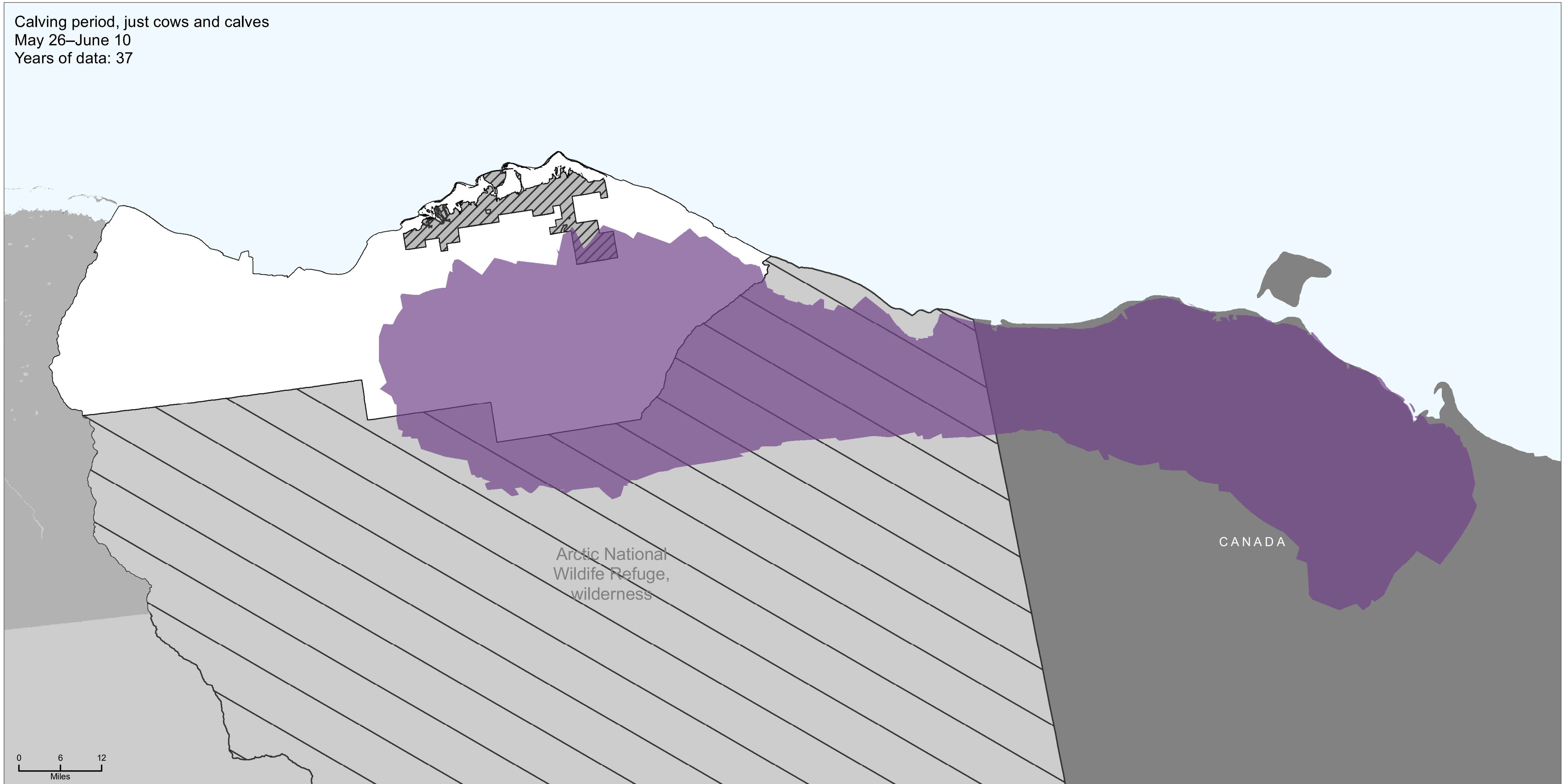
High Use Porcupine Caribou Herd Calving Area



Percent of years of caribou are present
- ≥40%

- Arctic National Wildlife Refuge, wilderness
- State
- Fish and Wildlife Service

- Coastal Plain Supplemental EIS boundary
- Excluded from Public Law 115-97 Coastal Plain or outside the BLM's oil and gas leasing authority

Data Source: BLM GIS 2022, USFWS GIS 2022
Print Date: 07/21/2023

Map E-1

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Table E-1
Lease Restrictions in High-Use Porcupine Caribou Herd Calving Area (acres)

Lease Stipulations	Alternative A	Alternative B	Alternative C	Alternative D
No surface occupancy/not offered for lease sale	728,300	135,500	713,900	714,100
Timing limitation	0	564,900	0	1,700
Controlled surface use	0	0	5,400	7,500
Subject to required operating procedures only	0	27,900	8,900	4,900

Source: BLM and USFWS GIS 2022

Table E-2
Summary of Impacts on Abundance and Availability of Major Subsistence Resources for Kaktovik, Nuiqsut, Arctic Village, and Venetie

Resource	Impact	Context	Alternative A		Alternative B		Alternative C		Alternative D		Cumulative	
			Abundance	Availability	Abundance	Availability	Abundance	Availability	Abundance	Availability	Abundance	Availability
Fish	Habitat loss or alteration	Site-specific	0	0	1	1	0	0	0	0	1	2
Fish	Disturbance or displacement	Regional	0	0	1	1	0	0	0	0	1	2
Fish	Injury or mortality	Site-specific	0	0	1	1	0	0	0	0	1	2
Marine mammals	Injury or mortality	Site-specific	0	0	1	0	1	0	1	0	2	0
Marine mammals	Disturbance or displacement	Regional	0	0	0	1	0	1	0	1	0	2
Caribou	Habitat loss or alteration	Site-specific	0	0	0	1	0	1	0	1	0	2
Caribou	Mortality or injury	Site-specific	0	0	1	0	1	0	1	0	1	0
Caribou	Altered movement	Local	0	0	0	2	0	2	0	2	2	2
Caribou	Altered behavior	Local	0	0	0	2	0	1	0	1	2	2
Caribou	Displacement of maternal caribou	Regional	0	0	2	0	1	0	1	0	2	2

Notes:
1. Table does not specify the degree to which each community is affected.
2. Gray (0) indicates no impact, yellow (1) indicates minor impact, orange (2) indicates moderate impact, and red (3) indicates major impact.

Table E-3
Summary of Impacts on Access to Major Subsistence Resources for Kaktovik, Nuiqsut, Arctic Village, and Venetie

Resource	Potential Effect	Context	Alternative A		Alternative B		Alternative C		Alternative D		Cumulative	
			Legal	Physical	Legal	Physical	Legal	Physical	Legal	Physical	Legal	Physical
Fish	Use of traditional fishing areas	Local	0	0	1	1	0	0	0	0	2	3
Marine mammals	Use of traditional marine mammal hunting areas	Local	0	0	1	1	0	0	0	0	2	3
Caribou	Use of traditional caribou hunting areas	Local	0	0	1	1	0	0	0	0	2	3

Notes:
1. Table does not specify the degree to which each community is affected.
2. Gray (0) indicates no impact, yellow (1) indicates minor impact, orange (2) indicates moderate impact, and red (3) indicates major impact.

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Appendix F

Approach to the Environmental Analysis

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Appendix F. Approach to the Environmental Analysis

F.1 INTRODUCTION

Issuance of oil and gas leases under the directives of Section 20001(c)(1) of Public Law (PL) 115-97 would have no direct impacts on the environment because by itself a lease does not authorize any on the ground oil and gas activities; however, issuance of a lease represents an irretrievable commitment of oil and gas resources for potential future exploration and development activities, subject to further environmental review and authorization, that would result in impacts on the environment. The impacts of such future exploration and development activities that may occur because of the issuance of leases are considered potential indirect impacts of leasing. Such post-lease activities could include seismic and drilling exploration, development, and transportation of oil and gas in and from the Coastal Plain. Therefore, the analysis in Chapter 3 is of potential direct, indirect, and cumulative impacts from on-the-ground post-lease activities.

The methodology for the impact assessment conforms to the guidance found in the following sections of the Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act (NEPA): 40 Code of Federal Regulations (CFR) 1502.16 (Environmental Consequences); 1502.23 (Methodology and Scientific Accuracy); 40 CFR 1508.1 (Definition of Effects or Impacts). CEQ regulations require that agencies evaluate the impact of all alternatives. Since the action alternatives presented in this supplemental environmental impact statement (SEIS) offer specific areas of the Coastal Plain as available for lease sale (subject to applicable laws, terms, conditions, and stipulations of the lease, as well as project specific environmental review and permits), rather than project-level exploration and development of oil and gas, the focus of the analysis is on the potential impacts of these future phases, which may follow leasing.

F.2 DIRECT AND INDIRECT IMPACTS

Direct and indirect impacts are considered in **Chapter 3**, consistent with direction provided in 40 CFR 1502.16.

> **Direct Effects**—Effects that are caused by the proposed action and occur at the same time and place (40 CFR 1508.8). Examples of direct effects are filling of wetlands through the placement of gravel pads, and direct mortality of wildlife or vegetation.

> **Indirect Effects—**Effects that are caused by the proposed action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects "may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8). Indirect effects are caused by the proposed action but do not occur at the same time or place as the direct effects.

Potential effects are quantified where possible using GIS and other applications; in the absence of quantitative data, best professional judgment prevailed. Impacts are sometimes described using ranges of potential impacts or in qualitative terms. The standard definitions for terms used in the analysis are as follows, unless otherwise stated:

Context—Describes the area or location (site-specific, local, program area-wide, or regional) in which the potential impact would occur. Site-specific impacts would occur at the location of the action, local impacts would occur in the general vicinity of the program area, program area-wide impacts would affect most or all of the program area, and regional impacts would extend beyond the program area boundaries.

Duration—Describes the length of time an effect would occur, either short term or long term. Short term is anticipated to begin and end within the first 5 years after the action is implemented. Long term lasts beyond 5 years.

Intensity—Impacts are discussed using quantitative data where possible.

F.2.1 Social Costs of GHG Emissions

The social cost of greenhouse gases (SC-GHG), including carbon, nitrous oxide, and methane, are estimates of the monetized damages associated with incremental increases in GHG emissions in a given year.

On January 20, 2021, President Biden issued E.O. 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.1 Section 1 of E.O. 13990 establishes an Administration policy to, among other things, listen to the science; improve public health and protect our environment; ensure access to clean air and water; reduce greenhouse gas emissions; and bolster resilience to the impacts of climate change.2 Section 2 of the E.O. calls for Federal agencies to review existing regulations and policies issued between January 20, 2017, and January 20, 2021, for consistency with the policy articulated in the E.O. and to take appropriate action.

Consistent with E.O. 13990, the Council on Environmental Quality (CEQ) rescinded its 2019 "Draft National Environmental Policy Act Guidance on Considering Greenhouse Gas Emissions" and issued interim NEPA Guidance on Consideration of Greenhouse Gas Emissions and Climate Change, seeking public comment on the interim guidance through April 10, 2023. 3 GHG guidance, effective upon publication, builds upon and updates the CEQ's 2016 Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews. While CEQ works on updated guidance, it has instructed agencies to consider and use all tools and resources available to them in assessing GHG emissions and climate change effects including the 2016 GHG Guidance and 2023 interim guidance. 4

Regarding the use of Social Cost of Carbon or other monetized costs and benefits of GHGs, the 2016 GHG Guidance noted that NEPA does not require monetizing costs and benefits.5 It also noted that "the weighing

[1] 86 FR 7037 (Jan. 25, 2021).
[2] *Id.*, sec. 1.
[3] 86 FR 1196 (January 9, 2023).
[4] *Id.*
[5] 2016 GHG Guidance, p. 32, available at: https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf

of the merits and drawbacks of the various alternatives need not be displayed using a monetary cost-benefit analysis and should not be when there are important qualitative considerations."6

Section 5 of E.O. 13990 emphasized how important it is for federal agencies to "capture the full costs of greenhouse gas emissions as accurately as possible, including by taking global damages into account" and established an Interagency Working Group on the Social Cost of Greenhouse Gases (the "IWG"). 7 "). In February of 2021, the IWG published Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates under Executive Order 13990(IWG, 2021).8 This is an interim report that updated previous guidance from 2016.

In accordance with this direction, this subsection provides estimates of the monetary value of changes in GHG emissions that could result from selecting each alternative. Such analysis should not be construed to mean a cost determination is necessary to address potential impacts of GHGs associated with specific alternatives. These numbers were monetized; however, they do not constitute a complete cost-benefit analysis, nor do the SC-GHG numbers present a direct comparison with other impacts analyzed in this document. For instance, the BLM's overall economic analysis for this lease sale does not monetize most of the major costs or benefits and does not include all revenue streams from the proposed action but seeks to quantify certain impacts related to employment numbers and labor income. SC-GHG is provided only as a useful measure of the benefits of GHG emissions reductions to inform agency decision-making.

For Federal agencies, the best currently available estimates of the SC-GHG are the interim estimates of the social cost of carbon dioxide (SC-CO2), methane (SC-CH4), and nitrous oxide (SC-N2O) developed by the Interagency Working Group (IWG) on the SC-GHG. Select estimates are published in the Technical Support Document (IWG 2021) and the complete set of annual estimates are available on the Office of Management and Budget's website.

The IWG's SC-GHG estimates are based on complex models describing how GHG emissions affect global temperatures, sea level rise, and other biophysical processes; how these changes affect society through, for example, agricultural, health, or other effects; and monetary estimates of the market and nonmarket values of these effects. One key parameter in the models is the discount rate, which is used to estimate the present value of the stream of future damages associated with emissions in a particular year. A higher discount rate assumes that future benefits or costs are more heavily discounted than benefits or costs occurring in the present (i.e., future benefits or costs are a less significant factor in present-day decisions). The current set of interim estimates of SC-GHG have been developed using three different annual discount rates: 2.5 percent, 3 percent, and 5 percent (IWG 2021).

As expected with such a complex model, there are multiple sources of uncertainty inherent in the SC-GHG estimates. Some sources of uncertainty relate to physical effects of GHG emissions, human behavior, future population growth and economic changes, and potential adaptation (IWG 2021). To better understand and communicate the quantifiable uncertainty, the IWG method generates several thousand estimates of the social cost for a specific gas, emitted in a specific year, with a specific discount rate. These estimates create

[6]2016 GHG Guidance, p. 32, available at: https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf
[7]E.O. 13990, Sec. 5.
[8]https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

a frequency distribution based on different values for key uncertain climate model parameters. The shape and characteristics of that frequency distribution demonstrate the magnitude of uncertainty relative to the average or expected outcome.

To further address uncertainty, the IWG recommends reporting four SC-GHG estimates in any analysis. Three of the SC-GHG estimates reflect the average damages from the multiple simulations at each of the three discount rates. The fourth value represents higher-than-expected economic impacts from climate change. Specifically, it represents the 95th percentile of damages estimated, applying a 3 percent annual discount rate for future economic effects. This is a low probability, but high damage scenario, represents an upper bound of damages within the 3 percent discount rate model. The estimates below follow the IWG recommendations and represent the present value of future market and nonmarket costs associated with net CO2, CH4, and N2O emissions stemming from future oil production in the Coastal Plains under each of the action alternatives. These net GHG emissions reflect increases in domestic and foreign GHG emissions that would be unrealized under the No action. Similarly, the social cost values for these emissions can be interpreted as avoided social costs under the No Action alternative. Estimates are calculated based on IWG estimates of the social cost per metric ton of emissions for a given emissions year and BLM's estimates of emissions in each year. They are rounded to the nearest $1,000.

Table F-1
Social Cost of GHGs Associated with Potential Coastal Plains Development

Alternative	Social Cost of GHG (Thousands of 2020 $s)			
	Average Value, 5% discount rate	Average Value, 3% discount rate	Average Value, 2.5% discount rate	95th Percentile Value, 3% discount rate
Alternative B	$2,331,469	$9,782,853	$15,121,244	$29,983,820
Alternative C	$2,205,175	$9,209,019	$14,218,460	$28,223,849
Alternative D	$1,001,619	$4,042,386	$6,194,260	$12,368,331

F.3 CUMULATIVE IMPACTS

The cumulative impact analysis considers impacts of a proposed action and its alternatives that may not be consequential when considered individually; however, when they are combined with impacts of other actions, they may be consequential. As defined by CEQ regulations (40 CFR 1508.1[g][3]), a cumulative impact is as follows:

> …the impact on the environment that results from the incremental effects of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

The purpose of the cumulative impacts analysis is to determine if the impacts of the actions considered in this SEIS, together with other past, present, and reasonably foreseeable future actions, could interact or accumulate over time and space, either through repetition or combined with other impacts, and under what circumstances and to what degree they might accumulate.

Additional requirements of other regulatory agencies would further reduce any cumulative impacts.

F.3.1 Method

The method used for cumulative impacts analysis in this SEIS consists of the following steps:

- Identify issues, characteristics, and trends in the affected environment that are relevant to assessing cumulative effects of the action alternatives. This includes discussions on lingering effects from past activities that demonstrate how they have contributed to the baseline condition for each resource. This information is summarized in **Chapter 3**.
- Describe the potential direct and indirect effects of future oil and gas exploration, development, and production. As noted above, issuance of oil and gas leases under the directives of Section 20001(c)(1) of PL 115-97 would have no direct impacts on the environment because by itself a lease does not authorize any on the ground oil and gas activities; however, issuance of a lease represents an irretrievable commitment of oil and gas resources for potential future exploration and development activities, subject to further environmental review and authorization, that would result in impacts on the environment. The impacts of such future exploration and development activities that may occur because of the issuance of leases are considered potential indirect impacts of leasing. Such post-lease activities could include seismic and drilling exploration, development, and transportation of oil and gas in and from the Coastal Plain. Therefore, the analysis in Chapter 3 for each resource is of potential direct, indirect, and cumulative impacts from on-the-ground post-lease activities.
- Define the spatial (geographic) and temporal (time) frame for the analysis. This timeframe may vary between resources depending on the historical data available and the relevance of past events to the current baseline.
- Identify past, present, and reasonably foreseeable future actions (RFFAs) such as other types of human activities and natural phenomena that could have additive or synergistic effects. Summarize past and present actions, within the defined temporal and spatial timeframes, and identify any RFFAs that could have additive, countervailing, or synergistic effects on identified resources.
- Use a specific method to screen all of the direct and indirect effects, when combined with the effects of external actions, to capture those synergistic and incremental effects that are potentially cumulative in nature. Both adverse and beneficial effects of external factors are assessed and then evaluated in combination with the direct and indirect effects for each alternative on the various resources to determine if there are cumulative effects.
- Evaluate the impact of the potential cumulative effects and assess the relative contribution of the action alternatives to cumulative effects.
- Discuss rationale for determining the impact rating, citing evidence from the peer-reviewed literature, and quantitative information where available. When confronted with incomplete or unavailable information, ensure compliance with 40 CFR 1502.22.

The analysis also considers the interaction among the impacts of the proposed action with the impacts of various past, present, and reasonably foreseeable future actions, as follows:

- Additive—the impacts of actions add together to make up the cumulative impact
- Countervailing—the impacts balance or mitigate the impacts of other actions
- Synergistic—the impact of the actions together is greater than the sum of their individual impacts

In this SEIS, both the temporal and geographic scope of the cumulative impact analysis could vary according to the resource under consideration. Generally, the appropriate timeframe for cumulative impacts analysis spans from the 1970s through full realization of the hypothetical development scenario (**Appendix B**), which is anticipated to occur approximately 50 years after the Record of Decision for this SEIS is signed, recognizing the timeframe for production could be more or less than 50 years given the speculative nature of the hypothetical development scenarios. The geographic scope generally encompasses the program area and the North Slope but extends beyond these areas for some resources (e.g., terrestrial wildlife), including into Canada. Details associated with the impact indicators, geographic scope, and analysis assumptions for each resource are found in **Section F.4**, below.

F.3.2 Past, Present, and Reasonably Foreseeable Future Actions

Relevant past and present actions are those that have influenced the current condition of the resource. For the purposes of this SEIS, past and present actions are both human controlled and natural events. Past actions were identified using agency documentation, NEPA analyses, reports and resource studies, peer-reviewed literature, and best professional judgment.

The term reasonably foreseeable future action (RFFA) is used in concert with the CEQ definitions of indirect and cumulative effects, but the term itself is not defined further. Most regulations that refer to “reasonably foreseeable” do not define the meaning of the words but do provide guidance on the term. For this analysis, RFFAs are those that are external to the proposed action and are likely (or reasonably certain) to occur, although they may be subject to a degree of uncertainty. Typically, they are based on such documents as plans, permit applications, and fiscal appropriations. RFFAs considered in the cumulative effects analysis consist of projects, actions, or developments that can be projected, with a reasonable degree of confidence to occur over the next 50 years.

Recent environmental reports, surveys, research plans, NEPA compliance documents, and other source documents have been evaluated to identify these actions. RFFAs were assessed to determine if they were speculative and would occur within the analytical timeframe of the SEIS. Projects and activities considered in the cumulative effects analysis are summarized in **Table F-2** and are discussed in more detail below.

Table F-2
Past, Present, and Reasonably Foreseeable Future Actions Considered in the Cumulative Effects Analysis

Category	Area	Actions/Activities	Description
Oil and gas exploration, development, and production	● Onshore North Slope ● State and federal waters (Beaufort Sea) ● Western Canadian Arctic	● Geological and geophysical surveys ● Infrastructure development ● Gravel mining ● Geotechnical borehole surveys ● Construction and maintenance ● Exploration activities associated with drilling ● Production wells ● Surface, air, and marine traffic ● Scientific research for avian studies, bathymetry, cultural resources, and fisheries (directly related to oil and gas)	Competitive oil and gas lease sales, lease exploration, and development have occurred across the North Slope; continued activity is expected. The number of flights by cargo-rated planes associated with oil and gas development tends to increase dramatically during summer. See below for an additional discussion.
Transportation (*separate from oil and gas*)	● Surface ● Air ● Marine	● Roads and vehicular traffic in communities ● International marine vessel traffic ● Shipping/barging to Kaktovik ● Aircraft traffic ● Winter trail ROW for access to inholdings (ANILCA Section 1110)	Surface, air, and marine transportation services are available in the program area. Federal, state, and tribal governments maintain plans for ongoing maintenance and development. Marine transportation is projected to increase with decreases in sea ice associated with climate change. See below for an additional discussion.
Subsistence Activities	● Kaktovik ● Nuiqsut ● Arctic Village ● Venetie ● Western Canadian Arctic	● Hunting ● Trapping ● Fishing ● Whaling ● Sealing ● Traveling ● Berry Picking	Anticipate a continuation of traditional past and present subsistence practices (See **Section 3.4.3**, Subsistence Uses and Resources) See below for an additional discussion.
Recreation and Tourism	● Arctic National Wildlife Refuge ● Various locations across the North Slope ● Beaufort Sea and nearshore areas ● North American Arctic	● Wildlife/Scenic viewing and photography including commercial polar bear viewing ● Sport/commercial hunting and fishing ● Boating and river recreation ● Camping ● Hiking ● Ecotourism	Past and present recreational uses of the Program Area are expected to continue (See **Section 3.4.6**, Recreation). See below for an additional discussion.

Category	Area	Actions/Activities	Description
Scientific Research	● Onshore North Slope ● Nearshore waters ● OCS waters ● Arctic National Wildlife Refuge	● Arctic National Wildlife Refuge studies ● Biological, geophysical, archaeological, and socioeconomic surveys ● Stock and harvest assessments	Scientific research and surveys have occurred throughout the Program Area and are expected to continue. See below for an additional discussion.
Community Development	● Kaktovik ● Arctic Village ● Venetie ● Utqiaġvik ● North Slope Borough	● Demographic/population change ● Migration ● Infrastructure development projects	Anticipate a continuation of infrastructure development projects. See below for an additional discussion.
Climate Change	Global	Trends in climate change are described in GMT2 SEIS (BLM 2018 Section 3.2.4) and are projected to continue and interact with other reasonably foreseeable future actions within the program area	Long-term changes in temperature and precipitation, with associated changes in the atmosphere, water resources, permafrost, vegetation, wetlands, fish and wildlife habitat, and subsistence practices

Oil and Gas Exploration, Development, and Production

Onshore oil development has been a primary agency of industrial change on the North Slope. Oil and gas exploration has occurred on the North Slope since the early 1900s, and culminated with the first oil production at Prudhoe Bay in 1977 BLM and surveys.

Both onshore and offshore reasonably foreseeable present and future oil and gas activities are considered in the cumulative effects analysis. The discussion does not include small discoveries and undiscovered resources that are unlikely to be developed within the temporal scope of this SEIS. The following reasonably foreseeable present and future onshore oil and gas projects are included in the cumulative effects analysis:

- **Nanushuk**—The project is southeast of the East Channel of the Colville River, approximately 52 miles west of Deadhorse and about 6.5 miles from Nuiqsut (at the southernmost project boundary). The project will include construction of the Nanushuk pad, comprised of Drill Site 1 and a Central Processing Facility, Drill Site 2, Drill Site 3, an operations center pad, infield pipelines, the export/import Nanushuk pipeline, infield roads, an access road, a tie-in pad, and a potable water system. The project also includes temporary discharges to 5.8 acres of jurisdictional waters of the United States (US) for screeding at the Oliktok Dock.
- **Alpine CD-5**—This Alpine field satellite development drill site is on Alaska Native Claims Settlement Act (ANCSA) corporation lands near Nuiqsut and is the first commercial oil production from the National Petroleum Reserve in Alaska (NPR-A). CD-5 went into production in late 2015. As a satellite to the Alpine Central Processing Facility (CPF), CD-5 has only minimal on-site processing facilities; however, it required 6 miles of gravel road, four bridges, and 32 miles of pipelines including completion of a gravel road and natural gas pipeline from Alpine CPF into Nuiqsut. ConocoPhillips Alaska, Inc. to expand CD-5 up to its full 43-well slot capacity; the project is exceeding its original production target of 16,000 barrels of oil per day (BOPD) gross, and is currently producing approximately 37,000 BOPD gross average, year to date. The company has drilled Alaska's 10 longest wells there, with one measuring over 33,000 feet in horizontal distance.

- **Greater Mooses Tooth**—The Greater Mooses Tooth-1 (GMT1) project is the first commercial development on federal lands in the NPR-A; first oil production was achieved in October 2018. The GMT1 development involves an 11.8-acre drilling pad, with a 7.6-mile-long road, two bridges, and pipelines that connect to Alpine CPF through the existing CD-5 road and pipeline extension. The drilling pad can support up to 33 wells; it currently has seven wells. Recent production from GMT1 has averaged about 20,000 BOPD. The Greater Mooses Tooth-2 (GMT2) is located 8 miles southwest of GMT1. First production occurred in December 2020. The 14-acre gravel pad can support up to 48 wells. The 8.2-mile gravel road and pipeline connects through GMT1 and then on to Alpine CPF. Production is approximately 20,000 BOPD.
- **Nuna**—This project will be developed from the 3T drill site within ConocoPhillips' Kuparuk River Unit (KPU), located just east of the Colville River and approximately 5 miles southwest of the Oooguruk Field. The Nuna project will add 29 development wells, on-pad infrastructure, and pipelines that tie back to existing KPU processing facilities. Construction activities will begin in 2023 and continue in 2024 with pipeline and on-pad construction. A gravel road and pad to the site were constructed in 2019 by Caelus for drill site 3T, which transferred its Nuna acreage to ConocoPhillips in 2019. Drilling is anticipated to begin in late 2024, with first oil anticipated by early 2025. Production is expected to peak at 20,000 BOPD.
- **Willow**—The Willow oil and gas prospect is located on Federal oil and gas leases ConocoPhillips holds within the Bear Tooth Unit of the NPR–A, approximately 30 air miles west of Nuiqsut. The proposed project would enable applicants to construct, operate, and maintain up to three drill sites with up to 50 well on each pad, a central processing facility, an operations center pad, gravel roads, ice roads and ice pads, one to two airstrips, a module transfer island, pipelines and a gravel mine site on BLM-managed lands within the NPR-A. Production from Willow is estimated at 180,000 BOPD. A SEIS has been finalized and first production is currently anticipated around 2024-2025.
- **Greater Prudhoe Bay/Kuparuk**—This main producing part of the North Slope is expected to have numerous small developments as smaller accumulations of oil are discovered and can be produced using existing infrastructure. In 2020, net crude oil production at Kuparuk averaged 52 million barrels of oil equivalent a day.
- **Point Thomson**—The Point Thomson development covers an area of approximately 150 square miles. It is located approximately 60 miles east of Prudhoe Bay on the coast of the Beaufort Sea. The Point Thomson field is estimated to hold eight trillion cubic feet of natural gas, and is designed to produce up to 10,000 bpd of gas condensate. First production from the field was achieved in April 2016. Gas condensate produced at Point Thomson is shipped via a 22-mile insulated pipeline to Pump Station 1 on the Trans-Alaska pipeline system. The project includes production pads, process facilities, an infield road system, a pipeline, infield gathering lines, and an airstrip.
- **Alaska LNG Project**—This development would include a gas treatment plant at Prudhoe Bay, a 42-inch-diameter, high-pressure, 800-mile pipeline, and eight compressor stations to move the gas to a proposed liquefaction plant at Nikiski, on the Kenai Peninsula. The pipeline would be designed to accommodate an initial mix of gas from the Prudhoe Bay and Point Thomson fields and room to accommodate other gas fields in the decades ahead.

Transportation

In addition to air, land, and marine transport associated with oil and gas activities, there is frequent marine and air traffic associated with coastal communities on the North Slope. It is reasonable to assume that trends associated with transportation to facilitate the maintenance and development of coastal communities will continue. Typically, vessels offshore of the program area are those that support oil and gas industries, barges or cargo vessels used to supply coastal villages, smaller vessels used for hunting and location transportation during the open water period, research vessels, and a limited number of recreational vessels. Passenger and air cargo flights between Fairbanks and each of the communities in the Arctic Refuge and across the North Slope often include several scheduled flights of small propeller-driven aircraft. Government agencies, researchers, and recreationists often charter aircraft for travel and research. Aircraft traffic is expected to continue; levels of traffic may increase because of increased industrial activity, tourism, and community development.

- **Arctic Strategic Transportation and Resources (ASTAR)**—The ASTAR program is a collaboration between the State of Alaska, the NSB, and other North Slope stakeholders. Its purposes are to prioritize community needs and to identify infrastructure opportunities that offer the most cumulative benefit for the region.

  ASTAR will consider a broad range of potential infrastructure projects, such as permanent and seasonal roads, utilities, new or updated community facilities, fiber optics, trail marking programs, airport facilities, and improved wastewater infrastructure (proposed road networks do not currently connect to Arctic Village or Venetie). The planning area includes the entire NSB boundary, including State lands, the NPR-A, and the Arctic Refuge.

  The effects of the ASTAR program could include increasing the cultural and community connectivity, lowering the cost of goods and services, preserving, or enhancing subsistence traditions, increasing health and safety for NPR-A residents and stakeholders, increasing access to education, improving workforce development opportunities, and reducing environmental impacts by identifying potential synergies between public and private projects.
- The USFWS has received ROW application (ANILCA 1110(b)) for a snow trail across upland habitats within the program area. The application is for a 20-year period of use and requests a 200-foot-wide ROW and the annual construction of a 25-foot-wide snow trail that would allow for transportation of goods for communities and the bi-directional movement of community vehicles. The applicant identified the following initial items for transport over the ROW during the term of the permit, including but not limited to: permanent school modules for Kaktovik and other building modules, movement of community vehicles, diesel fuel (transported in double-walled fuel tanks), and other consumables. The number of trips along the ROW would vary from year-to-year, depending on community needs. All products would be transported across the proposed ROW during winter using rolligon vehicles. A *Federal Register* notice announcing an extension to the timeframe for completing the EA was published on February 8, 2023.

Subsistence Activities

Subsistence activities occur throughout the program area and in the surrounding areas, including the western Canadian Arctic. Subsistence hunters primarily use boats and snowmachines for accessing subsistence resources. OHVs could be used for subsistence resource access by rural residents, subject to reasonable regulations, pursuant to ANILCA, Section 811(b). The types of subsistence uses and activities that were described in **Section 3.4.3**, Subsistence Uses and Resources, are expected to continue.

Recreation and Tourism

Until recently, recreation and tourism activities are generally pursued by non-resident visitors to the program area and surrounding areas. While a very small number of local residents have historically participated in recreational guiding and tourism, since 2010 residents have developed tourism around polar bear viewing, and in 2017 over 50 percent of the visitors to the program area are served by locally owned tourism businesses. Since 2020, commercial polar bear viewing within the program area has been paused by Secretarial Order 3392 and community prohibition; however, commercial polar bear viewing is expected to resume. types of recreation and tourism that were described in **Section 3.4.6**, Recreation, are expected to continue. Current and past sport hunting and fishing, or other recreation or tourism-related activities would be similar in the types of activities and areas used by the communities in the analysis area in the foreseeable future. Transport associated with recreation and tourism includes aircraft and powered and non-powered vessel traffic is expected to remain unchanged.

Scientific Research

There are scientific research programs that take place in the program area and the Arctic Refuge. These activities involve vessel, air, and overland transport of researchers and equipment, and could contribute to cumulative effects. This would come about through the disturbance of terrestrial and marine wildlife, impacts on subsistence harvest, or sediment/soil disturbance through biological or chemical sampling.

Community Development and Infrastructure Projects

Community development projects in Arctic communities involve both large and small infrastructure projects. For example, the new airport in Kaktovik is a past community development project. Smaller projects resulting from and leading to community growth could further increase demand for public services and infrastructure, such as airport construction upgrades, roads, port and dock construction, telecommunications, alternative energy infrastructure, and telecommunications projects.

The USFWS has received a ROW application for the installation, operation, and maintenance of a communication tower within the program area. The use and occupancy of Refuge lands for this or similar community development proposals will continue within the program area.

ANILCA 1310(b) allows for the establishment, operation, and maintenance of new air and water navigation aids and related facilities and facilities for national defense purposes, with conditions to minimize the adverse effects of such activities. The USFWS recently issued a ROW for specific installations within the program area under this provision.

Climate Change

Climate change is an ongoing factor in the consideration of cumulative effects in the Arctic. Climate change could affect the habitat, behavior, distribution, and populations of fish and wildlife within the program area. Climate change could also affect the availability of, or access to, subsistence resources. The trends in climate change that were described in the GMT2 Final SEIS (BLM 2018), and incorporated by reference into this EIS, are expected to continue.

F.3.3 Actions Not Included in the Cumulative Analysis

Developments for which a solid proposal has not been submitted or which seem unlikely to occur within the foreseeable future are considered speculative. These may include projects that are discussed in the public arena but are not currently authorized by law or for which there is no current proposal before an authorizing agency. Speculative developments are not considered reasonably foreseeable and are not evaluated as part of the cumulative impacts analysis.

Oil and Gas Activities on Non-Federal Lands

The program area is next to State of Alaska lands and waters and contains inholdings owned by ANCSA corporations. Although there are no present plans to develop these non-federal lands for oil and gas, leasing in the Coastal Plain could result in exploration and development of recoverable hydrocarbons. Future NEPA analyses associated with Coastal Plain leasing will consider oil and gas activities on non-federal lands once project-specific details are available.

F.4 Resource Indicators and Assumptions

For organizational purposes, **Chapter 3** is divided into sections by subject area (such as water resources, terrestrial mammals, and recreation). Though they are described and analyzed in discrete sections, these subjects are dynamic and interrelated. A change in one resource can have cascading or synergistic impacts on other resources. For example, water quality affects fish populations, which in turn influences subsistence harvests, which can have implications for other human outcomes such as health and sociocultural systems. As a result, there is some overlap among the resource sections in **Chapter 3** and the impacts described in one section may depend on the analysis from another section.

During the writing process, resource specialists shared data and discussed interrelated aspects of the analyses to better capture the interrelated nature of environmental resources. The indicators, analysis areas, and assumptions used for each resource analysis are detailed below.

F.4.1 Climate and Meteorology

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Emissions of greenhouse gases from production, processing, transportation, and downstream combustion of oil. Energy substitution could reduce Green House Gas emissions.	Cumulative addition to global atmospheric concentrations of GHGs, contributing to climate change.	GHG emissions (metric tons per year) from production, processing, transportation, and downstream combustion GHG emissions (metric tons per year) from substituted energy sources. Social Cost of GHG (dollars)
Emissions of GHG from the change in foreign oil consumption	Cumulative addition to global atmospheric concentrations of GHGs, contributing to climate change.	See Row 1

Impact Analysis Area

- Direct/Indirect—Program area; development/production GHG emissions estimates.
- Cumulative—Coastal Plain GHG emissions compared with Alaska, the US, and global total GHG emissions.

Analysis Assumptions

- The BLM EnergySub Model provides a reasonable estimate of substituted energy sources and the change in foreign oil consumption from production in the Coastal Plain

- The Bureau of Ocean Energy Management's Greenhouse Gas Life Cycle Energy Emissions Model as modified for the Willow MDP SEIS provides a reasonable estimate of lifecycle GHG emissions from oil produced in the planning area
- Produced gas would not be sent to market as there is no infrastructure to do so and it would likely take beyond the project timeline construct a gas pipeline back to southern Alaska. Gas would most likely be injected back into the formation to stimulate development, but it is possible that some could be used on site for running generators or other such uses.

F.4.2 Air Quality

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Leasing	Direct	Criteria pollutant impacts in micrograms per cubic meter relative to National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS). Hazardous air pollutant impacts in micrograms per cubic meter relative to short-term, chronic, and carcinogenic thresholds. Visibility (units of delta deciviews) Total deposition (units of kilograms per hectare per year) relative to critical loads.
Fuel combustion in construction and drilling/operations equipment, aircraft, vehicles, and machinery such as drill rigs, generators, pumps, and compressors by phase, as well as flaring of natural gas	Indirect, short term Long-term depending on source	Criteria pollutant impacts in micrograms per cubic meter relative to National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS). Hazardous air pollutant impacts in micrograms per cubic meter relative to short-term, chronic, and carcinogenic thresholds. Visibility (units of delta deciviews) Total deposition (units of kilograms per hectare per year) relative to critical loads.

Action Affecting Resource	Type of Impact	Impact Indicators
Construction of ice roads and airstrips to access the processing facilities and satellite well pads, as well as construction of the processing facilities and satellite pads themselves. Development of gravel pits to provide materials for road and pad construction.	Indirect, long term Localized	See Row 2
Operation of gravel pits	Indirect, long-term Localized	Qualitative discussion
Use of roads	Indirect, long-term Localized	See Row 2
Downstream combustion of oil produced in the Coastal Plain	Indirect, long term	Qualitative Discussion
Regional sources of air emissions	Cumulative	See Row 2

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—North Slope

Analysis Assumptions

- While stipulations determine where and when on-the-ground actions can occur under each alternative, they do not change the overall surface disturbance or level of well development under each alternative, based on the RFD.
- Future on-the-ground actions requiring the BLM approval will require further NEPA analysis based on specific and detailed information about what kind of activity is proposed and where it will take place. Additional site-specific terms and conditions that may be required before any oil and gas activity is authorized will be determined as part of this future site-specific NEPA analysis.
- Willow MDP Alternative E (from the Willow Master Development Plan Final SEIS [BLM 2023]) criteria and hazardous air pollutant emissions normalized to emissions per barrel of oil produced during peak production would be representative of Coastal Plain indirect emissions per barrel of oil produced in future developments.
- Willow MDP Alternative E (from the Willow Master Development Plan Final SEIS) well pads, pad sizes, sources, layout, and connecting infrastructure to processing facilities are generally representative of typical future development in the Coastal Plain.
- Produced gas would not be sent to market as there is no infrastructure to do so and it would likely take beyond the project timeline construct a gas pipeline back to southern Alaska. Gas would most likely be injected back into the formation to stimulate development, but it is possible that some could be used on site for running generators or other such uses.

F.4.3 Acoustic Environment

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Noise disturbance caused by oil and gas-related activities, to include: ● Noise generated by drilling ● Noise generated by aircraft used in fluid minerals activities ● Noise generated in the construction and operation of roads, well pads, and other ancillary support activities ● Noise from seismic exploration ● Noise from gravel mining and blasting ● Noise from the CPF ● Noise from flaring ● Noise from coastal and offshore sources ● Noise from the use of motorized equipment such as snow machines, all-terrain vehicles, occasional small aircraft, and limited local vehicle traffic associated with scientific activities	Impacts on human receptors from noise- and vibration-generating activities—Human receptors likely to be affected by post-lease oil and gas development activities are residents of Kaktovik; subsistence users of subsistence use areas; and recreationists Impacts on sensitive species from noise- and vibration-generating activities—Sensitive species such as caribou, polar bear, seals, whales, and migratory birds *[Note that species-specific impacts and impacts on subsistence resources are introduced in the affected environmental section but evaluated in those resource sections]*	● Sound intensity index—the relationship of background noise to an introduced sound level. ● Estimated sound levels from noise-generating activities in various distances in decibels and distance to audibility ● Duration of sound (short-term or long term) ● Number of flights per day ● Acres closed to leasing and designated NSO

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—North Slope

Analysis Assumptions

- Ambient noise levels are approximately 35 decibels (dB) in the Coastal Plain.
- Decibels typically attenuate at a rate of 6 dB per doubling of distance.
- Relationships of sound differences and audibility tables tabulated for the GMT2 SEIS analysis (BLM 2018) are generally representative of this EIS.

F.4.4 Physiography

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
• Temporary structures along coast • Gravel infrastructure • Gravel mines	Coastal erosion and deposition is both a direct and an indirect impact. Gravel infrastructure and mines are a direct impact on topography.	• Footprint of gravel fill, in acres • Size of gravel mines, in acres

Impact Analysis Area

- Direct/Indirect—Hypothetical development footprint for future gravel infrastructure and gravel mining within the program area
- Cumulative—Program area

Analysis Assumptions

- None

F.4.5 Geology and Minerals

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Development could affect the risk of some geologic hazards Solifluction and slope stability Riverbank erosion/slope stabilization at crossings No impacts on mineral resources other than petroleum and aggregate resources, which are addressed in other sections	Erosion at bridge and water crossings due to development activities Slope failures and solifluction due to thawing permafrost	Discussion is qualitative

Impact Analysis Area

- Direct/Indirect—Hypothetical development footprint for future gravel infrastructure and gravel mining within the program area
- Cumulative—Program area

Analysis Assumption

- Mineral exploration and leasing, other than for petroleum and aggregate, will continue to be disallowed in the program area.

F.4.6 Petroleum Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Extraction of oil and gas	Reduction of oil and gas resources available for future use	Percentage of estimated total available reserves removed
Spills of oil and gas and releases of gas to the atmosphere	Loss of oil and gas resources for productive use	Number and volume of spills and gas leaks
Exploration phase	Improved understanding of petroleum oil and gas resources	n/a

Impact Analysis Area

- Direct/Indirect—Reduction in oil and gas resources available in the program area.
- Cumulative—Program area

Analysis Assumptions

- Oil and gas development will occur under all action alternatives.
- Development will occur in a similar manner and have similar impacts to other North Slope oil and gas developments.
- There will be a pipeline available to transport oil to market during the life of the plan.
- No infrastructure for getting gas to market will exist during the life of the plan, any gas produced will be reinjected into the reservoir to stimulate production.

F.4.7 Paleontological Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Ground disturbance caused by facilities development including: • Gravel fill at locations of bedrock exposures with high potential fossil yield classification (PFYC) rankings • Gravel extraction • Drilling • Roads and access • Pipelines	No direct impact from leasing. Potential for subsequent ground disturbance at levels or depths where resources may be present. If gravel fill is placed over certain bedrock outcrops identified as having high paleontological yield potential, it would make them inaccessible for research. Infrastructure and increased human access would increase access to paleontological resources, which could result in potential looting and removal as well as adding to the identification and scientific body of knowledge of resources in the area.	• PFYC ranking of mapped units • Proximity to mapped units with assigned PFYC rankings • Extent of surface restrictions associated with the alternatives.

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumption

- PFYC rankings of 3, 4, 5, and U will require further field or other investigation for individual exploration projects and other subsequent activities.
- No additional localities have been documented or studies conducted in the Program area that would change PFYC classes at this point.
- Previous PFYC ranking included ranges. The practice now is to use the higher rank of the range only.

F.4.8 Soil Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
● Material resources extraction sites ● Access roads, pads, staging areas, and airstrips (gravel fill or ice) ● Off-tundra travel ● Ice road construction and seismic survey ● Construction of structures, such as pipeline vertical support members, and building foundations ● Reclamation of embankments and pads	● Direct surface disturbance to vegetation ● Dust impacts ● Flooding ● Removal of surface-insulating organics to cause thaw of frozen soils and destruction of surface landforms ● Sand and gravel mining in streams affecting stream structure ● Placement of fill for construction of pads and roads ● Installation of piling for vertical support members and infrastructure foundations	● Acres of disturbance to soil and permafrost ● Changes to soil and permafrost from placing fills for embankments and pad ● Changes to erosion of soil from placement of fills for embankments and pad ● Extent of fugitive dust what is the radius or extent from the road ● Changes in drainage patterns due to permafrost thaw and redirection by embankments

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Up to 2,000 acres of disturbance will occur on/across frozen soils under each action alternative.
- Pads and roads will be constructed to minimize potential thaw of frozen soils (use of thicker embankments or insulation).
- Water ponding will occur at base of embankments.
- Ice roads will be used to access material sites.
- Roads and pads will be reclaimed.
- Number of access days within the development areas for each alternative, i.e. winter travel days.

F.4.9 Sand and Gravel Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Ground disturbing activities such as: ● Material resources extraction sites ● Ice access roads ● Reclamation ● Sand and gravel mining in floodplains ● Winter Blasting	● Changes in availability of sand and gravel. ● Direct surface disturbance to vegetation; removal of surface-insulating organics to cause frozen soils to thaw and destruction of surface landforms potentially resulting in slope or soil stability issues in sand and gravel extraction ● Changes in surface drainage and water impoundment in gravel pits ● Changes in erosion where surface vegetation is removed, resulting in issues for sand and gravel extraction. ● Dust and the need for dust mitigation during operation.	● Acres/volume of material removed

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Sand and gravel extraction could occur in both uplands and floodplains except in streams that support resident, anadromous or endemic fish populations.
- Access roads constructed from ice roads will be required to access material sources.
- Material resources are included in 2,000-acre surface disturbance limitation.

F.4.10 Water Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Sand and gravel mining	• Alteration of stream morphology Alteration of surface water flow patterns and flow quality (base and peak) • River depletion due to flood plain gravel mining. • Creation of thaw bulbs in permafrost • Placement of gravel fill, disrupting recharge • Increased sedimentation • Changes in water quality, including turbidity and potential mobilization of contaminants • Establishment of new lakes/ponds following	• Change to surface water flow (drainage patterns and quantity, cfs) • Change to water levels (relative elevation, ft) • Change to surface water quality (turbidity, water chemistry) • Change to groundwater level in the active layer and due to thaw bulb (relative elevation, ft) • Change to total surface water (lake/pond) area (acres)
Camps and facilities	• Lower water levels from potable water, fire suppression, and maintenance activities • Discharge of treated domestic wastewater • Spills and contamination • Discharge of treated domestic wastewater • Loss of connectivity of aquatic habitat due to changes in water levels • Increased turbidity and other changes in water chemistry • Alteration of water flow patterns • Seasonal changes to water quantity and quality) • Changes in permafrost or groundwater sources	• Change to surface water flow (drainage patterns and quantity, cfs) • Change to surface water levels (relative elevation, ft) • Change to surface water quality (turbidity, water chemistry, contaminants) • Changes to soil moisture (%) • Change to total surface water area (acres)

Action Affecting Resource	Type of Impact	Impact Indicators
Construction and maintenance of gravel pads, roads, and air access facilities	● Alteration of flow patterns ● Spills and contamination ● Impacts to water quality from gravel dust and gravel spray ● Impacts to water quality from temporary turbidity and sedimentation during gravel placement, compaction, and grading	● Change to surface water flow (drainage patterns and quantity, cfs) ● Change to surface water levels (relative elevation, ft) ● Change to surface water quality (turbidity, water chemistry) ● Change to groundwater in the active layer and due to thaw bulb (relative elevation, ft) ● Change to marine water quality (turbidity, water chemistry, contaminants) ● Changes to soil moisture (%) ● Change to total surface water area (acres)
Installation of culverts and bridges	● Alteration to stream hydraulics and drainage patterns (e.g., velocity) and drainage patterns ● Inundation and starvation of areas ● Increased erosion and sedimentation ● Reduced surface water connectivity	● Change to surface water flow (drainage patterns and quantity, cfs) ● Change to surface water quality (turbidity) ● Water levels
Pipeline construction	● Increased sedimentation during construction ● Spills and contamination around bridge pilings ● Increased erosion and sedimentation	● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants)
Snow roads	● Alteration of natural drainage patterns ● Creating thaw bulbs in permafrost from damage to tundra or ponding of water	● Change to surface water flow (drainage patterns and quantity, cfs) ● Change to total surface water area (acres)
Ice roads, bridges, pads, and airstrips	● Alteration of natural drainage patterns ● Increased erosion and sedimentation ● Lower lake levels ● Ice jamming during breakup	● Change to surface water flow (drainage patterns and quantity, cfs) ● Change to surface water quality ● Change to water levels
Barge docks and seawater treatment plant construction and operation	● Increased turbidity during construction ● Spills and contamination both inland and marine waters ● Coastal erosion from barge waves	● Change to marine water quality ● Change to surface water quality (turbidity, water chemistry, contaminants)

Action Affecting Resource	Type of Impact	Impact Indicators
Drilling and operation including injection of drilling muds and pumpable waste	● Spills and contamination ● Lower water levels from hydrostatic testing ● Fracture or alteration of groundwater flows; disrupting surface spring flow and water quality	● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants) ● Change to groundwater level (relative elevation, ft) ● Change to marine water quality (turbidity, water chemistry, contaminants)
Seawater treatment plant (STP) construction and operation, including withdrawal, discharge, and water distribution pipeline	● Increased turbidity during construction and ice trenching ● Spills and contamination ● Impacts on water quality from discharged water and use ● Changes to local salinity	● Change to marine water quality (salinity, turbidity, water chemistry, contaminants) ● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants) ● Footprint of ice trenching to install water intake (acres)
Drilling and operation including injection of drilling muds and pumpable waste	● Spills and contamination ● Lower water levels from hydrostatic testing ● Fracture or alteration of groundwater flows; disrupting surface spring flow and water quality ● Injection of drilling muds and pumpable waste disrupting groundwater, springs, and streams ● Contamination of springs or surface waters	● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants) ● Change to groundwater level (relative elevation, ft) ● Change to marine water quality (turbidity, water chemistry, contaminants)
Seismic exploration	● Alternation of natural drainage patterns ● Spills and contaminants ● Lake water withdrawals ● Impacts on lake recharge ● Creating thaw bulbs in permafrost from damage to tundra or ponding of water	● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants) ● Change to total surface water area (acres) ● Change to surface water levels (relative elevation, ft)

Action Affecting Resource	Type of Impact	Impact Indicators
Off-road vehicle activity on tundra (for operations, pipeline maintenance, and spill preparedness and planning)	● Alternation of natural drainage patterns ● Spills and contaminants	● Change to surface water flow (drainage patterns and quantity, cfs) ● Changes to surface water quality (turbidity, water chemistry, contaminants) ● Change to total surface water area (acres) ● Change to surface water levels (relative elevation, ft)

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- The eastern and western program area boundaries follow the Staines River to the west and Aichilik River to the east.
- Impacts on water resources are similar to those described in the GMT2 SEIS (BLM 2018) and other North Slope EISs, noting that topography and water distribution in the program area differ from other North Slope areas previously analyzed for development. Discussions of impacts will be modified where data specific to the program area is available.
- The hypothetical development scenarios have similar impact but vary in scale and intensity, depending on what project is ultimately developed.
- No specific developments or infrastructure needs have been identified beyond the scenarios identified in **Appendix B**.

F.4.11 Solid and Hazardous Waste

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Management of solid waste generated by the development and operation of facilities: ● Exploratory drilling ● Facility operations ● Seismic activities ● Road/facility construction Introduction of contaminants including petroleum products caused by: ● Spills ● Vehicle accidents/rollovers ● Well blowouts ● Pipeline leaks ● Tank overfills Disposal of unregulated nonhazardous fluids ● Injection of nonhazardous fluids through Class I UIC	● Introduction of contaminants including petroleum products and heavy metals caused by the development and operation of facilities ● Temporary and permanent storage of solid waste generated from activities (storage area, landfill, or monofill) ● Air quality impacts from burning solid waste ● Design and implementation of wastewater facilities ● Creation of landfill, monofill, other ● Management of spills ● Underground injection well ● Staging and storage areas ● Underground injection control (Class I or II wells)	● Solid waste cubic yards per day (based on annual average ● Solid waste generated per day, calculations for air emissions of burning solid waste. ● Sewage lagoon to be x acres to treat y volume per day (based on annual average). ● Underground injection control wells depth of discharge and quantity

Impact Analysis Area

- Direct/Indirect—Direct impacts evaluated for the geographic extent of hypothetical future development areas (up to 2,000 acres of development) within the program area. The indirect impacts area is 0.25 mile outside of the direct impact geographic area.
- Cumulative—Cumulative impacts are evaluated for the same geographic area as the indirect impacts area.

Analysis Assumptions

- Projects will require a stormwater pollution prevention plan (SWPPP), a SPCC, a solid waste general permit, and an ODPCP.
- Facilities will require a facility response plan to operate.
- Wastewater design will require approval from the DEC.
- Class I or II underground injection wells will require a permit/authorization from DEC.
- Storage of greater than 55 gallons (individual container) of oils and other hazardous materials will have appropriate secondary containment.
- Best management practices will be implemented to prevent the discharge or accidental spill of petroleum or hazardous materials.
- Access to the landfill or sewage lagoon will be controlled.

F.4.12 Vegetation and Wetlands

Impacts and Indicators—Vegetation

Action Affecting Resource	Type of Impact	Impact Indicators
Seismic exploration: Development of exploration vehicle or other all-terrain vehicle (ATV) trails	Vegetation and plant community alteration from exploration vehicle or ATV traffic	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Exploration drilling: Ice placement for ice roads and pads	Vegetation and plant community alteration from ice placement and operation of ice roads	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Exploration drilling: Water withdrawal from lakes to support ice road and ice pad construction and other uses	Lacustrine (emergent) vegetation alteration from changing water levels	No quantitative indicator available
Project construction: Direct effects of gravel mining	Permanent loss of vegetation types	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project construction: Direct effects of gravel placement for roads and pads	Permanent loss of vegetation types	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project operations: Indirect effects of gravel roads and pads and pipeline corridors	Vegetation and plant community alteration from drifted snow and altered drainage patterns	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project operations: Traffic on gravel roads	Vegetation and plant community alteration from gravel spray and dust fallout	Acreages of vegetation types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.

Action Affecting Resource	Type of Impact	Impact Indicators
Project construction and operations: All disturbances with the capacity to introduce nonnative, invasive species	Changes to plant community structure, with the potential introduction of invasive or noxious nonnative plants	Acreages of vegetation types present within accessible areas for each alternative, stratifies by oil production and EIS-specific development stipulations. No indicator available to assess possible plant community changes
Project construction and operations: Oil and contaminant spills	Vegetation and plant community alteration from tundra spills	No indicator available to assess possible spill locations in relation to vegetation types

Impacts and Indicators—Wetlands

Action Affecting Resource	Type of Impact	Impact Indicators
Seismic exploration Development of exploration vehicle or other ATV trails	Permanent loss or alteration of wetland types from rolligon/ORV traffic	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Exploration drilling: Ice placement for ice roads and pads	Permanent loss or alteration of wetland types from ice placement and operation of ice roads	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Exploration drilling: Water withdrawal from lakes to support ice road and ice pad construction and other uses	Lacustrine fringe and aquatic wetland loss or alteration from changing water levels	Acres of wetland types present within accessible areas for each alternative, stratified by oil potential and EIS specific development stipulations.
Project construction: Gravel mining	Permanent loss of wetlands	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project construction: Direct effects of gravel placement for roads and pads	Permanent loss of wetlands	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project operations: Indirect effects of gravel roads and pads and pipeline corridors	Alteration of wetland types from drifted snow and altered drainage patterns	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.

Action Affecting Resource	Type of Impact	Impact Indicators
Project operations: Traffic on gravel roads	Alteration of wetland types from gravel spray and dust fallout	Acres of wetland types in accessible areas for each alternative, stratified by oil potential and EIS-specific development stipulations; site-specific acreages were not used due to hypothetical anchor development location and poor data quality.
Project construction and operations: All disturbances with the capacity to introduce nonnative, invasive species	Changes to plant community structure in wetlands, with the potential introduction of invasive or noxious nonnative plants	No quantitative indicator; qualitative discussion on possible plant community changes
Project construction and operations: Oil and contaminant spills	Wetland and plant community alteration from spills on tundra	No quantitative indicator; qualitative discussion on possible spill locations in relation to wetland types

Impact Analysis Area—Vegetation and Wetlands

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions—Vegetation and Wetlands

- The final footprint of the anchor development, specific to each alternative will be used as described in Chapter 2. The indirect area was calculated by buffering the 750-acre gravel footprint by 328 feet for an indirect effects area of 6,607 acres.
- The relative proportions for each area open for development under the alternatives and development stipulations will be affected in similar proportions under the anchor footprint. This is because spatially explicit information about where potential projects might be developed was absent for this programmatic EIS format.

F.4.13 Fish and Aquatic Species

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Seismic Surveys: Use of rolligons or other off-road vehicles (ORV) Use of vibroseis to image the subsurface	Habitat Alteration—Flow alteration and fish passage: Compaction of ice over and surrounding waterbodies could cause short-term delays in melt. Disturbance, injury, or mortality—Increased sound pressure in unfrozen waterbodies, including springs, could disturb, injure, or kill fish.	Qualitative discussion; cannot be quantified without an estimate of miles of off-road travel.
Establishment of camps and camp moves	Contaminants and waste from camps Stream crossings and potential increase in disturbance	Changes to water quality; disturbances to habitat; sedimentation.

Action Affecting Resource	Type of Impact	Impact Indicators
Water withdrawal from lakes or streams: ● Winter activities: ice roads, camp water supply, exploration (e.g., test wells) ● Spring activities: camp water supply, construction activities ● Summer activities: dust suppression, construction activities, camp water supply Water withdrawal from marine or brackish water (Salinity Treatment Plant)	Alteration or loss of winter and summer aquatic habitat due to water withdrawal activities may include the following: ● Changes in water levels ● Ice compaction ● Changes in water chemistry – Declines in dissolved oxygen – Increases in solutes ● Alteration of water flow during breakup (seasonal changes to water quantity and quality) ● Changes in permafrost or groundwater sources ● Loss of littoral habitat and wet meadow zones due to shallowing ● Increased freeze down of substrate used by some aquatic invertebrates Injury or mortality of fish from entrainment or impingement at water intake.	Types and extent of effects by aquatic habitat (lakes, rivers, springs) Discussed in context of the scarcity of unfrozen water in winter. Describe stream miles and acreage that could be affected
Water withdrawal from marine or brackish water (Seawater Treatment Plant [STP])	Alteration or loss of aquatic habitat due to water withdrawal activities may include changes in local salinity. Injury or mortality of fish from entrainment or impingement at water intake.	Type of habitat around STP intake offshore. Changes to water quality baseline because of water withdrawal described in **Section 3.2.10**, Water Resources
STP facility construction including intake and discharge pipelines, and distribution pipelines	● Alteration of marine or brackish water habitat (sedimentation) during construction. ● Disturbance (temporary alteration of fish migratory route), injury, or mortality of fish due to ice trenching (winter construction) for intake pipe placement.	General footprint of ice trenching within 0.5-mile buffer zone (to be confirmed from water quality or water resource section) to account for: ● noise effects ● sedimentation ● Habitat alteration
STP discharge to marine waters (if UIC disposal, then delete this row)	Changes to salinity or other water quality from discharge of brine from saltwater treatment plant	● Changes to water quality baseline described in **Section 3.2.10**, Water Resources ● Acres of expected mixing zone.

Action Affecting Resource	Type of Impact	Impact Indicators
Gravel mining for road and pad construction	● Alteration or loss of aquatic habitat ● Creation of deep aquatic habitat in gravel pits ● Changes in water quality, including turbidity and mobilization of contaminants ● Direct mortality if mining occurs in water bodies	Acres of potential habitat affected by mining (acres of gravel sites, assuming all acres would be in rivers), and acres of gravel sites in the 50-year floodplain (indirect impacts on aquatic habitat).
Construction and maintenance of gravel roads, pads, culverts, and bridges	Direct aquatic habitat loss or blockage of fish passage Indirect aquatic habitat alteration from: ● Gravel dust and spray ● Temporary and periodic turbidity, sedimentation, and contaminant mobilization during gravel placement, compaction, and grading ● Changes in natural drainage patterns, such as water impoundment and ice damming	Qualitative description of direct and indirect effects by aquatic habitat types and their context on the landscape.
Vehicle traffic on ice or gravel infrastructure	Displacement of fish due to blocked fish passage from delayed melt of ice roads or pads and ice plugs in culverts or blockage at bridges Habitat and water quality alterations due to dust, gravel spray, or sediment runoff from gravel roads	Describe ice infrastructure effects and their context on the landscape. Acres within 100 m of gravel infrastructure (use linear miles of road and pads) that would be altered by dust, gravel spray. Changes resulting from erosion or thermokarst described in **Section 3.2.8**, Soils
Barging of materials	Disturbance and displacement of fishes during barging Invasive invertebrate and fish species introduced from released ballast water Accidental spills in marine waters	General description of noise associated with barging. Qualitative discussion of BMPs that reduce or negate invasive species introduction (ballast water exchange requirements)
Barge landing or dock (if this is not included in Alts then delete row)	Potential alteration of rearing or nearshore foraging habitat Disturbance and displacement of fishes Accidental spills in marine waters	Acres of fill required, type of infrastructure required (such as overwater structure or sea wall) Number of barge trips required

Action Affecting Resource	Type of Impact	Impact Indicators
Pipeline construction Trenching for optic cable at stream and road-crossings (assumes trenching in, under, or next to pipe)	Loss or alteration of habitat Loss or alteration of aquatic habitat from changes in water flow or ice-blockage during spring break up, water quality. Disturbance or displacement of fish during in-water construction (or assume all work in winter and thus no in-water work). Disturbance, injury, or mortality of fish due to noise or vibration during pipeline installation. Accidental spills in or adjacent to waterbodies Contaminants associated with drilling/construction	Describe direct and indirect effects of placing VSMs in the water column by aquatic habitat types and their context on the landscape.
Bridge construction ● placement of bridge piers or pile foundations in water ● pile driving	Loss or alteration of aquatic habitat from changes in water flow or ice-blockage during spring breakup Disturbance or displacement of fish during in-water bridge construction (or assume all work in winter and thus no in-water work) Disturbance, injury, or mortality of fish due to noise or vibration during bridge construction	Describe fish-bearing streams that could require bridges, describe overwintering habitat at or near those waterbodies.
Spills from: ● storage, use, and transport of waste and hazardous materials (including crude oil, fuels, salt water, drilling fluids, and other chemicals). ● wells, pipelines, or other infrastructure.	Habitat alteration or loss due to spills or leaks Injury or mortality of fish from spilled material if it enters water bodies Impacts to water quality	Described on broad level by habitat type (e.g., nearshore, mountain streams, and springs) and species affected Number of spills
Off-road vehicle activity on tundra (for operations, pipeline maintenance, and spill preparedness and planning)	Habitat alteration due to compression or damage to vegetation resulting in soil exposure, sediment runoff, and contaminant mobilization	Qualitatively describe by habitat type (e.g., mountain streams and springs) and species affected.
Injection of drilling muds and pumpable waste disrupting groundwater, springs, and streams	Alteration of spring and surface water connection Contamination of springs or surface waters	Miles of perennial springs within the program area. Miles of streams within the program area.

Impact Analysis Area

- Direct/Indirect—The program area plus the upstream extent of overwintering habitat for fishes. The nearshore area within the barge route, STP mixing zone, or other connected actions.
- Cumulative—Many of the species have life histories that include migrations from the program area west to Utqiagvik, east to the Mackenzie River, and upstream into freshwaters of the larger Arctic Coastal Plain

Analysis Assumptions

- The BLM leases are for onshore development; offshore activities could be considered connected actions, but the analysis does not include offshore infrastructure.
- A barge landing or dock will be part of the alternatives.
- There is more fish and aquatic invertebrate use of program area waters than have been confirmed to date (use over a broader area and by a higher number of species).
- There are contradictions in known ranges for certain species, such as Pink salmon, and slimy sculpin. These species are present and use the program area.
- Alternatives will include water withdrawal either from freshwater sources or, more likely, from marine waters via an onshore STP.

F.4.14 Birds

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Winter seismic surveys	Direct compaction of snow and vegetation, delayed snowmelt, and damage to taller tussock and low shrub tundra in seismic tracks. Disturbance to overwintering bird species?	Habitats and approximate acreages affected, if possible
Gravel placement for roads and pads	Habitat loss	Acres of habitat affected
Gravel mining for roads and pads and construction of pipeline corridors	Direct habitat loss	Acres of habitats affected
Road traffic on gravel roads	Habitat alteration from gravel spray and dust fallout	Acres of habitat affected (use dust fallout buffer)
Ice placement for ice roads and pads to support winter exploration and construction	Habitat alteration by ice roads and pads	Habitat affected (qualitative)
Water withdrawal from lakes to support ice road construction, water supply, dust suppression, and other uses	Habitat alteration by reduced/fluctuating water levels, loss of nesting sites on lakeshores, and reduced water quality and fish availability	Describe extent of effect in qualitative terms by aquatic habitat (lakes, rivers, springs)
Water withdrawal from and discharge to the marine environment (STP)	Alteration of aquatic habitat (salinity) for fish (consumed by birds) and potential injury to or mortality of fish at intake	Describe changes in water quality (refer to **Section 3.2.10**, Water Resources) and area of potential mixing zone

Action Affecting Resource	Type of Impact	Impact Indicators
Gravel mining and placement for roads and pads and construction of pipeline corridors	Habitat loss: with rehabilitation after abandonment, potential creation of avian habitats previously absent on that site for some species Indirect habitat alteration from drifted snow and altered drainage patterns adjacent to gravel mining areas Indirect hydrological changes in drainage patterns, flow, and blockages	Acres of habitat affected (to include dust fallout buffer where applicable) Acres of habitat affected from Water Resources section.
Road traffic, air traffic, noise, and human activities	Disturbance and displacement of birds from affected areas	Acres of habitat affected (noise buffer)
Road traffic	Injury and mortality from accidental collisions	Describe potential for vehicle collisions
Spills from: ● storage, use, and transport of waste and hazardous materials (including crude oil, fuels, salt water, drilling fluids, and other chemicals). ● wells, pipelines, or other infrastructure.	Injury and mortality from accidental releases, discharges, or insecure containment Habitat alteration or loss due to spills or leaks	Describe potential for accidental exposure for individuals and habitats Number of spills
Human activities and waste management	Attraction of predators and scavengers, including increased abundance of some birds, and resulting decrease in survival and nesting success for prey species	Potential impacts on bird populations and predator/prey dynamics
Barging materials and modules	Disturbance and displacement of birds from nearshore habitats, potential alteration of aquatic habitats by open water dredging	Describe potential displacement of birds
Human activities, including road and air traffic	Disturbance and displacement of large flocks of staging snow geese	Potential disturbance and displacement (no estimate of distance effect)
Gravel mine site rehabilitation and infrastructure removal	Habitat change; with rehabilitation after abandonment, potential creation of avian habitats previously absent on that site(s) for some species	Qualitative discussion of habitats most likely affected.

Impact Analysis Area

- Direct/Indirect—Program area and adjacent marine habitats;
- Cumulative—North Slope from NPR-A east to Program Area and Canada border

Analysis Assumptions

- For many actions, impacts can be described qualitatively either because resource and impact data are unavailable, or project details are uncertain or unknown at the time of this preliminary analysis (e.g., the locations of lease sales and specific development project area within lease areas are unknown). For most types of habitat impacts and for some types of behavioral disturbance, semi-quantitative estimates of areas affected are possible.

- Habitat Loss and Alteration (including disturbance and displacement): impact analysis will assume 1) that acreages of bird habitats affected by development would occur in the same proportions as those habitats occur within each area available for leasing, and 2) recognizing the potential for a greater use of moist tundra, apply a weighting factor to preferentially push development acreage into encompassing greater proportions of moist tundra habitat. This would be done while taking into account the lease stipulations and ROPs that restrict development in and near specific areas. An upper limit of 2,000 acres for all project development in the Program Area is set by the Public Law 115-97.
  - Using a drawing of a standardized anchor field footprint (one CPF and six radiating access roads to six drill pads, one STP pad and a 30-mile access road, totaling 750 acres), estimate the area within 328 feet (for impacts of dust fallout, gravel spray, thermokarsting, and impoundments) and within 656 feet (for impacts of disturbance and displacement).
  - Extrapolate to a footprint of 2,000 acres using the proportional increase in area that was calculated for each buffer area based on the 750-acre footprint.
- The analysis for waterbirds would use the Arctic Coastal Plain-wide and spatially specific breeding densities calculated by Amundson et al. (2019; see New Data below) to estimate the number of birds of each species (pending available data) that could be affected by development in the Program Area.

F.4.15 Terrestrial Mammals

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Seismic exploration	Direct and indirect effects on vegetation and behavioral disturbance affecting caribou, other ungulates, carnivores (including denning grizzly bears), and small mammals	Area (acres or km²) available for seismic activity under different alternatives (assume no seismic exploration occurs in areas not offered for lease sale?)
Ice placement for ice roads and pads to support winter exploration and construction	Habitat alteration by ice roads and pads	Area (acres or mi²) available for ice road placement by habitat type and alternative, and by high, medium, low oil potential
Gravel placement for roads and pads	Direct habitat loss	Area (acres or mi²) available for gravel road placement by habitat type and alternative, and by high, medium, low oil potential
Traffic on gravel roads	Habitat alteration from gravel spray and dust fallout	Area (acres or mi²) of affected habitat, by habitat type
Gravel mining	Direct habitat loss With rehabilitation after abandonment Indirect habitat loss by disturbance during mining	Area (acres or mi²) of affected habitat, by habitat type Acres of different polygons from Severson (2021) within different stipulations
Road traffic, air traffic, noise, and human activities	Disturbance and displacement of caribou and other species from affected areas	Proportion of years that areas are used by Porcupine Caribou Herd per season.

Action Affecting Resource	Type of Impact	Impact Indicators
Roads and pipelines	Potential obstructions to caribou movements to and from insect-relief habitat Habitat loss due to spills or leaks	Proportion of Central Arctic Herd caribou using the program area alternatives by season (based on percent of seasonal use density from kernel density) or telemetry locations within Project area) Proportion of years areas are used by Porcupine Caribou Herd caribou by season
Road traffic	Injury and mortality from accidental collisions	Qualitative assessment
Potential spills from: ● storage, use, and transport of waste and hazardous materials (including crude oil, fuels, salt water, drilling fluids, and other chemicals). ● wells, pipelines, or other infrastructure.	Injury and mortality from accidental releases and discharges or insecure containment	Describe potential accidental exposure for individuals and habitats
Human activities and waste management	Attraction of predators and scavengers, potential defense of life and property, mortality of grizzly bears Increase in red fox density and decline in arctic fox density	Qualitative assessment
Roads and pads	Increased or altered access for subsistence hunters, non-local hunters, and other recreationists Change in mosquito relief areas used by caribou (ridges instead of coastline)	Qualitative assessment

Impact Analysis Area

- Direct/Indirect—Program area (non-marine habitats)
- Cumulative—Annual ranges of the Porcupine Caribou Herd and Central Arctic Herd.

Analysis Assumptions

- Subsistence hunting will be allowed along gravel roads.
- Access approvals for recreation or non-subsistence uses within the program area will be dealt with at the APD phase when users apply for use permit.
- Oil development more likely in the high oil potential area, less likely in the low oil potential area.
- Zone of influence during calving season—Maternal caribou may be displaced by up to 2.5 miles from roads and pads during and immediately after calving, spanning 3 weeks, based on research in North Slope oilfields. Areas of high-density development avoided by calving caribou.
- Roads and pipelines may deflect and delay caribou movements, but those effects can be mitigated by appropriate design features (pipeline height 7 feet or more, pipeline/road separation 500 feet or

more) and management of human activities, as developed in the existing North Slope oilfields. Uncertainties regarding hunting on roads, previous levels of exposure to development, and large groups sizes in Porcupine Caribou Herd during post calving.

- Occupied grizzly bear dens will be avoided by at least 0.5 mile, as stipulated by the State of Alaska.

F.4.16 Marine Mammals

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Winter activities: Seismic exploration; construction and use of ice roads and pads; gravel mining/blasting, hauling, and placement	Direct habitat loss of polar bear critical habitat and potential maternal denning habitat from gravel mining and placement Alteration of habitat and temporary loss of use of polar bear critical habitat and potential maternal denning habitat from construction of ice roads and pads Behavioral disturbance of polar bears, especially denning females. Possible den abandonment and loss of cubs Temporary alteration of ringed seal habitat, including lair habitat Behavioral disturbance of ringed seals	Acreage of critical and maternal polar bear denning habitat affected by seismic exploration Apply distance buffer of 1 mile around maternal dens from literature-based assessment of disturbance from equipment operation and noise, and regulatory requirements under ITRs Acreage of nearshore, coastal habitat (less than 3m bathymetry limit) possibly used as lair sites for ringed seals that could be affected by seismic exploration Apply NMFS-approved distance buffer around known ringed seal lairs
Marine vessel traffic during open-water season	Behavioral disturbance of marine mammals by vessel passage and off-loading during open-water season Behavioral disturbance to polar bears onshore related to landings of marine vessels	Apply distance buffers along vessel route, from literature-based assessment of disturbance responses
Traffic, aircraft, noise, and human activities throughout the year	Behavioral disturbance and displacement from affected areas Injury and mortality from vehicle strikes	Apply distance buffer of 1 mile from literature-based assessment of disturbance from equipment operation and noise, and no-disturbance buffer around barrier islands unit of critical habitat
Waste management and use and storage of hazardous materials throughout the year	Potential attraction and injury or mortality of some polar bears Injury and mortality from accidental releases and discharges or insecure containment	Qualitative assessment, considering ROPs for waste handling and human/bear interaction plans

Impact Analysis Area

- Direct/Indirect—Program area (including docking structures and adjacent marine habitats) and associated marine transportation routes.

- Cumulative—Range of affected species population/stock, such as the Southern Beaufort Sea stock of polar bears and Western Arctic stock of bowhead whales

Analysis Assumptions

- Onshore activities will affect polar bears only, except for those in the vicinity of marine docking structures and module-staging pads at the coast.
- Alternatives will avoid destruction or adverse modification of designated critical habitat (to be addressed in the Biological Assessment and Biological Opinion, which are being prepared separately.
- Maternal den surveys for polar bears will be conducted before any activities occur in the program area, so that occupied dens can be avoided by at least 1 mile during exploration and development. All dens may not be identified during den surveys.
- An average of two barge landings per year is anticipated; the number of transports would vary based on ice conditions and the large equipment needed for upcoming development phases.
- Barge landings may require benthic habitat modification, such as dredging or screeding, that has direct effects (habitat modification) and indirect effects (loss of habitat use through disturbance from noise and activity).

F.4.17 Landownership and Use

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
• Areas open/closed to leasing and infrastructure development • Protective measures that influence the placement or design of uses	Restrictions on infrastructure development, including type, location, and design	• Acres made available for lease sale where new oil and gas related uses could be developed • Acres where protection measures would influence the design, location, and season or type of use
Landownership changes	Conveyance of lands out of federal ownership	Acres of landownership

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Demand for ancillary uses and permits, such as for communication sites, will increase in conjunction with oil and gas development.
- There will be no lands conveyed into or out of federal ownership as part of this EIS.
- Research ROWs and leaseholder studies ROWs would be needed.

F.4.18 Cultural Resources

Impacts and Indicators

Note: Types of impact are not mutually exclusive and may occur across all actions impacting resources.

Action Affecting Resource	Type of Impact	Impact Indicators
Construction: ● Ground disturbance ● Traffic ● Human presence ● Ice roads ● Water use requirements	● Physical destruction or damage ● Removal of the cultural resource from its original location/loss of context ● Vulnerability to erosion ● Theft and vandalism ● Introduction of vibration, noise, or atmospheric elements, such as visual, dust, and olfactory. ● Increased access to culturally sensitive areas	● Number of previously documented AHRS and TLUI sites in potentially affected area ● Indigenous place names and ethnographic resources (e.g., traditional use areas, historic travel routes. ● Traditional knowledge of culturally sensitive areas and traditional use areas and sites
Proposed operational infrastructure: ● CPFs ● Drill rigs and pads ● Pipelines/VSMs ● Roads ● Material sites	● Change in character and setting ● Change in use or access to traditional sites ● Proximity of proposed Project components to culturally sensitive areas ● Introduction of vibration, noise, or atmospheric elements, such as visual, dust, and olfactory ● Increased access to culturally sensitive areas	● Same as above
Operations: ● Traffic ● Human presence ● Maintenance and security activities ● Proposed program policies	● Introduction of vibration, noise, or atmospheric elements, such as visual, dust, and olfactory ● Increased access to culturally sensitive areas	● Same as above
Oil Spills ● Damage from spill and cleanup activities	● Physical destruction or damage, including issues with dating damaged artifacts	● Same as above
Presence of Development in the Coastal Plain	● Loss of cultural identity with a resource ● Impacts on beliefs and traditional religious practices ● Neglect of a cultural resource that causes its deterioration ● Lack of access to traditional use areas and impacts on broader cultural landscape	● Same as above
Scientific, Environmental, and Seismic Surveys ● Ground disturbance ● Traffic ● Human presences	● Physical destruction or damage ● Removal of the cultural resource from its original location/loss of context ● Theft/vandalism ● Increased access to culturally sensitive areas	● Same as above

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—North Slope and Gwich'in communities who place significance on cultural resources in the program area

Analysis Assumptions

- All unsurveyed areas of the program area could contain cultural resources. Furthermore, past surveys have been cursory and likely did not adequately identify cultural resources.
- Cultural resource sites are treated as eligible for listing on the NRHP, until they are sufficiently evaluated as determined by the BLM.

F.4.19 Subsistence Uses and Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Noise, traffic, and human activity: ● Construction noise ● Gravel mining ● Air traffic ● Ground traffic ● Seismic activity ● Barge traffic ● Drilling noise ● Human presence	Reduced resource availability due to changes in resource abundance, migration, distribution, or behavior Increased costs and time associated with harvesting resources Increased safety risks associated with traveling farther to harvest resources Reduced user access due to harvester avoiding development and human activity Increased competition with outsider populations	● Results of **Section 3.3.4**, Terrestrial Mammals and **Section 3.3.5**, Marine Mammals regarding impacts of noise, traffic, and human activity on wildlife ● Percent of harvests coming from program area (where data are available) ● Percent of harvesters using the program area, by resource ● Analysis of material and cultural importance of subsistence species ● Analysis of Alaska Wildlife Harvest database—Requires data sharing agreement and estimate 1 month or more to develop agreement and analyze data. ● Traditional knowledge regarding impacts on subsistence uses, resources, and activities.

Action Affecting Resource	Type of Impact	Impact Indicators
Infrastructure ● Gravel roads ● Ice roads ● Pipelines ● Gravel pads ● Bridges ● Gravel Mines ● Runways	Loss of subsistence use areas to development infrastructure Physical obstructions to hunters traveling overland Physical obstructions to hunters along the coast due to pipelines Reduced resource availability due to changes in resource abundance, migration, distribution, or behavior Increased costs and time associated with harvesting resources Increased safety risks associated with traveling farther to harvest resources Reduced user access due to harvester avoiding development infrastructure Increased user access due to use of project roads for subsistence activities Increased competition along new hunting corridors (roads)	● See above

Action Affecting Resource	Type of Impact	Impact Indicators
Contamination ● Oil spills ● Air pollution ● Release, discharge, or insecure containment of hazardous materials or wastes ● Smells	Reduced resource availability due to changes in resource abundance Reduced resource availability due to changes in distribution resulting from new smells Reduced resource availability due to harvester avoiding contaminated resources Reduced user access due to harvester avoidance because of concerns about contamination	● Results of **Section 3.3.4**, Terrestrial Mammals and **Section 3.3.5**, Marine Mammals regarding impacts of oil spills on wildlife ● Results of **Section 3.2.2**, Air Quality and **Section 3.4.11**, Public Health and Safety regarding impacts of air pollution on wildlife and human health ● Traditional knowledge
Legal or regulatory barriers ● Security restrictions	Reduced user access due to security restrictions around development infrastructure Reduced user access due to harvester avoidance resulting from concerns about security restrictions/personnel Reduced resource availability due to inability to hunt in or around certain infrastructure	● Percent of harvests coming from study area (where data are available) ● Percent of harvesters using the study area, by resource ● Traditional knowledge
Increased Employment/Revenue	Increased subsistence activity due to cash from employment and other revenue Decreased subsistence activity due to increased employment and resulting lack of time Decreased overall community harvests resulting from lack of time to engage in subsistence activities	● Results of **Section 3.4.10**, Economy ● Traditional knowledge
General development	Impacts on cultural practices, values, and beliefs	● Traditional knowledge

Impact Analysis Area

- Direct/Indirect—All areas used by the 22 Alaskan caribou study communities and seven Canadian user groups subsistence study communities
- Cumulative—Same as direct/indirect analysis area

Analysis Assumption

- There will be oil and gas exploration, construction, drilling, and operations activities occurring in the Coastal Plain similar to other developments on the North Slope.

F.4.20 Sociocultural Systems

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Changes in income and employment levels	• No economic activity associated with regional or village corporation to many Arctic Village and Venetie residents • Influx of cash and impacts on social ties and political organizations • Hiring super household hunters • Lack of time for subsistence activities • Increased cash to support subsistence activities	• Results of **Section 3.4.10**, Economy regarding potential changes in employment and income • Results of **Section 3.4.3**, Subsistence Uses and Resources • Traditional knowledge
Disruptions to subsistence activities and uses	• Social stresses associated with reduced harvests or changes in effort, costs, and risk • Changes in social ties and organizations resulting from changes in subsistence providers • Loss of traditional use areas and knowledge associated with those places	• Results of **Section 3.4.3**, Subsistence Uses and Resources regarding impacts on subsistence • Traditional knowledge
Influx of non-resident temporary workers associated with project	• Conflicts between subsistence users and workers • Discomfort hunting in traditional use areas	• Results of economy chapter regarding outside workers • Results of **Section 3.4.3**, Subsistence Uses and Resources • Traditional knowledge
Influx of outsiders into community	• Increased social problems • Lack of infrastructure to support populations • Lack of knowledge and respect of traditional values, history, and beliefs	• Results of **Section 3.4.6**, Recreation • Results of **Section 3.4.11**, Public Health and Safety • Traditional knowledge
Changes in available technologies	• Changes in equipment for subsistence • Changes in transportation routes • Changes in social ties, sharing, and interactions	• Results of **Section 3.4.10**, Economy regarding potential changes in employment and income • Traditional knowledge
General development	• Impacts on belief systems • Impacts on cultural identity	• Traditional knowledge

Impact Analysis Area

- Direct/Indirect—All of the subsistence study communities (Kaktovik, Nuiqsut, Arctic Village, and Venetie).
- Cumulative—Same as direct/indirect analysis area

Analysis Assumption

- There will eventually be oil and gas exploration, development, and production activities in the Coastal Plain similar to other developments on the North Slope

F.4.21 Environmental Justice

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
• Exploration phase activities • Development/construction phase activities • Operations phase activities • Production of oil and gas resources	Direct and Indirect Effects • Subsistence effects • Sociocultural effects • Economic effects • Public health and safety effects	High and adverse effects identified in other resource area analyses that can be shown to disproportionately accrue to minority populations, low-income populations, or Alaska Native tribal entities as defined or described under CEQ guidance on the implementation of EO 12898

Impact Analysis Area

- Direct/Indirect—All of the subsistence study communities (Kaktovik, Nuiqsut, Arctic Village, and Venetie).
- Cumulative—Same as direct/indirect analysis area

Analysis Assumptions

- Environmental justice impacts will derive from disproportionately high and adverse human health or environmental effects identified in other resource area analyses that could accrue to minority populations, low-income populations, and/or Alaska Native tribal entities. This could include such effects identified in any specific resource analysis, but primarily with subsistence, sociocultural, economics, and public health and safety.
- Minority populations and low-income populations are be defined by CEQ guidance on the implementation of EO 12898. The general reference population for this analysis is the State of Alaska.
- Communities specifically included in the local and regional analyses of direct and indirect Environmental justice effects are Kaktovik, Nuiqsut, Arctic Village, and Venetie. These communities have been identified based on the results of the subsistence, sociocultural, economic, and/or public health and safety analyses in conjunction with community demographic information establishing minority and/or low-income population status.

F.4.22 Recreation

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Surface disturbance and changes in use within priority recreation areas (direct)	• Change in the quality of the recreation setting or user experiences (viewsheds, aesthetics, etc.) • Displacement of recreation opportunities (from surface disturbance) • Change in the level of access to recreation, including specially permitted commercial activities • Change in the social setting due to a concentration of users in a smaller area	• Proximity/overlap of priority recreation areas to areas available for leasing (and not subject to surface use restrictions such as NSO, CSU). • Acres of program area not available to leasing and acres that are subject to NSO. • Use of popular landing locations for non-recreation activities (if data available), potentially leading to changes in access and locations of recreation use. • Changes in ORVs or characteristics for special designations as a result of disturbances (specifically, Hulahula River).
Noise, lights, and human activity (direct and indirect)	• Change in the quality of the recreation setting and/or user experiences • Displacement of recreation opportunities (from surface disturbance)	• Changes in scenic values within proximity to priority recreation areas due to availability for leasing (refer to visual resource section). • Acres where protective measures that minimize impacts on recreation would apply (acres not available for leasing or with NSO, CSU)
Change in resource values (e.g., wildlife) that contribute to the quality of the recreation setting (indirect)	Change in the quality of the recreation setting and/or user experiences	• Impacts to water quality or quantity, leading to changes in recreational use (displacement of users, change in use/location such as hunting or fishing; refer to water resource analysis). • Impacts to water quality or quantity, leading to changes in recreational use (displacement of users, change in use/location such as hunting or fishing; refer to water resource analysis). • Acres where protective measures that minimize impacts on the resource and that contribute to recreation settings and experiences would apply

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Current recreation in the planning area will continue.
- The potential for user interactions between all types of users will increase with increasing use.
- Landing locations and frequency of use of these locations are used as a proxy to identify priority/popular recreation.
- Areas where landing is possible within areas open to leasing may be used for both recreation and oil and gas operations
- Assume commercial use recreation reporting reflects the majority of recreational activities within the program area.

F.4.23 Special Designations

Impacts and Indicators

Action Impacting Resource	Type of Impact	Impact Indicators
• Areas open and closed to fluid mineral leasing • Marine Protected Areas: Lease Stipulation 4 – Nearshore marine, lagoon, and barrier island habitats of the Southern Beaufort Sea within the boundary of the Arctic National Wildlife Refuge and Lease Stipulation 9 – Coastal Area • Wild and Scenic Rivers: Lease Stipulation 1 – Rivers and Streams and Lease Stipulation 3 – Springs/aufeis (and ROPs 8 and 24) also apply to WSR characteristic protections. • Wilderness: Lease Stipulation 10 – Wilderness Boundary	• Development and activities that could affect MPA natural biodiversity/heritage, WSR characteristics: classification/ORVs/free-flowing conditions/water quality, wilderness conditions. • Surface occupancy of infrastructure	• Acres of special designations intersected with acres open and closed to fluid mineral leasing. • Natural Heritage, the primary conservation focus. • River values: ORVs, tentative classification, water quality, and free-flowing nature of the river segment or corridor. • Changes to the untrammeled and naturalness of the program area, opportunities for solitude or primitive and unconfined recreation, and unique or supplemental values.

Impact Analysis Area

- Direct/Indirect
  - MPAs—All marine waters and lagoons located within and off the northern coast of the program area.
  - WSR Value Characteristics—Up to 4 miles of either side of the ordinary high-water mark of the eligible or suitable rivers in the program area.
  - Wilderness Characteristics, Qualities, and Values—Program area.
- Cumulative
  - MPAs—All marine waters and lagoons located within the Arctic Refuge and off the northern coast of the program area.

- WSR Value Characteristics—Up to 4 miles of either side of the ordinary high-water mark of the eligible or suitable rivers in the Arctic Refuge.
- Wilderness Characteristics, Quality, and Values—All lands in the Arctic Refuge, with an emphasis on the Mollie Beattie Wilderness Area.

Analysis Assumptions

- The MPA in the program area will continue to be managed in accordance with EO 13158, Marine Protected Areas, May 26, 2000, and guidance from the National Oceanic and Atmospheric Administration on their website: https://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/mpaviewer/.
- Any eligible or suitable rivers in the program area will be managed under interim protective measures required by the WSR Act until Congress makes a decision regarding WSR designation into the NWSRS.
- The BLM will not permit any actions that would adversely affect the free-flowing condition, ORVs, or tentative classification of any portion of the suitable river or actions that will reduce water quality to the extent that rivers would degrade the ORVs.
- The area recommended for wilderness designation would continue to be managed under the minimal management category which would protect its wilderness characteristics in a manner that would not impair the suitability of this area for preservation as wilderness.

F.4.24 Visual Resources

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Surface disturbances, gravel mining, and construction of structures, including pipelines	New structures and disturbances that do not resemble other elements in an undeveloped landscape	Changes to the form, line, color, and texture of landform, vegetation, and water, as well as changes to dark skies and wildlife

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Visual resources in the program area will become more sensitive to visual change; in other words, they will increase in value over time.
- Visual resources will become increasingly important to residents of and visitors to the area.
- Residents of, and visitors to the program area are sensitive to changes in visual quality and to the overall scenic quality of the area that contributes to living conditions and the visitor experience.
- Activities that cause the most contrast and are the most noticeable to the viewer will have the greatest impact on scenic quality.
- As the number of acres of disturbance increase, the amount of impacts on visual resources will also increase.

- The severity of a visual impact depends on a variety of factors, including the size of a project, such as the area disturbed and physical size of structures; the location and design of structures, roads, and pipelines; and the overall visibility of disturbed areas and structures.
- The more protection that is associated with the management of other resources and special designations, the greater the benefit to the visual resources of the surrounding viewsheds.
- Best management practices and project design, avoidance, or mitigation can reduce but not entirely prevent impacts on visual resources.
- Due to the slow rate of recovery of vegetation and surface conditions, all impacts on visual resources from surface disturbances will be long-term.
- The BLM visual resource management system/visual resource contrast rating process (BLM Handbook H-8431-1) will be used for site-specific actions.

F.4.25 Transportation

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
• Areas available or unavailable for new transportation infrastructure • Seasonal or other timing-related restrictions on access	• Change in the location or type of new transportation infrastructure allowed	• Acres made available for leasing that are not subject to NSO stipulations where transportation infrastructure could be placed • Acres subject to CSU or TLs that could influence the type, location, or design of transportation infrastructure
New infrastructure limiting public or subsistence access	Change in the level (increase or decrease) of access for public or subsistence use	Acres made available for leasing that are not subject to NSO stipulations where transportation infrastructure could increase or decrease the level of access for the public or subsistence user

Impact Analysis Area

- Direct/Indirect—Program area
- Cumulative—Program area

Analysis Assumptions

- Roads developed for oil and gas development will not be available for public use but could be seasonally available for subsistence users.
- Commercial and visits from non-residents will continue to increase, thereby increasing the demand for public access
- Those seeking access in the decision area have different and potentially conflicting ideas of what should constitute public access on public lands.
- The primary means of access in the decision area will continue to be by aircraft and, to a lesser extent, boat (summer) and snowmachine (winter).

F.4.26 Economy

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
• Exploration phase activities • Development/construction phase activities • Operations phase activities • Production of oil and gas resources • Abandonment/Reclamation phase activities	• Direct and indirect effects • Employment effects • Income effects • Fiscal effects • Effects on public infrastructure and services • Effects on relevant/selected economic sectors	• Average part-time and full-time jobs (number of jobs) • Income (wages in dollars) • Government revenues (dollars) • Qualitative discussion of potential increase or decrease in economic activity in various economic sectors

Impact Analysis Area

- Direct/Indirect—Local (Kaktovik), other communities outside of the NSB to include Arctic Village and Venetie, regional (NSB), State, National (qualitative discussion of potential contribution to a leasing program to the national economy and a discussion of the non-market environmental values of the Arctic Refuge).
- Cumulative—Same as direct/indirect

Analysis Assumptions

- Description of potential oil and gas activities and timeframes under each alternative—The RFD assumptions regarding exploration, development, and production activities are the basis for quantifying the magnitude and scale of economic impacts.
- Production volumes by year—Oil production data are used to calculate potential royalty payments and other State and the federal government tax payments.
- Oil price forecasts—The oil price forecast from the Energy Information Administration (EIA) Annual Energy Outlook 2018 was used to quantify the potential royalty payments and other fiscal effects of the proposed project.
- Construction costs and construction schedule—This information was used to calculate direct and indirect (or multiplier) employment and income effects of construction spending, as well as potential government revenues, including oil and gas property taxes and State corporate income taxes. The MAG-PLAN model and data from previous oil and gas development studies in the North Slope served as the basis for developing rough order of magnitude cost estimates.
- Annual operations and maintenance costs of the facilities—This information was used to calculate direct and indirect (or multiplier) employment and income effects of operations and maintenance spending, as well as potential government revenues, including State corporate income taxes. Prevailing operations costs in other North Slope fields were the basis for developing rough order of magnitude cost estimates.
- Tariffs and transportation costs—This information was used to calculate royalty payments. Data on existing tariffs and transportation costs in the North Slope were obtained from the ADOR Revenue Sources Book.

F.4.27 Public Health

Impacts and Indicators

Action Affecting Resource	Type of Impact	Impact Indicators
Surface disturbance associated with oil and gas development	Impacts on subsistence harvest	• Acres of subsistence harvesting area disturbed • Change in wildlife patterns and avoidance of oil and gas development • Change in Kaktovik resident travel patterns for subsistence harvest
Oil and gas development	Increased construction and vehicle traffic	Change in traffic injury rates
Oil and gas development	Increase in air pollution	Change in quantity of air pollutants introduced from oil and gas operations
Oil and gas development	Increase in noise pollution	Change in use of cabins and camps for subsistence harvesting.
Oil and gas development	Increase in water pollution	• Possibility of oil and other hazardous materials spills • Change in quantity of water pollutants introduced from oil and gas operations • Change in contaminants in fish used for subsistence foods
Oil and gas development	Change in demand for the Kaktovik public health system	• Change in unintentional accidents and injuries • Change in oil and gas revenue for the North Slope Borough and Kaktovik
Oil and gas development	Changes in perception of food contamination. Changes in mental and physical health as a result of limiting subsistence harvest.	• Changes in anxiety and mental health as a result of limiting subsistence harvest due to perceived contamination.
Oil and gas development	Influx of workers into the program area	• Change in infectious disease rates • Increase in drug, alcohol, tobacco rates
Oil and gas development	Economic impacts on health	Change in oil and gas revenue for Kaktovik residents, the North Slope Borough, and Kaktovik
Oil and gas development	Accidents and safety	Changes in Kaktovik resident travel patterns for subsistence harvest

Impact Analysis Area

- Direct/indirect—Program area, including Kaktovik; food, nutrition, and subsistence activities analysis includes the villages of Arctic Village, Nuiqsut, and Venetie. Transboundary impacts are the NWT Gwich'in people, Vuntut Gwich'in people, and Inuvialuit villages in western Canada.
- Cumulative—Program area, including Kaktovik; Food, Nutrition, And Subsistence Activities Analysis includes the villages of Arctic Village, Nuiqsut, and Venetie. Transboundary impacts are the NWT Gwich'in people, Vuntut Gwich'in people, and Inuvialuit villages in western Canada.

Analysis Assumptions

- A health impact assessment will be required for specific oil and gas developments once the lease sale is complete.

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Appendix G

Potential Fossil Yield Classification System

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Appendix G. Potential Fossil Yield Classification System

G.1 INTRODUCTION

The Potential Classification Yield Classification (PFYC) system allows Bureau of Land Management (BLM) employees to make initial assessments of paleontological resources; to analyze potential effects of a proposed action under the National Environmental Policy Act (NEPA); and to conduct other BLM resource-related activities. The PFYC system can also highlight the areas for paleontological research efforts or predict illegal collecting. The system provides a consistent and streamlined approach to determine if a potential action may affect paleontological resources.

The PFYC system provides baseline guidance for assessing paleontological resources. The classification should be considered early in an analysis and should be used to assist in determining the need for further assessment or actions. When considering proposed actions, the PFYC system should be used in conjunction with a map of known fossil localities.

Occurrences of paleontological resources are known to be correlated with mapped geologic units (i.e., formations). The PFYC is created from available geologic maps and assigns a class value to each geological unit, representing the potential abundance and significance of paleontological resources that occur in that geological unit. PFYC assignments should be considered as only a first approximation of the potential presence of paleontological resources, subject to change, based on ground verification.

In the PFYC system, geologic units are assigned a class based on the relative abundance of significant paleontological resources and their sensitivity to adverse impacts. This classification is applied to the geologic formation, member, or other mapped unit. The classification is not intended to be applied to specific paleontological localities or small areas in units. Although significant localities of paleontological resources may occasionally occur in a geologic unit that has been assigned a lower PFYC classification, widely scattered important fossils or localities do not necessarily indicate a higher class assignment. Instead, the overall abundance of scientifically important localities is intended to be the major determinant for the assigned classification.

The descriptions for the class assignments below serve as guidelines rather than as strict definitions. Knowledge of the geology and the paleontological potential for individual geological units are considered when developing PFYC assignments. These assignments must be developed using scientific expertise with input from a BLM paleontologist; however, they may include collaboration and peer review from outside researchers who are knowledgeable about both the geology and the nature of paleontological resources that may be found in each geological unit. Each state has unique geologic maps and unique PFYC assignments. It is possible, and occasionally desirable, to have different assignments for a similar geologic unit across separate states.

G.1.1 Class 1—Very Low

These are geologic units that are not likely to contain recognizable paleontological resources. Units assigned to Class 1 typically have one or more of the following characteristics:

- Geologic units are igneous or metamorphic, excluding air-fall and reworked volcanic ash units.
- Geologic units are Precambrian in age.

Management concerns for paleontological resources in Class 1 units are usually negligible or not applicable. Paleontological mitigation is unlikely to be necessary, except in very rare or isolated circumstances that result in the unanticipated presence of paleontological resources, such as unmapped geology contained in a mapped geologic unit. For example, young fissure-fill deposits often contain fossils but are too limited in extent to be represented on a geological map; a lava flow that preserves evidence of past life, or caves that contain important paleontological resources. (Such exceptions are the reason that no geologic unit is assigned a Class 0.)

Overall, the probability of affecting significant paleontological resources is very low, and further assessment of paleontological resources is usually unnecessary. An assignment of Class 1 normally does not trigger a further analysis, unless paleontological resources are known or found to exist; however, standard stipulations should be put in place before any land use action is authorized, in order to accommodate an unanticipated discovery.

G.1.2 Class 2—Low

This is assigned to geologic units that are not likely to contain paleontological resources. Such units typically have one or more of the following characteristics:

- Field surveys have verified that significant paleontological resources are not present or are very rare.
- Units are generally younger than 10,000 years before present.
- There are recent aeolian (wind-driven) deposits.
- Sediments exhibit significant physical and chemical changes (i.e., diagenetic alteration) that make fossil preservation unlikely.

Except where paleontological resources are known or found to exist, management concerns for paleontological resources are generally low and further assessment is usually unnecessary, except in occasional or isolated circumstances. Paleontological mitigation is necessary only where paleontological resources are known or found to exist.

The probability of affecting significant paleontological resources is low. Localities containing important paleontological resources may exist, but they are occasional and should be managed on a case-by-case basis. An assignment of Class 2 may not trigger further analysis unless paleontological resources are known or found to exist; however, standard stipulations should be put in place before any land use action is authorized to accommodate unanticipated discoveries.

G.1.3 Class 3—Moderate

This is assigned to sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Units assigned to Class 3 have some of the following characteristics:

- Fossils are marine in origin, with sporadic known occurrences of paleontological resources.
- Paleontological resources may occur intermittently, but abundance is known to be low.
- Units may contain significant paleontological resources, but these occurrences are widely scattered.
- The potential for an authorized land use to affect a significant paleontological resource is known to be low-to-moderate.

Management concerns for paleontological resources are moderate because the existence of significant paleontological resources is known to be low. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for casual collecting.

Paleontological mitigation strategies will be proposed, based on the nature of the proposed activity.

This classification includes units of moderate or infrequent occurrence of paleontological resources. Management considerations cover a broad range of options that may include record searches, pre-disturbance surveys, monitoring, mitigation, or avoidance. Surface-disturbing activities may require assessment by a qualified paleontologist to determine whether significant paleontological resources occur in the area of a proposed action and whether the action could affect the paleontological resources.

G.1.4 Class 4—High

This is assigned to geologic units that are known to contain a high occurrence of paleontological resources. Units assigned to Class 4 typically have the following characteristics:

- Significant paleontological resources have been documented but may vary in occurrence and predictability.
- Surface-disturbing activities may adversely affect paleontological resources.
- Rare or uncommon fossils, including nonvertebrate (such as soft body preservation) or unusual plant fossils, may be present.
- Illegal collecting may affect some areas.

Management concerns for paleontological resources in Class 4 are moderate to high, depending on the proposed action.

Paleontological mitigation strategies will depend on the nature of the proposed activity, but field assessment by a qualified paleontologist is normally needed to assess local conditions.

The probability for affecting significant paleontological resources is moderate to high and depends on the proposed action. Mitigation planners must consider the nature of the proposed disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access that could result in looting. Detailed field assessment is normally required, and on-site monitoring or spot-checking may be necessary during land-disturbing activities. In some cases, avoiding known paleontological resources may be necessary.

G.1.5 Class 5—Very High

These are highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources. Units assigned to Class 5 have some or all the following characteristics:

- Significant paleontological resources have been documented and occur consistently.
- Paleontological resources are highly susceptible to adverse impacts from surface-disturbing activities.
- The unit is frequently the focus of illegal collecting.

Management concerns for paleontological resources in Class 5 areas are high to very high.

A field survey by a qualified paleontologist is almost always needed. Paleontological mitigation may be necessary before or during surface-disturbing activities.

The probability for affecting significant paleontological resources is high. The area should be assessed before land tenure adjustments. Pre-work surveys are usually needed, and on-site monitoring may be necessary during land use activities. Avoidance or resource preservation through controlled access, designation of areas of avoidance, or special management designations should be considered.

G.1.6 Class U—Unknown Potential

These are such geologic units that cannot receive an informed PFYC assignment. Characteristics of Class U may include the following:

- Geological units may exhibit features or preservation conditions that suggest significant paleontological resources could be present, but little information about the actual paleontological resources of the unit or area is known.
- Geological units represented on a map are based on lithologic character or basis of origin but have not been studied in detail.
- Scientific literature does not exist or does not reveal the nature of paleontological resources.
- Reports of paleontological resources are anecdotal or have not been verified.
- The area or geologic unit is poorly or under studied.
- BLM staff has not yet been able to assess the nature of the geologic unit.

Until a provisional assignment is made, geologic units that have an unknown potential have medium to high management concerns.

Lacking other information, field surveys are normally necessary, especially before a ground-disturbing activity is authorized. An assignment of Class U may indicate the unit or area is poorly studied, and field surveys are needed to verify the presence or absence of paleontological resources. Literature searches or consultation with professional colleagues may allow an unknown unit to be provisionally assigned to another PFYC, but the geological unit should be formally assigned to a class after adequate survey and research is performed to make an informed determination.

G.1.7 Class W—Water

This class is assigned to any surface area that is mapped as water. Most bodies of water do not normally contain paleontological resources; however, shorelines should be carefully considered for uncovered or transported paleontological resources. Reservoirs are a special concern because important paleontological resources are often exposed during low water intervals. In karst areas, sinkholes and cenotes[1] may trap animals and contain paleontological resources. Dredging river systems may disturb sediments that contain paleontological resources.

G.1.8 Class I—Ice

Includes any area that is mapped as ice or snow. Receding glaciers, including exposed lateral and terminal moraines, should be considered for their potential to reveal recently exposed paleontological resources. Other considerations are melting snow fields that may contain paleontological resources, with possible soft-tissue preservation.

G.1.9 Special Notes

When developing PFYC assignments, the following should be considered:

- Standard stipulations should always be in place before any land use action is authorized, in order to accommodate an unanticipated discovery.
- Class 1 and 2 and Class 4 and 5 units may be combined for broad applications, such as large-scale planning or programmatic assessments, or when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation, and other management considerations will need to be addressed when actual land-disturbing activities are proposed.
- Where large projects affect multiple geologic units with different PFYCs, field surveys and monitoring should be applied appropriately. For example, the BLM Authorized Officer may determine that on-the-ground (pedestrian) surveys are necessary for the Class 4 and 5 formations but not for Class 2 formations.
- Based on information gained by surveys, the BLM may adjust PFYC assignments appropriately. Actual survey and monitoring intensities, as well as the extent of discoveries, should be included in any assessment, mitigation, or permit report so the BLM may reevaluate PFYC assignments.
- A geologic unit may receive a higher or lower classification in specific areas where the occurrence of fossils is known to be higher or lower than in other areas where the unit is exposed.
- Some areas are difficult to evaluate, such as talus, colluvium, tailings, fill, borrow, and other mapped features. A PFYC assignment should be made for each area using available information, or the area should be assigned to Class U.
- The BLM-wide PFYC assignments are maintained and periodically updated by the BLM paleontology team and may be obtained by contacting the BLM state or regional paleontologist assigned to an area.

[1]Deep sinkholes formed by the collapse of limestone cavities and having a pool at the bottom fed by groundwater.

G.2 COASTAL PLAIN GEOLOGIC UNITS' PFYC DESCRIPTIONS

The PFYC model for Alaska is in development as of November 2018; the excerpts below are preliminary PFYC rankings and descriptions for selected units in the program area.[2] Final rankings, descriptions, and associated citations will be incorporated when the PFYC model is complete.

G.2.1 Unconsolidated and Poorly Consolidated Surficial Deposits

PFYC: 3

Most Quaternary, Pleistocene, and uppermost Tertiary deposits have not been given formation names and are frequently mapped based on lithologic character and estimated age. Care should be taken with assessing these deposits for fossil resources, as it is very hard to predict which deposits might be fossiliferous. Many of these types of deposits contain significant flora and fauna, although the distribution of fossils is often spotty. These deposits should not be underestimated for their fossil potential. Recent Holocene and disturbed deposits are ranked very low potential.

G.2.2 Sagavanirktok Formation (Tertiary)

PFYC: 3-4

This formation contains floral fossils (Gryc et al. 1951). Fossil flora were collected from the Sagwon Member of this formation (*Metasequuoia occidentalis*, *Trapa microphylla*, and *Cinnamononum ficoides*; Spicer et al. 1994). There were no fossils from the Franklin Bluffs Member and it is not likely to produce any; the Nuwok Member contains mollusc fossils and prolific microfauna (foraminifers and ostracodes; Detterman et al. 1975). Mull et al. (2003) added the White Hills Member in addition to the Sagwon, Franklin Bluffs, and Nuwok Members. Mollusc fossils were found in what used to unofficially be called the Nuwok Formation (MacNeil 1957).

G.2.3 Jago River Formation (Upper Cretaceous)

PFYC: 3

This formation contains palynomorphs and plant fossils (Buckingham 1987; Molenaar et al. 1987). The Bathtub Graywacke is included in this formation, which does not contain any invertebrate fossils but has some plant fossils; however, the only identifiable material was an equisetum and a few fragments of the marine algae *Tyttodiscus* (Detterman et al. 1975).

G.2.4 Canning Formation (Cretaceous-Tertiary)

PFYC: 3

Palynomorphs were used to decide age (Bird and Molenaar 1987).

G.2.5 Seabee Formation (Upper Cretaceous)

PFYC: 4

Marine fossils found are *Scaphites delicatulus*, Borissjakoceras (ammonites), and Inoceramus (Gryc et al. 1951). Pelecypod and ammonite megafauna and microfauna were found in the lower part of the formation, Foraminifera and palynomorphs in upper part (Mull et al. 2003). Pelecypods, ammonites, fish

[2] B. Breithaupt, BLM Regional Paleontologist, email to Anna Kohl, HDR environmental scientist, on July 30, 2018, regarding preliminary PFYC rankings and unit descriptions for the program area.

scales, and vertebrae (Lindsey 1986) were also found. The Arctos database listed a therapod or small bird trace fossil (footprint).

G.2.6 Hue Shale (Lower Cretaceous)

PFYC: 3

This includes a bed that is rich in Inoceramus bivalve prisms and fish remains; more Inoceramus prisms are found higher in the formation, along with palynomorphs (Molenaar et al. 1987).

G.2.7 Kemik Sandstone (Lower Cretaceous)

PFYC: 3

This unit was previously a member of the Kongakut Formation. Molenaar (1988) mentions some marine mollusc fossils that were collected below this formation but not that they are from this formation particularly. Trace fossils were Skolithos, Dioplocraterion, Arenicolites, and Ophiomorpha (Reifenstuhl 1995). Arctos database lists: belemnite guards.

G.2.8 Wahoo Limestone (Lisburne Group) (Carboniferous)

PFYC: 3

The lower part of the unit has a brachiopod-bryozoan assemblage and corals; the upper part contains brachiopods (Brosgé et al. 1962). It contains some rugose and tabulate corals, but they are not very abundant (Armstrong and Mamet 1977). Colonial corals *Corwenia jagoensis* and *Lithostrotionella wahooensis* were found (Armstrong 1972).

G.2.9 Alapah Limestone (Lisburne Group) (Carboniferous)

PFYC: 3

Lithostrotionoid corals, broken shells, and fish teeth were found (Bowsher and Dutro 1957), along with molluscs, brachiopods, corals, and gastropods (Dutro 1987) and ammonites, plants, Nautiloids (Lindsey 1986).

G.2.10 Ivishak Formation (Sadlerochit Group) (Triassic)

PFYC: 3

This formation contains ammonoids (Keller et al. 1961). It includes the Kavik Member, Ledge Sandstone Member, Fire Creek Siltstone Member (Detterman et al. 1975). The Kavik Member contains ammonites, pelecypods, and a few microfossils; the Ledge Sandstone Member has sparse brachiopods and ammonites, most of which are fragmentary; and the Fire Creek Siltstone Member contains sparse Euflemingites ammonites and Lingula brachiopods (Detterman et al. 1975).

G.2.11 Echooka Formation (Sadlerochit Group) (Permian)

PFYC: 3

Keller et al. (1961) say this formation is fossiliferous, but they do not say what kinds of fossils. They were raised to the formation level and divided into two members by Detterman et al. (1975). The upper part of the Joe Creek Member is abundantly fossiliferous with brachiopods, and the lower part has more sparse fossils; the upper part of the Joe Creek Member also contains abundant bryozoans and corals and some trilobites and pelecypods (Detterman et al. 1975).

G.2.12 Kongakut Formation (Lower Cretaceous)

PFYC: 3

There are buchia shells, some poorly preserved pelecypods, and some microfossils that indicate a similarity to Barremian rocks of the Richardson Mountains in the Yukon Territory (Detterman et al. 1975).

G.2.13 Kingak Shale (Jurassic)

PFYC: 3

Crinoids, bivalves, cephalopods, and ammonites are found in this shale (Leffingwell 1919).

Also included are marine molluscs (bivalves, ammonites, cephalopods, and ammonites) and crinoids (Payne et al. 1951). Early Jurassic fossils in northeast Alaska are sparse but include pelecypods; crinoids are also present in the formation, as well as ammonites and microfossils associated with pelecypods and ammonites (Detterman et al. 1975). There are ammonites from the early Jurassic, but they are not abundant or well preserved (Lindsey 1986). Arctos database: guards from Belemnoidea.

Appendix H

Water Resources

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TABLES

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Appendix H. Water Resources

Table H-1
Average Monthly Air Temperatures at Barter Island, Toolik Lake, and Kuparuk

Barter Island Station: Average Monthly Temperature (°F)		Toolik Lake Station: Average Monthly Temperature (°F)						
Month	**2015**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Jan	no data	no data	-2.3	-2.8	-14.5	-5.1	-11.9	-4
Feb	no data	no data	9.2	12.3	-14.3	-20.2	-10.4	-9.1
Mar	no data	no data	8.1	16.3	-0.3	-3.3	-0.5	no data
Apr	no data	no data	9.7	11.1	11.4	10.3	10.9	no data
May	no data	no data	29.1	38.1	32.8	24.3	28.1	no data
Jun	no data	no data	41.6	47	47.7	49.3	45.6	no data
Jul	no data	no data	51.2	54.6	45.5	52.4	49.7	no data
Aug	no data	no data	39.9	41.1	46.2	41.5	43.6	no data
Sep	no data	32.7	35.2	34.6	32.1	28.4	36.2	no data
Oct	5.2	17	22.7	19.2	17.2	15.7	15.8	no data
Nov	no data	8.9	4.9	1.4	9.2	-7.6	8.2	no data
Dec	no data	10.3	-6.1	-5.1	-2.8	-7.1	1.9	no data

Adapted from *Global Summary of the Month Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-1 *(continued)*
Average Monthly Air Temperatures at Barter Island, Toolik Lake, and Kuparuk

Kuparuk Station: Average Annual Monthly Air Temp (°F)												
Month	**Years (2000 – 2011)**											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Jan	-14.4	-11.8	-20.6	-12	-14	-11	-16	-18	-21	-18	-18.7	-14.3
Feb	-16.7	-5.7	-22.6	-17	-29	-17	-6.6	-14	-19	-17	-12.7	-9.5
Mar	-15.5	-19.7	-4.8	-14	-20	-9.3	-19	-21	-21	-22	-12.7	-8.9
Apr	-1.8	0.8	3.3	7.1	-1	1.1	-4.5	7.6	9.2	3.6	11	-2.5
May	15.3	12.4	27.9	23.8	23.8	23.3	26.2	18.5	27.1	26.7	21.7	23.1
Jun	43.9	39.2	39.3	37.7	44.7	37.5	46.6	39.6	44.6	39	38.3	no data
Jul	46	47.1	45.2	48.5	49.4	40.4	47.6	46.8	49.7	47.5	49.2	no data
Aug	41.8	41.5	43.4	40.6	48.1	44.8	40.2	45.8	41.3	45.3	47.4	no data
Sep	32.8	35.1	38.9	33.1	33.8	34.9	39.7	38	34	34.8	37.5	no data
Oct	14.5	8.6	20.2	23.9	18.8	19.2	24.9	19.2	16.9	25	22.2	no data
Nov	-2.3	-2.4	7.1	-0.3	-1.4	-13	-1	10.7	0.9	-3.2	12.1	no data
Dec	-7.2	-11.8	-3.8	-9.8	-12	-5.9	-4.3	-4.5	-3.1	-3.4	-17.1	no data

Adapted from *Global Summary of the Month Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-1 *(continued)*
Average Monthly Air Temperatures at Barter Island, Toolik Lake, and Kuparuk

Kuparuk Station: Average Annual Monthly Air Temp (°F)												
Month	**Years (2012 – 2023)**											
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Jan	-26	-18	-10.1	-12.9	-4.5	-6	-9.3	-13.1	-22.1	-12.9	-21.8	-6
Feb	-14	-25	-13.5	-6.3	-5.4	-12	0.8	1.7	-29	-29.2	-24.4	no data
Mar	-29	-11	-8.2	-9.8	-7.4	-9.3	-2.2	6.6	-6.6	-14.9	-8.6	no data
Apr	2.2	-2.9	4.2	7.6	10.5	4.5	3.6	5.5	8.8	2	-0.2	no data
May	22	20.6	29.2	31	30.1	25.8	21.2	28.2	23.4	24.3	25.3	no data
Jun	41.8	44.1	38.5	48.1	43.6	38.8	34.5	40.3	40.3	41.9	42.7	no data
Jul	51.4	49.3	45.3	44.4	49.2	52.2	51.3	53	43.3	51.9	44.3	no data
Aug	no data	45.8	42.4	41.1	45.4	45.1	39	43.8	45.3	41.9	45.5	no data
Sep	no data	31.9	34.2	30.3	35.3	36.8	34.9	41.3	35	34.4	36.1	no data
Oct	23.8	22.5	22.1	20.3	24.9	21.3	23.1	26.7	23.6	19.7	22.8	no data
Nov	1	2.3	7.4	0.9	8.6	10.7	4.6	10.8	9.2	-0.9	8.8	no data
Dec	-18	no data	-10.2	-15.9	-8.2	3.9	-8.8	-9.3	-7.6	-14.9	-1.9	no data

Adapted from *Global Summary of the Month Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-2
Average Annual Monthly Precipitation at Toolik Lake and Kuparuk

Toolik Lake Station: Average Monthly Precipitation (Inches)							
Month	Years						
	2017	2018	2019	2020	2021	2022	2023
Jan	no data	0.12	no data	0.17	0.04	0.15	0.19
Feb	no data	0.44	no data	0.35	0.01	0.17	0.05
Mar	no data	0.2	no data	0.72	0.24	0.22	no data
Apr	no data	0.06	no data	1.12	0.33	0.15	no data
May	no data	0.9	no data	1.85	1.35	0.49	no data
Jun	no data	1.45	no data	1.85	1.67	1.46	no data
Jul	no data	3.41	no data	1.67	1.35	3.91	no data
Aug	no data	4.19	no data	1.17	2.01	1.7	no data
Sep	0.69	4.49	0.76	1.99	0.72	1.04	no data
Oct	0.81	no data	1.03	0.8	0.59	0.67	no data
Nov	0.62	no data	0.22	0.55	0.39	0.86	no data
Dec	0.12	no data	0.25	0.16	0.66	1.08	no data

Adapted from *Normals Annual/Seasonal Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-2 *(continued)*
Average Annual Monthly Precipitation at Toolik Lake and Kuparuk

Kuparuk Station: Average Annual Monthly Precipitation (Inches)												
Month	**Years (2000 – 2011)**											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Jan	0.09	0.01	0.21	0.09	0.01	0.2	0.19	0.45	0.04	0	0.21	0.22
Feb	0.12	0	0.15	0.13	0.3	0.09	0.11	0.02	0.19	0.17	0.11	0.26
Mar	0.06	0	0.12	0.02	0.3	0.03	0.01	0.06	0.08	0	0.21	0.03
Apr	0.07	0.01	0.14	0.18	0.04	0.05	0.31	0.14	0.09	0.2	0.12	0.07
May	0	0.03	0	0.19	0	0.14	0.04	0.29	0.56	0.04	0.08	0.51
Jun	0.16	0.35	1.05	0.01	0.4	0.01	0.78	0.22	0.43	0	0.05	no data
Jul	1.12	0.26	1.1	2.22	1.02	1.06	1.67	0.22	1.07	0.45	1.22	no data
Aug	0.38	1.35	1.93	0.67	0.61	0.5	1.07	0.11	0.62	2.13	0.4	no data
Sep	0.14	0.25	1.67	0.4	0.97	0.62	0.12	0.01	0.2	0.67	0	no data
Oct	0.13	0.28	0.46	0.87	0.5	0.21	0.35	0.15	0.52	0.33	0.34	no data
Nov	0.03	0.17	0.04	0.11	0.16	0.5	0.23	0.4	0.29	0.11	0.56	no data
Dec	0.05	0.08	0.44	0.14	0.28	0.25	0.27	0.09	0.19	0.15	0.17	no data

Adapted from *Normals Annual/Seasonal Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-2 *(continued)*
Average Annual Monthly Precipitation at Toolik Lake and Kuparuk

Kuparuk Station: Average Annual Monthly Precipitation (Inches)												
Month	Years (2012 - 2023)											
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	0.17	0.02	0.04	0.16	0.21	0.39	0.23	0.17	0.09	0.04	0.13	0.33
Feb	0.07	0.02	0.12	0.3	0.08	0.52	0.37	0.2	0.13	0.09	0	no data
Mar	0.1	0.2	0.01	0.15	0.2	0.09	0.11	0.33	0.31	0.09	0.01	no data
Apr	0.12	0.91	0.09	0.31	0.1	0.11	0.12	0.19	0.56	0.08	0.05	no data
May	0.09	0.43	0.76	0.09	0.11	0.18	0.25	0.14	0.02	0.11	0.08	no data
Jun	0.03	0.31	0.49	0.14	1.1	0.01	0.3	0.36	0.32	0.95	0.16	no data
Jul	0.1	1.77	1.09	0.28	0.81	0.67	1.59	0.89	0.8	1.15	3.19	no data
Aug	no data	0.89	0.44	2.58	1.63	2.16	1.51	2.68	0.44	0.86	1.22	no data
Sep	no data	1.02	0.5	0.33	1.63	1.02	0.71	0.65	0.61	0.67	0.13	no data
Oct	1.02	0.29	1.42	0.22	0.28	0.87	0.35	0.54	0.09	0.65	0.12	no data
Nov	0.36	0.41	0.5	0.27	0.81	0.83	0.43	0.28	0.47	0.56	0.53	no data
Dec	0.15	no data	0.76	0.05	0.13	0.74	0.33	0.19	0.22	0.32	0.2	no data

Adapted from *Normals Annual/Seasonal Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-3
Average Annual Monthly Snowfall at Kuparuk

Kuparuk Station: Average Annual Monthly Snowfall (Inches)												
Month	**Years (2000 - 2011)**											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Jan	4.1	0.6	4	2.4	0.2	3.5	4.3	5.3	1	0.4	7.4	0.6
Feb	5.5	1	1.4	4.8	2.7	2	2.6	0.5	3.4	5.4	3	1.9
Mar	3.3	0.9	1	2.1	5.1	1	0.8	1.2	2.6	0	4.8	0.8
Apr	4	1.2	1.8	4	1.5	1.3	5.5	3.9	7.2	2.7	2.6	1.9
May	2	7.4	0	6.5	0	3.7	0.8	10.3	0.8	1.6	0.3	1.3
Jun	0	0	1.8	0	0	0.2	0.3	0	0	0	0.3	no data
Jul	0	0	0	0	0	0	0	0	0	0	0	no data
Aug	1.7	0.1	0	0	0	0	0	0	0	0	0	no data
Sep	1.5	1.9	3.4	2.8	4.4	0.3	0	0	0.5	3.5	0	no data
Oct	5.5	7.5	15.3	7.9	8	4.7	6.5	5.1	17.3	6.9	9.3	no data
Nov	0.7	7.1	2.7	3.3	2	10.2	4.8	15.1	7.5	4.4	13.5	no data
Dec	1.1	4.2	9.3	5.4	2.7	5.3	5.5	3.7	4.3	4.2	4.4	no data

Adapted from *Normals Annual/Seasonal Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-3 *(continued)*
Average Annual Monthly Snowfall at Kuparuk

Kuparuk Station: Average Annual Monthly Snowfall (Inches)												
Month	**Years (2012 - 2023)**											
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Jan	2.2	0.9	1	4.1	3.9	1.8	5.2	2.1	1.5	1	1	6.1
Feb	1.4	1	2	3.3	1.1	6.3	6.3	2.6	6	1.3	0	no data
Mar	1.3	4	1.5	3.4	5	3.3	1.5	3.5	2.6	2	0.1	no data
Apr	3	8.9	4.1	10.2	1.3	2.9	0.9	3.5	3	0.7	1.1	no data
May	1.6	4.7	4.4	0.2	0	0.8	4.3	0	0	0.9	0	no data
Jun	0	0	1.4	1	2.5	0	0	0	0	0	0	no data
Jul	0	0	0	0	0	0	0	0	0	0	0	no data
Aug	no data	0	0	0	0	0	0	0	0	0	0	no data
Sep	no data	6	0.6	3.1	0.2	0	0.2	0	7.8	1.5	0.2	no data
Oct	7.1	5.2	7	2.8	1.1	3	3.1	1.7	0.9	10.2	3.2	no data
Nov	3.5	5.2	5.1	4.5	17.2	11.2	5	6.2	3.6	5.6	6.1	no data
Dec	1.7	no data	11.7	1.7	2.5	5.2	5.5	1.7	2	3.3	2.5	no data

Adapted from *Normals Annual/Seasonal Station Details* by the National Centers for Environmental Information: https://www.ncdc.noaa.gov/cdo-web/search

Table H-4
Summary of Drainage Basins and Streams in the Coastal Plain

Drainage Basin	Water Bodies (Notable Streams)	Headwater Origin	Receiving Water	Drainage Area (Square Miles)	Length (Miles)
Aichilik River	None	Romanzof Mountains	Beaufort Lagoon	—	75
Akutoktak (Akootoaktuk) River	None	Romanzof Mountains	Okpilak River	97	11.8
Angun River	None	Tundra Drainage	Angun Lagoon, Beaufort Sea	745	30
Canning River	Marsh Fork	Franlin Mountains	Camden Bay	1930	125
Hulahula River	None	Romanzof Mountains	Camden Bay	685	90
Itkilyariak Creek, West Fork	Itkilyariak Creek, Salderochit River	Sadlerochit Mountains	Camden Bay	27	14.8
Jago River	None	McCall Glacier on Mt. Isto, Romanzof Mountains	Jago Lagoon, Beaufort Sea	798	90
Marsh Fork-Canning River	Canning River	Philip Smith Mountains	Canning River	—	50
Niguanak River	None	Tundra drainage	Oruktalik Lagoon	136	14.1
Okpilak	Akutoktak River	Okpilak Glacier, Brooks Range	Camden Bay	—	70
Sadlerochit River	Peters River	Franklin Mountains, Brooks Range	Camden Bay	520	0.2
Sadlerochit Spring Creek	Itkilyariak Creek, Salderochit River	Eastern Sadlerochit Mountains	Camden Bay	0.5	—
Sikrelurak River	None	Tundra drainage	West Fork Sikrelurak River	75	18.5
Tamayariak River	Upper Main Stem, Lower West Fork, Middle Fork, and Upper West Fork of Tamayariak River, Canning River	Sadlerochit Mountains	Beaufort Sea	350	19.3

Adapted from *Water Resource Inventory and Assessment* by the US Dept. of the Interior (1987–1992, Table 2), https://www.fws.gov/alaska/water/arctic.htm, and https://alaska.guide/Rivers.
Re-created from *National Hydrography Dataset: flowlines GIS data*. by the US Geological Survey and https://alaska.guide/Rivers.

Table H-5
Surface Water Discharge

Akutoktak River																
Recording Period	Average Daily Value (Cubic Feet/Second)									Period Measurement Summary						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM*)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	Instantaneous Peak Flow (IPF)	IPF Date	Total Runoff	Average Runoff	Total Runoff
May 19-Sep 26 1988	280	1000	20	10	20	5.9	33	111	5.5	89	6.03	119*	8/23/1988	23046	0.91	4.45
Jul 6- Aug 20 1989	295	1020	10	129	719	2.4	—	608	66	233	3.57	1703	8/20/1989	29096	2.4	5.62
May 18-Sep 19 1990	27	134	6.9	3	8	1.0	3	11	0.80	38	0.93	215	6/20/1990	9454	0.39	1.83
May 17-Sep 24 1991	255	1230	31	45	314	3.1	36	100	11	111	3.77	768	6/14/1991	28717	1.14	5.55
May 28–Sep 21 1992	180	630	11	10	29	4.3	105	943	7.5	104	5.57	1818	8/27/1992	24202	1.07	4.67

*Cubic Feet per Second per Square Mile
Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Itkilyariak Creek, West Fork																
Recording Period	Average Daily Value (Cubic Feet/Second)									Period Measurement Summary						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
1988	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
May 27–Sep 22 1989	42	90	4.9	49	320	0.0	101	554	25.0	59	1.88	1419	8/20/1989	13909	2.19	9.69
May 13–Sep 19 1990	30	89	4.9	7.6	49	0.0	5.0	21	1.2	54	0.53	160	6/19/1990	13921	2.01	9.70
May 18–Sep 24 1991	202	1120	37	11	37	6.0	25	173	4.1	85	2.89	276	6/14/1991	19624	3.14	13.68
May 29–Sep 21 1992	78	710	7.7	—	24	15	80	679	3.7	91	—	1255	8/27/1992	14740	3.37	10.27

*Estimate
Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Niguanak River (in cubic feet/second unless noted otherwise)																
	Average Daily Value (Cubic Feet/Second)									Period Measurement Summary						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
Recording Period	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
1988	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jun 9–Sep 22 1989	518	1360	53	76	311	18	193	1148	50	259	39.50	2071	8/21/1989	60670	1.90	8.35
May 11–Sep 19 1990	65	138	26	—	21	0.7	—	1	0.0	111	0.00	—	—	29170	0.82	4.02
May 17–Sep 24 1991	716	2000	215	123	515	41	22	52	9.3	282	4.11	1319	6/14/1991	73199	2.07	10.08
May 28- Jul 7 1992	321	1109	90	—	203	92	—	—	—	—	—	—	—	—	—	—

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Sadlerochit River																
Recording Period	Average Daily Value (cubic ft/sec)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
Jul 21–Sep 27 1988	—	—	—	—	846	342	—	1937	695	—	92.91	2194	8/22/1988	—	—	—
Jun 19–Sep 23 1989	—	3315	923	1672	4124	649	159	4385	572	1414	313.63	5733	8/4/1989	271966	2.72	9.80
Jun 11–Sep 3 1990	1333	2678	177	943	1429	633	432	662	271	833	333.05	4857	6/18/1990	140419	1.60	5.06
Jun 4–Sep 24 1991	1793	3715	365	1317	9190	399	692	1732	380	1035	122.67	21000	7/21/1991	203142	1.99	7.32
Jun 2 to Sep 21 1992	1563	2614	123	1670	5656	625	1034	4216	362	1240	88.97	9506	7/26/1992	280395	2.38	10.11

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service

Table H-5 *(continued)*
Surface Water Discharge

Sadlerochit Spring Creek																
Recording Period	Average Daily Value (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
Jul 22–Sep 30 1988	38	40	33	39	40	37	41	44	37	36	28	55	8/16/1988 8/19/1988	25795	—	967
Oct 1 1988–Sep 30 1989	37	42	32	43	52	38	58	81	46	41	28	108	8/20/1989	29334	—	1100
Oct 1 1989–Sep 30 1990	39	40	36	37	40	36	36	36	35	37	28	41	8/18/1990 8/19/1990	26825	—	1006
Oct 1 1990–Sep 30 1991	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct 1 1991–Sep 30 1992	38	40	36	42	45	40	45	51	45	36	28	61	8/27/1992	26075	—	978

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Sikrelurak River																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
Jun 8–Sep 22 1988	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jun 8–Sep 22 1989	336	1220	16	19	72	1.7	62	235	13	126	4.38	282	8/20/1989	28518	1.69	7.16
May 18–Sep 19 1990	22	47	11	2.2	9.2	1.7	0.3	1.5	0.0	42	0.00	117	9/7/1990	10386	0.56	2.61
May 17–Sep 24 1991	310	1480	44	33	118	13	11	28	4.6	108	3.14	1787	6/4/1991	28004	1.44	7.03
May 28–Sep 14 1992	767	930	15	6	26	1.3	1.4	2.0	1.3	99	1.35	1057	6/10/1992	19654	1.33	4.93

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987-1992): Appendix A* by the US Fish and Wildlife Service

Table H-5 *(continued)*
Surface Water Discharge

Tamayariak River																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Table						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
May 26–Sep 26 1988	563	1400	160	70	140	18	312	1039	120	279	21.07	1996	8/12/1988	68526	2.05	9.44
Jun 1–Sep 22 1989	696	2140	114	242	823	53	338	778	138	383	93.54	997	7/17/1989	86571	2.81	11.93
May 11 to Sep 19 1990	197	794	88	56	146	30	116	1100	21	247	23.57	4099	9/6/1990	64748	1.82	8.92
May 17–Sep 24 1991	681	2000	139	288	1400	66	279	2442	72	381	62.13	3244	8/22/1991	98928	2.80	13.63
May 27–Aug 26 1992	385	1032	109	65	154	32	1777	68	25	217	27.69	2856	8/27/1992	39564	1.59	5.45
Jun 1–Sep 20 2008	173	347	60	87	457	27	238	1340	27	a	—	—	—	—	—	—
Oct 1 2008-Sep 30 2009	595	1550	117	68	239	20	172	533	32	94	0.00	2250	6/5/2009	67840	0.63	8.54
Oct 1 2009-Sep 30 2010	330	704	116	119	310	48	220	1000	39	70	0.00	1570	8/7/2010	50360	0.47	6.34
Oct 1 2010–Sep 30 2011	311	615	76	71	203	40	57	180	30	88	0.00	3230	5/26/2011	63280	0.587	7.96
Oct 1 2011–Sep 30 2012	286	775	76	82	249	38	181	465	74	72	0.00	1190	5/31/2012	52070	0.48	6.55

Note: a denotes statistics not provided by USGS due to partial water year.
Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service and *USGS Water Data Reports 2008–2012 Station 15960000 Tamayariak R near Kaktovik, Alaska.*

Table H-5 *(continued)*
Surface Water Discharge

Tamayariak River, Lower West Fork																	
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report							
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
May 28–Sep 26 1988	403	1380	50	20	40	11	114	392	9.4	155	10.17	496	9/5/1988	38123	1.58	7.28
Jun 1–Sep 20 1989	525	1880	10	115	345	43	153	477	44	221	25.14	647	8/21/1989	49204	2.26	9.40
May 18–Sep 19 1990	43	110	20	11	20	6.1	3.8	6.1	2.2	133	2.41	2455	9/6/1990	32981	1.36	6.30
May 17–Sep 24 1991	493	2050	135	129	960	24	50	241	19	206	21.50	1750	7/23/1991	53649	2.10	10.25
Oct 1991–Sep 1992	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987-\–1992): Appendix A* by the US Fish and Wildlife Service

Table H-5 *(continued)*
Surface Water Discharge

Tamayariak River, Middle Fork																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
May 26–Sep 26 1988	384	1300	50	8.6	40	2.2	100	351	1.4	139	2.02	618	9/5/1988	34185	2.27	10.46
Jun 5–Sep 20 1989	454	1780	26	70	255	14	127	282	43	193	18.87	303	8/21/1989	42889	3.15	13.12
May 11–Sep 19 1990	39	151	12	3.5	11	0.82	0.78	4.7	0.41	69	0.46	637	9/6/1990	18165	1.13	5.56
May 17–Sep 24 1991	373	1580	38	90	800	14	34	225	6.9	144	6.11	1867	6/4/1991	37507	2.35	11.47
May 28–Sep 15 1992	90	470	12	3.7	17	0.80	65	1026	0.60	73	0.71	1455	8/27/1992	16024	1.19	4.90

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Tamayariak River, Upper West Fork																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
May 26–Sep 26	439	1490	60	9.4	50	0.8	85	271	1.1	144	0.92	404	8/13/1988	35536	2.94	13.54
Jun 1–Sep 20 1989	418	2050	24	55	220	3.4	126	530	37	175	10.89	1478	8/20/1989	38785	3.55	14.78
May 18–Sep 19 1990	26	130	6.0	1.9	6.2	0.00	17	323	0.00	79	0.00	1328	9/6/1990	19597	1.61	7.47
May 17–Sep 24 1991	350	1820	82	99	681	9.1	38	202	6.3	145	2.70	1219	8/22/1991	37794	2.96	14.40
May 28–Aug 25 1992	154	890	6.6	11	40	4.0	0.73	4.0	0.00	89	0.00	996	6/10/1992	16042	1.81	6.11

Adapted from *Water Resource Inventory and Assessment Arctic National Wildlife Refuge (1987–1992): Appendix A* by the US Fish and Wildlife Service.

Table H-5 *(continued)*
Surface Water Discharge

Canning River																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
Jun 23–Sep 30 2008	—	—	—	4779	13200	1990	4317	12800	1180	a	—	—	—	—	—	—
Oct 1 2008–Sep 31 2009	11260	28900	4550	4435	11200	2240	2505	5040	1370	1961	0.00	32700	6/10/2009	1420000	1.02	13.79
Oct 1 2009–Sep 31 2010	4555	9000	1760	4906	15300	2190	6315	16900	2520	1629	20	19200	7/31/2010	1180000	0.84	11.46
Oct 1 2010–Sep 31 2011	3749	10300	1300	3811	11900	1970	2588	6610	1310	1502	20	a*	a	1088000	0.78	10.57
Oct 1 2011–Sep 31 2012	5161	10200	2410	4713	10900	2400	4094	9390	1830	1541	2	13000	7/26/2012	1118000	0.80	10.87

*Denotes statistics not calculated by US Geological Survey.
Adapted from USGS Water Report 2008–2012 15955000 Canning River Above Staines River Near Deadhorse AK

Table H-5 *(continued)*
Surface Water Discharge

Hulahula River																
Recording Period	Average Daily Values (Cubic Feet/Second)									Period Summary Report						
	Jun			Jul			Aug			(Cubic Feet/Second)				(Ac-Ft)	(CFSM)	(In)
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Seven-Day Low Flow	IPF	IPF Date	Total Runoff	Average Runoff	Total Runoff
Oct 1 2010–Sep 31 2011	1157	4960	257	1869	5720	765	945	3690	362	489	0	12800	5/24/2011	354200	0.71	9.7
Oct 1 2011–Sep 31 2012	1783	3930	523	2329	4940	1420	1234	2650	545	535	0	6640	7/25/2012	388300	0.78	10.63
Oct 1 2012–Sep 31 2013	3198	9500	429	2766	6780	1290	1933	4840	576	745	0	12700	6/17/2013	539300	1.09	14.77
Oct 1 2013–Sep 31 2014	2366	4090	1390	2399	4630	847	1176	2760	784	563	0	6240	7/4/2014	a*	0.82	11.2
Oct 1 2014–Sep 31 2015	1259	2510	324	1571	3310	690	1466	3170	732	492	0	4830 b	5/26/2015	a	0.72	9.76
Oct 1 2015–Sep 31 2016	2580	8750	293	2299	8890	666	1584	2800	731	653	0	13500	7/8/2016	a	0.95	13
Oct 1 2016–Sep 31 2017	1392	2440	722	2089	4950	1440	2150	3140	1380	579	0	6870	7/24/2017	a	0.85	11.5
Oct 1 2017–Sep 30 2018	1753	5150	249	2880	5570	1100	1374	3180	425	639	0	5570	7/29/2018	a	0.933	12.7
Oct 1 2018–Sep 30 2019	1990	9770	835	2603	7450	1440	1424	3200	690	685	0	16300	6/30/2019	a	0.997	13.5
Oct 1 2019–Sep 30 2020	1650	3190	784	948	2220	414	1131	2610	563	390	0	3740	6/25/2020	a	0.568	7.73
Oct 1 2020–Sep 30 2021	2013	4780	176	2536	10500	862	1413	4780	176	558	0	21200	7/4/2021	a	0.811	11
Oct 1 2021–Sep 30 2022	1928	3197	1157	2213	2880	948	1436	2150	945	539	0	13000	7/4/2022	a	0.784	10.6

*Denotes statistics not calculated by USGS. b denotes discharge due to snowmelt, ice jam, or debris breakup
Adapted from *USGS Water Report 2011–2021 15980000 Hulahula River Near Kaktovik, AK* and *USGS Water-Data Report 2018 15980000 Hulahula River Near Kaktovik, AK*

Table H-6
Summary of Data for Lakes in Regions of the Program Area

Ice Depth		0 Feet (Ft) Ice		4 Ft Ice (Jan 4)		7 Ft Ice (Apr 16)	
Region	**No. Lakes**	**Volume (Acre-Ft)**	**Percent of Total**	**Volume (Acre-Ft)**	**Percent of Total**	**Volume (Acre-Ft)**	**Percent of Total**
Canning	43	35,541	64.2	12,378	69.7	2,669	79.3
Katakturuk	2	339	0.6	93	0.5	6	0.2
Sadlerochit	34	9,959	18.0	2,504	14.1	186	5.5
Jago	40	9,543	17.2	2,783	15.7	505	15.0
Totals	**119**	**55,382**	**100.0**	**17,758**	**100.0**	**3,366**	**100.0**

Re-created from *Distribution and quantification of water within the lakes of the 1002 Area, Arctic National Wildlife Refuge, Alaska*: *Table 1* (USFWS 2015).

H.1 Reference

USFWS (US Fish and Wildlife Service). 2015. Arctic National Wildlife Refuge Revised Comprehensive Conservation Plan. US Fish and Wildlife Service, Final Environmental Impact Statement, Vol. 1. Internet website: https://www.fws.gov/home/arctic-ccp/.

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Appendix I

Solid and Hazardous Waste

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Appendix I. Solid and Hazardous Waste

Table I-1
Facilities Registered with the EPA and ADEC in the Vicinity of the Coastal Plain

EPA or ADEC Registry ID	Facility Name	Description	Location
110067059523	Bill Sands Camp	Mobile camp; various sites	Beaufort Lagoon
110064792112	USFWS Arctic Refuge: Griffin Point DEW Line Staging Site	—	Griffin Point
110003039104	Kaktovik Department of Municipal Services	Conditional exempt small quantity generator	Kaktovik
110030898544	Kaktovik Wastewater Treatment Facility	Wastewater treatment facility	Kaktovik
110006878129	US Air Force LRRS - Barter Island	Various facilities DEW Line and LRRS	Kaktovik
110006877610	USFWS Nuvagapak DEW Line Site	—	Nuvagapak Point
AKG573038	Kaktovik Sewage Lagoon	File not available	Kaktovik
POA-2001-1081-M11	Beaufort Sea Exxon Point Thomson Project	Placement of fill in wetlands and streams	Kaktovik
AKG572024	Kaktovik Wastewater Treatment Facility	Authorization to discharge effluent into a mixing zone in Kaktovik Lagoon	Kaktovik
2016DB0001-0023	Point Thomson Central Pad	Injection of nonhazardous wastes in a Class I Underground Injection Control Well	Kaktovik
POA-2001-1082-M11	Beaufort Sea Exxon Point Thomson Project	File not available	Kaktovik
POA-2011-1092	Beaufort Sea NSB Material Site	Placement of fill in 105.04 acres of wetland	Kaktovik
POA-2011-957	Beaufort Sea NSB Airport	Placement of fill in 31.36 acres of wetland	Kaktovik
POA-2004-8	Kaktovik Lagoon Kaktovik Subdivision	Placement of fill in 7.6 acres of wetland	Kaktovik

Sources: EPA 2023; ADEC GIS 2023

Table I-2
Solid Waste Facilities in the Vicinity of the Coastal Plain

Facility Name	Classification	Location	Status
Kaktovik Landfill	Class III landfill[1]	Kaktovik	Closed
Kaktovik Community Tank Farm	Tank farm	Kaktovik	Active
Kaktovik Barter Island LRRS Hanger	Military	Kaktovik	Active
Kaktovik Barter Island LRRS Refueling Area	Polluted soil	Kaktovik	Active
Kaktovik 1.9 SE Landfill	Class III landfill	Kaktovik	Active
Barter Island LRRS-C&D GP	Inert monofill	Kaktovik	Retired
Barter Island LRRS Biosolids Land Application	Land application site	Kaktovik	Retired
Barter Island (Kaktovik) LRRS (BAR-Main DEWline)	Class III camp landfill	Kaktovik	Retired

Source: ADEC 2023a

Table I-3
ADEC Identified Contaminated Sites in the Vicinity of the Coastal Plain

ADEC Hazard ID	Site Name	Status
737	Brownlow Point/DERP	Cleanup complete
752	Barter Island DEW—POL catchment	Cleanup complete
753	Barter Island DEW—old dump site (LF019)	Cleanup complete
755	Barter Island Dew—garage (SS014)	Cleanup complete, institutional controls
756	Barter Island DEW—weather station	Cleanup complete
757	Barter Island DEW—POL tanks	Cleanup complete, institutional controls
759	Barter Island DEW—JP-4 spill (SS021)	Cleanup complete
760	Barter Island DEW—old landfill (LF001)	Cleanup complete
761	Barter Island DEW—runway Dump	Cleanup complete
801	Barter Island DEW—contamination ditch (SD008)	Cleanup complete
1431	Waldo arms fuel	Cleanup complete
1679	Collinson Point DEW Line—Sitewide	Informational
1680	Nuvagapak Point DEW line – Sitewide	Informational
1681	Griffin Point/DERP	Cleanup complete
1686	Manning Point/DERP	Cleanup complete
1921	Kaktovik Kaveolook School	Cleanup complete
2306	NSB Kaktovik power plant tank farm	Active
2307	NSB Kaktovik tank farm terminal	Active
2327	NSB Kaktovik KIC pad	Active
3085	Barter Island—staging area	Cleanup complete
4036	Barter Island DEW—air terminal (SS011)	Cleanup complete, institutional controls
4038	Barter Island DEW—dump area NW (LF009)	Cleanup complete
4222	Barter Island LRRS refueling area (CG002)	Cleanup complete
4229	Barter Island LRRS hangar (SS022)	Active
25328	Collinson Point DEW Line POL pipeline corridor	Active
25329	Collinson Point DEW Line AST pad and AST pond	Active
25330	Collinson Point DEW Line Quonset hut #3	Active

[1]Rural landfills often not connected by road to a larger landfill or are more than 50 miles by road from a larger landfill. The landfill serves fewer than 1,500 people.

ADEC Hazard ID	Site Name	Status
25331	Collinson Point DEW Line shop building area	Active
25332	Collinson Point DEW Line composite building area	Active
25333	Nuvagapak Point DEW Line AST pad area	Active
25334	Nuvagapak Point DEW Line Composite Building	Active
25335	Nuvagapak Point DEW Line dump site D	Active
25336	Nuvagapak Point DEW Line debris pile A (Grid Area)	Active
25337	Nuvagapak Point DEW Line Kogotpak River dump site E	Active
26499	Nuvagapak Point DEW Line Shop Area	Active
26827	NSB Kaktovik transformer	Active
27709	Barter Island DEW-New CERCLA Landfill (LF001)	Active

Source: ADEC 2023b, 2023c

Table I-4
ADEC 1995–2023 Database Spill Records for Areas near Kaktovik, Alaska[2]

Year	Number of Spill Records	Annual Cumulative Spill Volume (Gallons)	Substance Spilled
1996	1	150	Diesel
1999	3	545	Diesel and engine lube oil
2004	3	561	Used oil and diesel
2005	1	*28 pounds*	Other
2006	1	100	Diesel
2008	4	2,065	Gasoline and diesel
2009	1	75	Ethylene glycol (antifreeze)
2010	2	2,456	Diesel
2011	1	25	Engine lube oil
2014	3	355	Glycol and propylene glycol
2015	1	5,250	Diesel
2016	4	201	Ethylene glycol, process water, diesel, and other
2017	6	4,415	Diesel, ethylene glycol, and unknown
2018	2	630	Diesel and gasoline
2020	3	70	Diesel and other
2021	2	659	Diesel and engine lube oil
2022	3	1,270	Diesel and process water

Source: ADEC 2023c

[2] Database search ended March 31, 2023; no spills occurred for years not included in Table I-4

Table I-5
ADEC 1995–2023 Database Spill Records for the North Slope, Alaska

Year	Number of Spills	Very Small Spills[1]	Small Spills[2]	Medium Spills[3]	Large Spills[4]	Very Large Spills[5]
1995	222	129	59	20	14	0
1996	434	222	152	48	12	0
1997	467	220	159	67	20	1
1998	430	213	158	45	14	0
1999	375	206	115	43	11	0
2000	392	222	117	41	12	0
2001	535	315	149	56	15	0
2002	504	313	134	38	19	0
2003	423	259	106	45	13	0
2004	428	253	114	47	14	0
2005	442	231	129	68	14	0
2006	500	261	135	88	13	3
2007	581	348	139	75	19	0
2008	546	331	125	72	17	1
2009	484	290	121	53	20	0
2010	380	192	116	67	5	0
2011	340	211	83	35	11	0
2012	379	253	75	44	7	0
2013	331	197	80	39	14	1
2014	377	238	82	44	13	0
2015	368	229	92	42	5	0
2016	311	177	72	29	33	0
2017	247	148	66	26	7	0
2018	228	135	61	24	8	0
2019	265	174	59	23	9	0
2020	184	129	39	11	5	0
2021	166	95	49	19	3	0
2022	271	157	76	29	9	0
2023[3]	62	40	15	7	0	0

Source: ADEC 2023d
[1]Less than 0.24 barrels (10 gallons)
[2]0.24–2.4 barrels (10–99 gallons)
[3]2.4–24 barrels (100–999 gallons)
[4]24–2,380 barrels (1,000–100,000 gallons)
[5]More than 2,380 barrels (100,000 gallons)

[3] Data for 2023 is January 1, 2023 to March 31, 2023

Table I-6
1.5 Billion Barrels of Oil Produced Estimated Spill Count

Substance	Spill Size			
	Small	Medium	Large	Total
Crude Oil	194.30	3.95	0.30	198.54
Refined Oil	845.06	2.12	0.00[4]	847.17
Seawater and Produced Water	141.86	12.12	2.12	156.09
Other Hazardous Materials	579.24	4.85	0.30	584.39
Total	1,760.45	23.03	2.72	1,786.19

Source: NPR-A IAP/EIS Appendix I Table I-1 North Slope Spill Rates by Substances and Size per Billion Barrels of Oil Produced (2000-2018)

Table I-7
10.0 Billion Barrels of Oil Produced Estimated Spill Count

Substance	Spill Size			
	Small	Medium	Large	Total
Crude Oil	1,942.95	39.45	3.00	1,985.40
Refined Oil	8,450.55	21.15	0.00[4]	8,471.70
Seawater and Produced Water	1,418.55	121.20	21.15	1,560.90
Other Hazardous Materials	5,792.40	48.45	3.00	5,843.85
Total	17,604.45	230.25	27.15	17,861.85

Source: NPR-A IAP/EIS Appendix I Table I-1 North Slope Spill Rates by Substances and Size per Billion Barrels of Oil Produced (2000-2018)

[4] Large spills of refined oil for production exceeding 1 billion barrels of oil may be larger than 0.00

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Appendix J

Vegetation and Wetlands, Birds, Terrestrial Mammals, and Marine Mammals

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TABLES

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Appendix J. Vegetation and Wetlands, Birds, Terrestrial Mammals, and Marine Mammals

J.1 Vegetation and Wetlands

The vegetation mapping used in this SEIS is based on land cover mapping of the Arctic National Wildlife Refuge prepared by ABR (Macander et al. 2020). The land cover map used existing data from 789 vegetation plots sampled in 3 previous studies as well as helicopter and ground surveys conducted in 2019. Data collected at each plot included soil stratigraphy, physiography, and other environmental variables as well as detailed information on plant cover, including vascular plants, mosses, and lichens. Soils samples were collected and analyzed for properties including texture, pH, and electrical conductivity. These data sets, combined with interpretation of remote sensing imagery, were used to develop and map 20 land cover classes, including 1 forested, 5 shrub, 10 herbaceous, 2 sparsely vegetated types, and 2 abiotic classes. The overall accuracy of the map was approximately 85%; where errors occurred, they typically involved similar classes (e.g., dryas dwarf shrub and moist sedge-dryas tundra). These land cover classes were used as the vegetation types to describe the affected environment of the program area and analyze potential impacts under each alternative.

Table J-1 provides a brief description of each land cover type, including environmental characteristics and typical species. **Table J-2** lists rare vascular plant species with documented occurrences in the program area. **Table J-3** provides a comparison across alternative of the acreage of each land cover class that would fall within each land use category. For each alternative, **Table J-4** lists the acres of each land cover class that would be directly and indirectly impacted based on the maximum development footprint scenario under each alternative (i.e., areas available for leasing under each alternative).

Table J-5 describes the wetland classes that occur in the project area and lists the specific wetland types included in each class. **Table J-6** provides a comparison across alternative of the acreage of each wetland class that would fall within each land use category. For each alternative, **Table J-7** lists the acres of each wetland class that would be directly and indirectly impacted based on the maximum development footprint for each alternative (i.e., areas available for leasing under each alternative).

Table J-1
Descriptions of Land Cover Classes[1] in the Program Area

Land Cover Class	Description	Typical Species
Poplar forest	Distribution: Very limited in extent in the project area. It occurs in small patches in riverine and upland physiography on a river bar at Sadlerochit Springs, at the east end of the Sadlerochit Mountains, and on a terrace above the Hulahula River Soils: Rocky, no additional information available Permafrost: Absent or present at a depth >2 meters Vegetation: Forested; some stands exhibit a stunted growth form	Trees: *Populus balsamifera* Shrubs: *Salix alaxensis, Dasiphora fruticosa, Arctous rubra, Dryas integrifolia* Grasses: *Festuca altaica, Leymus innovates* Other herbaceous: *Senecio lugens, Anemone parviflora, Pyrola grandiflora, Polygonum bistorta* Mosses: *Sanionia uncinate* Lichens: *Peltigera elisabethae*
Low and tall riverine willow shrub	Distribution: Riverine physiography, including active and inactive riverbanks Slope: Flat to nearly level Soils: Moderately well drained to excessively drained, alkaline, surface organic layer absent to thin Permafrost: Typically, absent Vegetation: Open and closed shrub communities dominated by low and tall willows	Shrubs: *Salix alaxensis*, *S. glauca*, *S. richardsonii, Dryas integrifolia* Herbaceous: *Equisetum variegatum, Lupinus arcticus* Mosses: *Tomenthypnum nitens, Hylocomium splendens*
Low and dwarf birch shrub	Distribution: Lowland, and upland physiography, particularly in the foothills of the Brooks Range Slope: Gently to strongly sloping Soils: Moderately well drained to well drained, acidic to circumneutral, organic layer very thin to moderately thick Permafrost: Typically present, average thaw depth 42 centimeters Vegetation: Open and closed shrub communities dominated by low and dwarf birch; willows may also be present; substantial moss component.	Shrubs: *Betula nana, Salix glauca, S. pulchra, Vaccinium vitis-idaea* Sedges: *Carex aquatilis, Eriophorum angustifolium* Other herbaceous: *Petasites frigidus, Rubus chamaemorus* Mosses*: Hylocomium splendens, Aulacomnium turgidum, A. palustre, Tomenthypnum nitens*
Ericaceous dwarf shrub	Distribution: Upland physiography, typically associated with hummocks or high-center polygons Slope: Strongly sloping to moderately steep Soils: Well-drained to excessively drained, acidic to circumneutral, surface organic layer very thin to moderately thick Permafrost: Typically present, average thaw depth 40 centimeters Vegetation: Dwarf shrub-dominated communities with substantial moss and lichen components	Shrubs: *Vaccinium vitis-idaea, Ledum decumbens, Betula nana, Cassiope tetragona* Sedges: *Eriophorum vaginatum* Other herbaceous: *Rubus chamaemorus* Mosses: *Hylocomium splendens, Tomenthypnum nitens* Lichens: *Flavocetraria cucullata, Dactylina arctica*

Land Cover Class	Description	Typical Species
Dryas dwarf shrub	Distribution: Upland, and riverine physiography, including hillsides and old river terraces Slope: Nearly level to strongly sloping Soils: Moderately well drained to excessively drained, circumneutral to alkaline, surface organic layer very thin to thin Permafrost: Typically present, average thaw depth 79 centimeters Vegetation: Dwarf shrub-dominated communities with substantial moss and lichen components	Shrubs: *Dryas integrifolia*, *Salix reticulata* Sedges: *Carex bigelowii* Other herbaceous: *Equisetum variegatum* Mosses: *Tomenthypnum nitens, Hylocomium splendens, Rhytidium rugosum* Lichens: *Flavocetraria cucullata, Cetraria islandica*
Moist sedge-dryas tundra	Distribution: Lowland, riverine, and upland physiography, typically associated with hummocks or high-center polygons Slope: Nearly level to gently sloping Soils: Poorly drained to moderately well drained, circumneutral to alkaline, surface organic layer thin to moderately thick Permafrost: Typically present, average thaw depth 50 centimeters Vegetation: Communities dominated by sedges and dwarf shrubs, with a substantial moss component	Shrubs: *Dryas integrifolia*, *Salix reticulata*, *Cassiope tetragona* Sedges: *Carex bigelowii, Eriophorum angustifolium, E. vaginatum* Mosses and liverworts: *Tomenthypnum nitens Hylocomium splendens, Ptilidum ciliare,*
Shrub tussock tundra	Distribution: Widespread in lowland and upland physiography Slope: Typically, gently sloping Soils: Somewhat poorly drained, acidic to circumneutral, surface organic layer moderately thick Permafrost: Typically present, average thaw depth 43 centimeters Vegetation: Tundra dominated by tussock cottongrass (*Eriophorum vaginatum*) and low shrubs, with a substantial moss component	Shrubs: *Betula nana, Vaccinium vitis-idaea, Salix pulchra*, *Ledum decumbens* Sedges: *Eriophorum vaginatum, E. angustifolium, Carex bigelowii* Mosses and liverworts: *Hylocomium splendens, Aulacomnium turgidum, Ptilidum ciliare, Tomenthypnum nitens*
Tussock tundra	Distribution: Widespread in lowland and upland physiography Slope: Nearly level to gently sloping Soils: Somewhat poorly drained to moderately well drained, circumneutral to alkaline, surface organic layer moderately thick Permafrost: Typically present, average thaw depth 47 centimeters Vegetation: Tundra dominated by tussock cottongrass (*Eriophorum vaginatum*), with a substantial moss component	Sedges: *Eriophorum vaginatum, E. angustifolium, Carex bigelowii* Shrubs: *Vaccinium vitis-idaea, Salix pulchra, S. reticulata, Betula nana, Dryas integrifolia* Mosses and liverworts: *Hylocomium splendens, Tomenthypnum nitens, Aulacomnium turgidum, Ptilidum ciliare*

Land Cover Class	Description	Typical Species
Moist sedge-willow tundra	Distribution: Lowland, riverine, and upland physiography Slope: Nearly level to gently sloping Soils: Somewhat poorly drained to moderately well drained, circumneutral to alkaline, surface organic layer very thin to moderately thick Permafrost: Typically present, average thaw depth 62 centimeters Vegetation: Tundra communities dominated by sedges and low and dwarf willows, with a substantial moss component	Shrubs: *Salix pulchra, S. reticulata, S. richardsonii, Dryas integrifolia* Sedges: *Eriophorum angustifolium, Carex aquatilis, C. bigelowii, E. vaginatum* Mosses: *Tomenthypnum nitens, Hylocomium splendens, Aulacomnium turgidum, A. palustre*
Sedge-willow tundra in drainage tracks	Distribution: Lowland and upland physiography; associated with water tracks (non-incised drainages) in moist tundra; often occurs as a mosaic with shrub tussock tundra Slope: Gently to strongly sloping Soils: Very poorly drained to somewhat poorly drained, typically circumneutral, surface organic layer thin to moderately thick Permafrost: Typically present, average thaw depth 61 centimeters Vegetation: Low willow communities with varying sedge components	Shrubs: *Salix pulchra, S. reticulata, Dryas integrifolia* Sedges: *Eriophorum angustifolium, Carex aquatilis* Mosses: *Hylocomium splendens, Tomenthypnum nitens, Aulacomnium palustre*
Moist sedge-shrub tundra with wet inclusions	Distribution: Lowland, riverine, and upland physiography; commonly associated with high-centered polygons and other polygonized or hummocky surface forms Slope: Level to nearly level Soils: Somewhat poorly drained to moderately well drained, circumneutral to alkaline, coarse fragments common, surface organic layer very thin to moderately thick Permafrost: Typically present, average thaw depth 69 centimeters Vegetation: Moist sedge-shrub communities with inclusions of wet sedge tundra and marsh vegetation	Shrubs: *Salix pulchra, Betula nana* Sedges: *Carex aquatilis, Eriophorum angustifolium* Mosses/Liverworts: *Tomenthypnum nitens, Ptlidium ciliare, Hylocomium splendens, Campyllium stellatum*
Wet sedge-shrub tundra with moist inclusions	Distribution: Lowland and riverine physiography; commonly associated hummocks and high-center polygons Slope: Level to nearly level Soils: Very poorly drained to moderately well drained, circumneutral to alkaline (water pH), surface organic layer thin to thick Permafrost: Common, average thaw depth 60 centimeters Vegetation: Wet sedge or sedge-shrub communities with inclusions of moist shrub or sedge-shrub vegetation	Shrubs: *Salix pulchra, Betula nana* Sedges: *Carex aquatilis, Eriophorum angustifolium* Mosses/Liverworts: *Scorpidium scorpioides*, *Campyllium stellatum, Tomenthypnum nitens,*

Land Cover Class	Description	Typical Species
Wet sedge meadow tundra	Distribution: Widespread in lacustrine, lowland, and riverine physiography Slope: Typically, level Soils: Very poorly drained to somewhat poorly drained, circumneutral to alkaline (water pH), surface organic layer thin to thick Permafrost: Common, average thaw depth 32 centimeters Vegetation: Wet sedge or sedge-shrub communities	Shrubs: *Salix ovalifoia,S. reticulata, S. pulchra, S. arctica, Dryas integrifolia* Sedges: *Carex aquatilis, Eriophorum angustifolium* Mosses: *Tomenthypnum nitens, Campyllium stellatum, Meesia triquetra,*
Freshwater marsh	Distribution: Limited distribution in lacustrine, lowland, and riverine physiography Slope: Typically, level Hydrology: Soils: Flooded to poorly drained, circumneutral to alkaline (water pH), surface organic layer typically moderately thick Permafrost: Common, average thaw depth 58 centimeters Vegetation: Sedge or grass marsh communities, typically in small patches along lake and pond margins and in beaded streams.	Sedges: *Carex aquatilis* Grasses: *Arctophila fulva* Other herbaceous: *Hippuris vulgaris*
Salt marsh	Distribution: Coastal physiography; occurs on active and inactive tidal flats in areas characterized by frequent saltwater inundation Slope: Typically, level Hydrology: Poorly drained Soils: Circumneutral to alkaline (water pH), coarse fragments absent, surface organic layer moderately thick to thick Permafrost: Common, average thaw depth 63 centimeters Vegetation: Halophytic sedge or sedge-grass wet meadows	Shrubs: *Salix ovalifolia* Sedges: *Carex subspathacea, C. ramenskii, C. ursina* Grasses: *Dupontia fisheri* Mosses: *Bryum pseudotriquetrum, Campyllium stellatum*
Water	This landcover class includes both marine and freshwater, and occurs in coastal, lowland, and riverine physiography.	Not applicable
Snowbed	This landcover class occurs in upland, and riverine physiography, on landforms and leeward slope positions with late-lying snow (snow free date is typically after July 1); vegetation commonly includes wet sedge meadow tundra, moist sedge-shrub tundra, *Cassiope* dwarf shrub tundra, and partially vegetated areas	Detailed species information not available

Land Cover Class	Description	Typical Species
Partially vegetated	Distribution: Occurs in all physiographies; most common in riverine, and uplands; commonly associated with river channels and sand dunes Slope: Level to strongly sloping Soils: Somewhat excessively drained to excessively drained, typically alkaline, surface organic layer typically absent Permafrost: Infrequent, average thaw depth 137 centimeters Vegetation: Common types include early successional riparian vegetation and *Leymus* (dunegrass) communities	Shrubs: *Salix alaxensis, S. ovalifolia, Dryas integrifolia* Grasses: *Leymus mollis, Trisetum spicatum* Mosses: *Racomitrium lanuginosum, Campyllium stellatum*
Barrens	Distribution: Coastal and riverine physiography, including channel deposits and marine beaches Soils: Well-drained to excessively well drained, typically alkaline, surface organic layer absent Permafrost: Infrequent, average thaw depth 160 centimeters Vegetation: Largely absent	Not applicable
Snow/Ice	This land cover class includes permanent patches of snow and ice, typically found in riverine physiography.	Not applciable

[1] Mapping terminology for vegetation types.

Table J-2
Rare[1] Vascular Plant Species with Documented Occurrences in the Program Area

Taxon	State Rank[3]	Global Rank[3]	Federal Status[4]
Cardamine microphylla[2]	S2	G4	BLM watch
Carex atherodes	S3S4	G5	—
Chrysosplenium rosendahlii	S1S2	G4G5Q	—
Festuca viviparoidea ssp. *viviparoidea*	S3S4	G4G5T4T5	—
Papaver gorodkovii	S2S3	G3	BLM sensitive
Poa sublanata	S2	GNR	BLM sensitive
Puccinellia andersonii	S1S2	G4G5	—
Puccinellia vaginata	S2	G5	BLM sensitive
Puccinellia vahliana	S3	G4G5	BLM watch
Symphyotrichum pygmaeum	S2	G2G4	BLM sensitive

[1] Vascular plant species with documented occurrences in the Program Area tracked through the Alaska Center for Conservation Science Rare Plant Data Portal (ACCS 2023) with a state ranking of S3 or higher and/or a global rank of G4 or higher.
[2] Unclear whether this record (1985) corresponds to the currently identified taxon *C. microphylla aff. microphylla*, which is included on the BLM watch list.
[3] State and Global rankings per ACCS and NatureServe ranking methodologies. See rare and sensitive state and global ranking descriptions below.
[4] Sensitive and watch plant species for the BLM Alaska Special Status Species List – 2019.

Rare and sensitive global and state ranking descriptions are described below.

Global Rank:

- G1: Critically imperiled globally because of extreme rarity (<5 occurrences or few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction (critically endangered throughout its range).
- G2: Imperiled globally because of rarity (6-20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range (endangered throughout its range).
- G3: Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (21 to 100 occurrences) (threatened throughout its range).
- G4: Widespread and apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
- G5: Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
- T#: Global rank of the described species.

- G#G#: Global rank of species uncertain, best described range lies between the two ranks.
- G3Q: Indicates some uncertainty about taxonomic status that might affect global rank.

State Rank:

- S1: Critically imperiled in state because of extreme rarity (<5 occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction (critically endangered throughout the state).
- S2: Imperiled in state because of rarity (6-20 occurrences), or because of other factors making it very vulnerable to extirpation from the state.
- S3: Rare or uncommon in state (21-100 occurrences).

Table J-3
Land Cover Class[1] Acreage Analysis by Alternative

Land Cover Class[1] in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
No Sale (Subtotal)	**0**	**0.0** [2]	**526,259**	**33.7** [2]	**797,264**	**51.0** [2]
Poplar forest	0	0.0	2	0.0	2	0.0
Low and tall riverine willow shrub	0	0.0	9,135	1.7	12,906	1.6
Low and dwarf birch shrub	0	0.0	28,807	5.5	33,043	4.1
Ericaceous dwarf shrub	0	0.0	1,510	0.3	2,299	0.3
Dryas dwarf shrub	0	0.0	1,410	0.3	4,197	0.5
Moist sedge-dryas tundra	0	0.0	17,096	3.2	34,838	4.4
Shrub tussock tundra	0	0.0	96,388	18.3	142,895	17.9
Tussock tundra	0	0.0	120,705	22.9	161,638	20.3
Moist sedge-willow tundra	0	0.0	24,814	4.7	43,644	5.5
Sedge-willow tundra in drainage tracks	0	0.0	29,380	5.6	43,920	5.5
Moist sedge-shrub tundra with wet inclusions	0	0.0	84,560	16.1	151,606	19.0
Wet sedge meadow tundra with moist inclusions	0	0.0	22,753	4.3	33,061	4.1
Wet sedge meadow tundra	0	0.0	71,629	13.6	92,392	11.6
Freshwater marsh	0	0.0	48	0.0	87	0.0
Salt marsh	0	0.0	205	0.0	388	0.0
Water	0	0.0	5,941	1.1	20,600	2.6
Snowbed	0	0.0	1,165	0.2	2,330	0.3
Partially vegetated	0	0.0	8,021	1.5	12,656	1.6
Barrens	0	0.0	2,526	0.5	4,523	0.6
Snow/ice	0	0.0	164	0.0	241	0.0
Controlled Surface Use (CSU)	**0**	**0.0** [2]	**123,867**	**7.9** [2]	**15,870**	**1.0** [2]
Low and tall riverine willow shrub	0	0.0	170	0.1	0	0.0
Low and dwarf birch shrub	0	0.0	4,092	3.3	235	1.5
Ericaceous dwarf shrub	0	0.0	106	0.1	25	0.2
Dryas dwarf shrub	0	0.0	417	0.3	98	0.6
Moist sedge-dryas tundra	0	0.0	4,278	3.5	833	5.2
Shrub tussock tundra	0	0.0	23,917	19.3	2,331	14.7
Tussock tundra	0	0.0	52,292	42.2	4,478	28.2
Moist sedge-willow tundra	0	0.0	17,884	14.4	744	4.7

Land Cover Class[1] in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Sedge-willow tundra in drainage tracks	0	0.0	11,522	9.3	334	2.1
Moist sedge-shrub tundra with wet inclusions	0	0.0	5,128	4.1	5,276	33.2
Wet sedge meadow tundra with moist inclusions	0	0.0	643	0.5	782	4.9
Wet sedge meadow tundra	0	0.0	2,439	2.0	677	4.3
Freshwater marsh	0	0.0	0	0.0	0	0.0
Water	0	0.0	113	0.1	45	0.3
Snowbed	0	0.0	666	0.5	8	0.0
Partially vegetated	0	0.0	118	0.1	3	0.0
Barrens	0	0.0	2	0.0	0	0.0
Snow/ice	0	0.0	79	0.1	0	0.0
No Surface Occupancy (NSO)	**357,951**	**22.9** [1]	**708,170**	**45.3** [2]	**726,298**	**45.9** [2]
Poplar forest	2	0.0	0	0.0	0	0.0
Low and tall riverine willow shrub	10,402	2.9	5,962	0.8	2,456	0.3
Low and dwarf birch shrub	4,964	1.4	9,068	1.3	12,207	1.7
Ericaceous dwarf shrub	946	0.3	985	0.1	323	0.0
Dryas dwarf shrub	5,899	1.6	10,801	1.5	8,991	1.2
Moist sedge dryas tundra	22,634	6.3	40,587	5.7	30,277	4.2
Shrub tussock tundra	25,844	7.2	63,172	8.9	58,538	8.1
Tussock tundra	38,183	10.7	114,586	16.2	175,123	24.1
Moist sedge-willow tundra	8,544	2.4	27,691	3.9	57,286	7.9
Sedge-willow tundra in drainage tracks	6,260	1.7	18,508	2.6	24,177	3.4
Moist sedge-shrub tundra with wet inclusions	31,884	8.9	145,990	20.6	117,402	16.2
Wet sedge meadow tundra with moist inclusions	17,967	5.0	33,446	4.7	28,428	3.9
Wet sedge meadow tundra	51,148	14.3	89,084	12.6	80,684	11.1
Freshwater marsh	79	0.0	252	0.0	242	0.0
Salt marsh	714	0.2	1,470	0.2	1,286	0.2
Water	88,611	24.8	98,587	13.9	86,070	11.9
Snowbed	1,353	0.4	2,884	0.4	3,372	0.5
Partially vegetated	32,190	9.0	34,831	4.9	31,159	4.3
Barrens	10,054	2.8	10,070	1.4	8,078	1.1
Snow/ice	273	0.1	197	0.0	199	0.0
Timing Limitations (TL)	**585,419**	**37.4** [1]	**19**	**0.0** [2]	**1,815**	**0.1** [2]
Low and tall riverine willow shrub	4,132	0.7	0	0.0	0	0.0

Land Cover Class[1] in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Low and dwarf birch shrub	27,543	4.7	0	0.4	0	0.0
Ericaceous dwarf shrub	1,166	0.2	0	0.0	0	0.0
Dryas dwarf shrub	2,190	0.4	0	0.0	3	0.2
Moist sedge-dryas tundra	21,391	3.7	0	2.1	98	5.4
Shrub tussock tundra	87,486	14.9	0	1.3	0	0.0
Tussock tundra	129,207	22.1	2	9.8	82	4.5
Moist sedge-willow tundra	26,436	4.5	0	1.4	36	2.0
Sedge-willow tundra in drainage tracks	26,417	4.5	0	0.0	0	0.0
Moist sedge-shrub tundra with wet inclusions	139,496	23.8	10	52.2	1,505	82.9
Wet sedge meadow tundra with moist inclusions	28,010	4.8	1	6.7	1	0.1
Wet sedge meadow tundra	78,952	13.5	5	25.9	86	4.7
Freshwater marsh	96	0.0	0	0.0	0	0.0
Salt marsh	288	0.0	0	0.0	0	0.0
Water	4,732	0.8	0	0.0	0	0.0
Snowbed	1,587	0.3	0	0.1	0	0.0
Partially vegetated	4,581	0.8	0	0.1	3	0.2
Snow/ice	41	0.0	0	0.0	0	0.0
Barrens	1,667	0.3	0	0.0	0	0.0
Standard Terms and Conditions (STC)	**619,998**	**39.7** [1]	**205,054**	**13.1** [2]	**22,121**	**2.0** [2]
Low and tall riverine willow shrub	828	0.1	96	0.0	0	0.0
Low and dwarf birch shrub	12,982	2.1	3,521	1.7	3	0.0
Ericaceous dwarf shrub	535	0.1	46	0.0	0	0.0
Dryas dwarf shrub	5,233	0.8	695	0.3	34	0.1
Moist sedge-dryas tundra	22,220	3.6	4,284	2.1	199	.9
Shrub tussock tundra	90,496	14.6	20,348	9.9	62	0.2
Tussock tundra	175,330	28.3	55,135	26.9	1,398	6.3
Moist sedge-willow tundra	67,074	10.8	31,665	15.4	343	1.6
Sedge-willow tundra in drainage tracks	35,772	5.8	9,039	4.4	18	0.1
Moist sedge-shrub tundra with wet inclusions	120,823	19.5	56,515	27.6	16,423	74.2
Wet sedge meadow tundra with moist inclusions	17,526	2.8	6,659	3.2	1,231	5.6
Wet sedge meadow tundra	45,272	7.3	12,215	6.0	1,535	6.9
Freshwater marsh	164	0.0	40	0.0	10	0.0
Salt marsh	673	0.1	0	0.0	0	0.0

Land Cover Class[1] in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Water	14,207	2.3	2,908	1.4	831	3.8
Snowbed	2,771	0.4	996	0.5	1	0.0
Partially vegetated	7,063	1.1	864	0.4	11	0.0
Snow/ice	126	0.0	1	0.0	0	0.0
Barrens	906	0.1	29	0.0	22	0.1
Total	**1,563,368**	**NA**	**1,563,368**	**NA**	**1,563,368**	**NA**

[1] Mapping terminology for vegetation types.

[2] This value represents the percent the land use category (e.g., no sale, controlled surface use, no surface occupancy) represents for the total program area.

Table J-4
Maximum Direct and Indirect Impact Acreage for each Land Cover Class by Alternative

Land Cover Class	Alt B Available [1] acres (%)	Alt B Direct Impact (acres)	Alt B Indirect Impact (acres)	Alt B Total Impact (acres)	Alt C Available [1] acres (%)	Alt C Direct Impact (acres)	Alt C Indirect Impact (acres)	Alt C Total Impact (acres)	Alt D Available [1] acres (%)	Alt D Direct Impact (acres)	Alt D Indirect Impact (acres)	Alt D Total Impact (acres)
Poplar forest	2 (< 0.1%)	0	0	0	0 (0.0%)	0	0	0	0 (0.0%)	0	0	0
Low and tall riverine willow shrub	15,400 (1.0%)	20	173	193	6,265 (0.6%)	9	78	87	2,494 (0.3%)	3	30	33
Low and dwarf birch shrub	45,500 (2.9%)	58	512	570	16,693 (1.6%)	24	207	231	12,457 (1.6%)	17	149	166
Ericaceous dwarf shrub	2,600 (0.2%)	3	29	33	1,090 (0.1%)	2	14	15	301 (< 0.1%)	0	4	4
Dryas dwarf shrub	13,300 (0.9%)	17	150	167	11,890 (1.1%)	17	148	164	9,103 (1.2%)	12	109	121
Moist sedge-dryas tundra	66,300 (4.2%)	85	746	831	49,204 (4.7%)	69	611	680	31,462 (4.1%)	43	376	418
Shrub tussock tundra	203,800 (13.0%)	261	2,294	2,554	107,412 (10.4%)	152	1,334	1,485	60,905 (7.9%)	83	727	810
Tussock tundra	342,700 (21.9%)	438	3,857	4,295	221,995 (21.4%)	313	2,756	3,069	181,062 (23.6%)	246	2,161	2,407
Moist sedge-willow tundra	102,100 (6.5%)	131	1,149	1,280	77,286 (7.4%)	109	960	1,069	58,456 (7.6%)	79	698	777
Sedge-willow tundra in drainage tracks	68,400 (4.4%)	87	770	857	39,020 (3.8%)	55	484	540	24,480 (3.2%)	33	292	325
Moist sedge-shrub tundra with wet inclusions	292,200 (18.7%)	374	3,288	3,662	207,640 (20.0%)	293	2,578	2,871	140,594 (18.3%)	191	1,678	1,869
Wet sedge meadow tundra with moist inclusions	63,500 (4.1%)	81	715	796	40,747 (3.9%)	57	506	563	30,439 (4.0%)	41	363	405
Wet sedge meadow tundra	175,400 (11.2%)	224	1,974	2,198	103,771 (10.0%)	146	1,288	1,435	83,008 (10.8%)	113	991	1,104
Freshwater marsh	300 (< 0.1%)	0	3	4	252 (< 0.1%)	0	3	3	213 (< 0.1%)	0	3	3
Salt marsh	1,700 (0.1%)	2	19	21	1,495 (0.1%)	2	19	21	1,312 (0.2%)	2	16	17
Water	107,700 (6.9%)	138	1,212	1,350	101,759 (9.8%)	144	1,263	1,407	87,100 (11.4%)	118	1,040	1,158
Snowbed	5,700 (0.4%)	7	64	71	4,535 (0.4%)	6	56	63	3,370 (0.4%)	5	40	45
Partially vegetated	43,900 (2.8%)	56	494	550	35,879 (3.5%)	51	445	496	31,244 (4.1%)	42	373	415

Land Cover Class	Alt B Available [1] acres (%)	Alt B Direct Impact (acres)	Alt B Indirect Impact (acres)	Alt B Total Impact (acres)	Alt C Available [1] acres (%)	Alt C Direct Impact (acres)	Alt C Indirect Impact (acres)	Alt C Total Impact (acres)	Alt D Available [1] acres (%)	Alt D Direct Impact (acres)	Alt D Indirect Impact (acres)	Alt D Total Impact (acres)
Barrens	12,800 (0.8%)	16	144	160	10,274 (1.0%)	14	128	142	8,277 (1.1%)	11	99	110
Snow/ice	400 (< 0.1%)	1	5	5	236 (< 0.1%)	0	3	3	159 (< 0.1%)	0	2	2
Total	**1,563,900 (100.0%)**	**2,000**	**17,600**	**19,600**	**1,037,641 (100.0%)**	**1,464**	**12,883**	**14,347**	**766,636 (100.0%)**	**1,040**	**9,152**	**10,192**

[1] This represents the total area available for leasing under the given alternative.

Table J-5
Wetland Class Crosswalk and Descriptions[1]

Wetland and Waters Class	Wetland Types within Class	Description
Open water	NA	NA
Nearshore waters	M1UBL	Subtidal portions of the Beaufort Sea coast beyond barrier islands or where no barrier islands are present.
Estuarine open water	E1UBL	Subtidal portions of the Beaufort Sea coast between barrier islands and the mainland.
Tidal influenced palustrine waters	PUBT, PUBV	Open, shallow, and permanently flooded freshwater bodies less than 20 acres in size that receive regular or seasonal saltwater input through tidal fluctuations or seasonal storm surge events. Occurs along the Beaufort Sea coastline at the mouth of large river deltas.
Lentic freshwater	L2UBH	Permanently flooded and shallow freshwater bodies greater than 20 acres in size. Occurs in the Canning River Delta and throughout the lowlands south of Kaktovik.
Palustrine waters	PUBF, PUBH	Open, shallow, and permanently flooded freshwater bodies less than 20 acres in size. Occurs most commonly within the Canning and Jago River deltas and throughout the lowlands south of Kaktovik.
Tidal influenced lotic freshwater	R1UBT, R1UBV, R1US1Q, R1US3Q, R1USQ	Active channels and unvegetated channel deposits within the intertidal section of freshwater rivers. Occurs along the Beaufort Sea coast in large tidal riverine deltas.
Lotic freshwater	R2UB3F, R2UBF, R2UBH, R3UBH, R4SBC	Lower and upper perennial stream channels and intermittent stream beads conveying freshwater. Occurs throughout the program area from stream headwaters to the limit of tidal fluctuations.
Estuarine wetlands and mudflats	NA	NA
Estuarine mudflat	E2US2N, E2USM, E2USN, E2USP	Unvegetated and tidally flooded substrates along the Beaufort Sea coast including barrier islands, spits, and river deltas.
Estuarine salt marsh	E2EM1/USN, E2EM1/USP, E2EM1N, E2EM1P, E2EM2/SS1P, E2EM2/USN, E2EM2/USP, E2EM2N, E2SS1/EM1P, E2SS1P, E2US/EM1N, E2US/EM1P, E2US/EM2N, E2US1/EM1N	Tidally flooded vegetation along the Beaufort Sea coast. Located within riverine deltas, particularly the Hulahula and Jago rivers, and along the fringes of lagoons.
Palustrine wetlands and barrens	NA	NA

Wetland and Waters Class	Wetland Types within Class	Description
Tidal influenced emergent meadow	PEM1/SS1R, PEM1/SS1S, PEM1/SS1T, PEM1/UBT, PEM1/USR, PEM1/USS, PEM1R, PEM1S, PEM1T, PEM2T, PUB/EM1T	Flooded wetlands whose hydrology is driven by nontidal inputs, yet still influenced by tides. Primarily dominated by persistent emergent vegetation (grasses and sedges) and can form complexes with deciduous shrubs and unvegetated substrates. Located along the Beaufort Sea coast inland of estuarine waters, wetlands, and mudflats.
Tidal influenced shrub scrub	PSS1/EM1R, PSS1/EM1T, PSS1R	Flooded wetlands whose hydrology is driven by nontidal inputs, yet still influenced by tides. Primarily dominated by broadleaf deciduous shrubs (willows), can form complexes with persistent emergent vegetation and unvegetated substrates. Located along the Beaufort Sea coast inland of estuarine waters, wetlands, and mudflats, these wetlands are in relatively small and scattered patches along the margins of tidal influenced emergent meadow in the Canning and Katakturuk river deltas, Pokok Bay, and Nuvagapak Lagoon.
Littoral mudflat	L2UBV, L2US5C, PUS2R	Seasonally flooded lake and pond basins. Limited to two features within the program area: one small pond breached by coastal erosion in Camden Bay and one lake breached by the Canning River.
Littoral wetlands	L2ABF, L2EM2/UBF, L2EM2F, PAB3/UBF, PAB3F, PAB3H, PUB/EM1F	Semi-permanently to permanently flooded littoral areas, where water depths are shallow enough to support vegetative growth. These features are predominantly located in the Caning River Delta and the lowlands south and east of Kaktovik.
Flooded emergent meadow	PEM1/SS1F, PEM1/UBF, PEM1F, PEM2/SS1F, PEM2/UBF, PEM2F	Semi-permanently flooded wetlands dominated by persistent emergent vegetation (grasses and sedges), can form complexes with deciduous shrubs and unvegetated substrates. This wetland class is ubiquitous throughout the program area, extending from the Beaufort Sea coast south into the Brooks Range foothills, presumably in lower lying landscape positions than seasonally flooded emergent meadow.
Partially vegetated barrens	PUS/EM1C, PUS/EM1E, PUS/SS1A, PUS2/EM1C, PUS5/EM1C, PUS5/SS1C	Seasonally flooded unvegetated wetlands can form complexes with persistent emergent (grasses and sedges) and broadleaf deciduous (willows) vegetation. Located on gravel bars or proximal to channels of rivers within the program area, including the Staines, Canning, Katakturuk, Okpilik, and Jago rivers.
Saturated emergent meadow	PEM1/SS1B, PEM1/SS1D, PEM1B, PEM1D	Saturated wetlands that generally lack abundant surface water and are dominated by persistent emergent vegetation (grasses and sedges) but can form complexes with broadleaf deciduous shrubs (willows). This wetland class is ubiquitous throughout the program area, extending from the Beaufort Sea coast south into the Brooks Range foothills, presumably in higher landscape positions than seasonally flooded emergent meadow.
Seasonally flooded emergent meadow	PEM1/SS1A, PEM1/SS1C, PEM1/SS1E, PEM1/US5A, PEM1/US5C, PEM1/USA, PEM1/USC, PEM1/USE, PEM1A, PEM1C, PEM1E	Wetlands that flood seasonally and are dominated by persistent emergent vegetation (grasses and sedges) but can form complexes with broadleaf deciduous shrubs (willows). This wetland class is ubiquitous throughout the program area, extending from the Beaufort Sea coast south into the Brooks Range foothills, intermixed with saturated emergent meadow and flooded emergent meadow wetlands.

Wetland and Waters Class	Wetland Types within Class	Description
Flooded shrub scrub	PSS1/EM1F, PSS1/UBF, PSS1/UBT, PSS1F	Semi-permanently flooded broadleaf deciduous shrub (willow) wetlands, including those that are tidally influenced. This wetland class is predominantly located in water tracks and drainages in the foothills in the southern portion of the program area, but scattered areas of flooded shrub scrub are associated with river deltas along the Beaufort Sea coast.
Saturated shrub scrub	PSS1/EM1B, PSS1/EM1D, PSS1B, PSS1D	Saturated wetlands that generally lack abundant surface water and are dominated by broadleaf deciduous shrubs (willows and dwarf birch) but can form complexes with persistent emergent vegetation (grasses and sedges). This wetland class is located in presumably higher landscape positions in the Brooks Range foothills and is generally absent from lowland areas.
Seasonally flooded shrub scrub	PSS1/EM1A, PSS1/EM1C, PSS1/EM1E, PSS1/US5C, PSS1/US5A, PSS1/USA, PSS1/USC, PSS1A, PSS1C, PSS1E	Wetlands that flood seasonally and are dominated by broadleaf deciduous shrubs (willows) but can form complexes with persistent emergent vegetation (grasses and sedges). This wetland class is predominantly located within drainages and lower landscape positions in the Brooks Range foothills but does extend along riverine corridors to the Beaufort Sea coast and small patches are present within lowland areas.
Riverine and riparian	NA	NA
Tidal influenced riverine wetlands	R1EM2T, R1EM2V, R1UB2V	Semi-permanent to permanently flooded riverine areas dominated by nonpersistent emergent vegetation (e.g., horsetail). This wetland class is located at the mouths of Marsh Creek and two nearby unnamed creeks.
Freshwater riverine wetlands	R2EM2/UBF, R2EM2F	Lower perennial riverine areas that are semi-permanently flooded and dominated by nonpersistent emergent vegetation but can form complexes with unvegetated wetlands. This wetland class is small, beaded streams located throughout the program area.
Riverine barrens	R2US5A, R2US5C, R2USA, R2USC, R2USE	Seasonally to temporarily flooded barrens along lower perennial rivers and streams. This class includes gravel bars of lower perennial systems throughout the program area.
Seasonally flooded barrens	PUS2C, PUS5C, PUSA, PUSC	Seasonally to temporarily flooded barrens located outside of riverine channels. This class includes gravel bars of lower perennial systems throughout the program area. This wetland class is scattered throughout the program area, from scattered presumably wind scoured barrens within the lowlands south of Kaktovik to unvegetated areas within floodplains.

[1] From broad-scale land USFWS NWI mapping Knopf 2022.
[2] The classification into fine scale wetland codes follows guidance in Cowardin et al. 1979.

Table J-6
Wetland Acreage Analysis by Alternative

Wetland Type in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
No Sale	**0**	**0.0** [1]	**526,259**	**33.7** [1]	**797,264**	**51.0** [1]
Nearshore waters	0	0.0	0	0.0	434	0.1
Estuarine open water	0	0.0	236	0.0	10,495	1.3
Tidal influenced palustrine waters	0	0.0	17	0.0	50	0.0
Lentic freshwater	0	0.0	1,852	0.4	2,930	0.4
Palustrine waters	0	0.0	928	0.2	1,861	0.2
Tidal influenced lotic freshwater	0	0.0	75	0.0	125	0.0
Lotic freshwater	0	0.0	11,820	2.2	14,940	1.9
Estuarine salt marsh	0	0.0	0	0.0	149	0.0
Estuarine mud flat	0	0.0	57	0.0	2,215	0.3
Tidal influenced shrub scrub	0	0.0	11	0.0	144	0.0
Tidal influenced emergent meadow	0	0.0	311	0.1	885	0.1
Littoral mud flat	0	0.0	0	0.0	44	0.0
Littoral wetlands	0	0.0	622	0.1	746	0.1
Flooded emergent meadow	0	0.0	120,167	22.8	160,055	20.1
Partially vegetated barrens	0	0.0	0	0.0	184	0.0
Saturated emergent meadow	0	0.0	94,695	18.0	153,532	19.3
Flooded shrub scrub	0	0.0	3,291	0.6	4,720	0.6
Saturated shrub scrub	0	0.0	30,997	5.9	65,602	8.2
Freshwater riverine wetlands	0	0.0	2,290	0.4	3,299	0.4
Riverine barrens	0	0.0	3,847	0.7	7,966	1.0
Seasonally flooded barrens	0	0.0	1	0.0	38	0.0
Seasonally flooded emergent meadow	0	0.0	155,368	29.5	242,580	30.4
Seasonally flooded shrub scrub	0	0.0	75,810	14.4	97,808	12.3
Upland	0	0.0	23,865	4.5	26,459	3.3
Controlled Surface Use (CSU)	**0**	**0.0** [1]	**123,867**	**7.9** [1]	**15,120**	**1.0** [1]
Lentic freshwater	0	0.0	77	0.1	10	0.1
Palustrine waters	0	0.0	29	0.0	32	0.2
Lotic freshwater	0	0.0	388	0.3	0	0.0
Flooded emergent meadow	0	0.0	8,465	6.8	3,571	23.0

Wetland Type in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Saturated emergent meadow	0	0.0	38,361	31.0	4,341	28.0
Flooded shrub scrub	0	0.0	925	0.7	0	0.0
Saturated shrub scrub	0	0.0	25,547	20.6	1,316	7.4
Freshwater riverine wetlands	0	0.0	647	0.5	0	0.0
Seasonally flooded emergent meadow	0	0.0	39,360	31.8	4,341	28.0
Seasonally flooded shrub scrub	0	0.0	9,177	7.4	1,089	7.1
Upland	0	0.0	890	0.7	420	2.6
No Surface Occupancy (NSO)	**357,951**	**22.9** [1]	**708,170**	**45.3** [1]	**722,366**	**45.9** [1]
Nearshore waters	2,368	0.7	4,641	0.7	4,209	.6
Estuarine open water	61,155	17.1	61,551	8.7	51,292	7.1
Tidal influenced palustrine waters	143	0.0	289	0.0	256	0.0
Lentic freshwater	3,242	0.9	9,402	1.3	9,466	1.3
Palustrine waters	2,083	0.6	3,806	0.5	3,778	0.5
Tidal influenced lotic freshwater	1,912	0.5	2,406	0.3	2,379	0.3
Lotic freshwater	31,256	8.7	29,160	4.1	28,302	4.0
Estuarine mud flat	11,938	3.3	13,601	1.9	10,820	1.5
Estuarine salt marsh	1,464	0.4	2,123	0.3	1,883	0.3
Tidal influenced emergent meadow	2,548	0.7	7,187	1.0	5,465	0.8
Tidal influenced shrub scrub	29	0.0	358	0.1	200	0.0
Littoral mud flat	124	0.0	189	0.0	145	0.0
Littoral wetlands	358	0.1	779	0.1	228	0.0
Flooded emergent meadow	53,192	14.9	119,924	16.9	104,018	14.0
Partially vegetated barrens	82	0.0	107	0.0	484	0.1
Saturated emergent meadow	44,210	12.4	136,059	19.2	159,611	22.2
Flooded shrub scrub	1,070	0.3	1,961	0.3	5,316	0.7
Saturated shrub scrub	14,114	3.9	53,309	7.5	61,322	8.5
Tidal influenced riverine wetlands	34	0.0	39	0.0	39	0.0
Freshwater riverine wetlands	413	0.1	1,693	0.2	1,886	0.3
Riverine barrens	16,323	4.6	15,305	2.2	11,185	1.6
Seasonally flooded barrens	88	0.0	148	0.0	111	0.0
Seasonally flooded emergent meadow	72,100	20.1	186,265	26.3	202,697	28.1
Seasonally flooded shrub scrub	31,571	8.8	51,855	7.3	53,669	7.5
Upland	6,133	1.7	6,011	0.8	3,605	0.5

Wetland Type in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Timing Limitations (TL)	**585,419**	**37.4** [1]	**19**	**0.0** [1]	**1,815**	**0.1** [1]
Nearshore waters	24	0.0	0	0.0	0	0.0
Estuarine open water	119	0.0	0	0.0	0	0.0
Tidal influenced palustrine waters	34	0.0	0	0.0	0	0.0
Lentic freshwater	2,541	0.4	0	0.0	0	0.0
Palustrine waters	1,551	0.3	0	0.0	0	0.0
Tidal influenced lotic freshwater	88	0.0	0	0.0	0	0.0
Lotic freshwater	5,258	0.9	0	0.3	0	0.0
Estuarine mud flat	151	0.0	0	0.0	0	0.0
Estuarine salt marsh	115	0.0	0	0.0	0	0.0
Tidal influenced emergent meadow	587	0.1	0	0.0	0	0.0
Tidal influenced shrub scrub	69	0.0	0	0.0	0	0.0
Littoral wetlands	877	0.1	0	0.0	0	0.0
Flooded emergent meadow	141,407	24.2	8	43.1	609	33.6
Partially vegetated barrens	9	0.0	0	0.0	0	0.0
Saturated emergent meadow	112,057	19.1	2	9.4	269	14.8
Flooded shrub scrub	2,970	0.5	0	0.0	0	0.0
Saturated shrub scrub	29,437	5.0	0	0.8	78	4.3
Freshwater riverine wetlands	2,450	0.4	0	0.2	0	0.0
Riverine barrens	1,929	0.3	0	0.0	0	0.0
Seasonally flooded barrens	11	0.0	0	0.0	0	0.0
Seasonally flooded emergent meadow	194,854	33.3	9	46.1	857	47.2
Seasonally flooded shrub scrub	68,483	11.7	0	0.0	1	0.1
Uplands	20,400	3.5	0	0.0	0	0.0
Standard Terms and Conditions (STC)	**619,998**	**39.7** [1]	**205,054**	**13.1** [1]	**22,798**	**2.0** [1]
Nearshore waters	2,614	0.4	365	0.2	363	1.6
Estuarine open water	515	0.1	2	0.0	2	0.0
Tidal influenced palustrine waters	129	0.0	0	0.0	0	0.0
Lentic freshwater	6,946	1.1	1,398	0.7	323	1.5
Palustrine waters	2,139	0.3	1,010	0.5	104	0.5
Tidal influenced lotic freshwater	481	0.1	0	0.0	0	0.0
Lotic freshwater	6,729	1.1	1,874	0.9	0	0.0
Estuarine mud flat	1,644	0.3	74	0.0	74	0.0

Wetland Type in Land Use Categories	Alternative B Area (acres)	Alternative B Area (%)	Alternative C Area (acres)	Alternative C Area (%)	Alternative D Area (acres)	Alternative D Area (%)
Estuarine salt marsh	544	0.1	0	0.0	0	0.0
Tidal influenced emergent meadow	4,363	0.7	0	0.0	0	0
Tidal influenced shrub scrub	270	0.0	0	0.0	24	0.1
Littoral mud flat	65	0.0	0	0.0	0	0.0
Littoral wetlands	248	0.0	82	0.0	0	0.0
Flooded emergent meadow	80,160	12.9	26,194	12.8	6,512	29.0
Partially vegetated barrens	21	0.0	4	0.0	0	0.0
Saturated emergent meadow	161,629	26.1	48,780	23.8	1,313	5.9
Flooded shrub scrub	6,028	1.0	3,891	1.9	0	0.0
Saturated shrub scrub	84,969	13.7	18,666	9.1	0	0.0
Tidal influenced riverine wetlands	5	0.0	0	0.0	0	0.0
Freshwater riverine wetlands	2,321	0.4	555	0.3	0	0.0
Riverine barrens	899	0.1	0	0.0	0	0.0
Seasonally flooded barrens	51	0.0	0	0.0	0	0.0
Seasonally flooded emergent meadow	199,791	32.2	85,743	41.8	13,180	60.0
Seasonally flooded shrub scrub	52,938	8.5	16,150	7.9	356	1.2
Uplands	4,498	0.7	265	0.1	547	1.8
Total	**1,563,368**	**NA**	**1,563,366**	**NA**	**1,563,366**	**NA**

[1] This value represents the percent the land use category (e.g., no sale, controlled surface use, no surface occupancy) represents for the total program area (1,563,366 acres).

Table J-7
Maximum Direct and Indirect Impact Acreage for each Wetland Class by Alternative

Wetland Class	Alt B Available [1] acres (%)	Alt B Direct Impact (acres)	Alt B Indirect Impact (acres)	Alt B Total Impact (acres)	Alt C Available [1] acres (%)	Alt C Direct Impact (acres)	Alt C Indirect Impact (acres)	Alt C Total Impact (acres)	Alt D Available [1] acres (%)	Alt D Direct Impact (acres)	Alt D Indirect Impact (acres)	Alt D Total Impact (acres)
Nearshore waters	5,000 (0.3%)	6	56	63	5,000 (0.5%)	7	62	69	4,600 (0.6%)	6	55	61
Estuarine open water	61,800 (4.0%)	79	695	775	61,600 (5.9%)	87	765	852	51,300 (6.7%)	70	613	682
Tidal influenced palustrine waters	300 (< 0.1%)	0	3	4	300 (< 0.1%)	0	4	4	300 (< 0.1%)	0	4	4
Lentic freshwater	12,800 (0.8%)	16	144	160	10,900 (1.1%)	15	135	151	9,800 (1.3%)	13	117	130
Palustrine waters	5,800 (0.4%)	7	65	73	4,800 (0.5%)	7	60	66	3,900 (0.5%)	5	47	52
Tidal influenced lotic freshwater	2,500 (0.2%)	3	28	31	2,400 (0.2%)	3	30	33	2,400 (0.3%)	3	29	32
Lotic freshwater	43,200 (2.8%)	55	486	541	31,400 (3.0%)	44	390	434	28,300 (3.7%)	38	338	376
Estuarine salt marsh	2,100 (0.1%)	3	24	26	2,100 (0.2%)	3	26	29	2,000 (0.3%)	3	24	27
Estuarine mud flat	13,700 (0.9%)	18	154	172	13,700 (1.3%)	19	170	189	11,500 (1.5%)	16	137	153
Tidal influenced shrub scrub	400 (< 0.1%)	1	5	5	400 (< 0.1%)	1	5	6	200 (< 0.1%)	0	2	3
Tidal influenced emergent meadow	7,500 (0.5%)	10	84	94	7,200 (0.7%)	10	89	100	6,600 (0.9%)	9	79	88
Littoral mud flat	200 (< 0.1%)	0	2	3	200 (< 0.1%)	0	2	3	100 (< 0.1%)	0	1	1
Littoral wetlands	1,500 (0.1%)	2	17	19	900 (0.1%)	1	11	12	200 (< 0.1%)	0	2	3
Flooded emergent meadow	274,800 (17.6%)	351	3,093	3,444	154,600 (14.9%)	218	1,920	2,138	114,700 (15.0%)	156	1,370	1,526
Partially vegetated barrens	100 (< 0.1%)	0	1	1	100 (< 0.1%)	0	1	1	500 (0.1%)	1	6	7
Saturated emergent meadow	317,900 (20.3%)	407	3,578	3,984	223,200 (21.5%)	315	2,771	3,086	164,400 (21.5%)	223	1,964	2,187
Flooded shrub scrub	10,100 (0.6%)	13	114	127	6,800 (0.7%)	10	84	94	5,300 (0.7%)	7	63	71
Saturated shrub scrub	128,500 (8.2%)	164	1,446	1,610	97,500 (9.4%)	138	1,211	1,348	62,900 (8.2 %)	85	751	837
Tidal influenced riverine wetlands	< 100 (< 0.1%)	0	0	0	< 100 (< 0.1%)	0	0	0	< 100 (< 0.1%)	0	0	0

Wetland Class	Alt B Available [1] acres (%)	Alt B Direct Impact (acres)	Alt B Indirect Impact (acres)	Alt B Total Impact (acres)	Alt C Available [1] acres (%)	Alt C Direct Impact (acres)	Alt C Indirect Impact (acres)	Alt C Total Impact (acres)	Alt D Available [1] acres (%)	Alt D Direct Impact (acres)	Alt D Indirect Impact (acres)	Alt D Total Impact (acres)
Freshwater riverine wetlands	5,200 (0.3%)	7	59	65	2,900 (0.3%)	4	36	40	1,900 (0.2%)	3	23	25
Riverine barrens	19,200 (1.2%)	25	216	241	15,300 (1.5%)	22	190	212	11,200 (1.5%)	15	134	149
Seasonally flooded barrens	100 (< 0.1%)	0	1	1	100 (< 0.1%)	0	1	1	100 (< 0.1%)	0	1	1
Seasonally flooded emergent meadow	466,700 (29.8%)	597	5,252	5,849	311,400 (30.0%)	439	3,866	4,306	224,200 (29.3%)	304	2,678	2,983
Seasonally flooded shrub scrub	153,000 (9.8%)	196	1,722	1,918	77,200 (7.4%)	109	959	1,067	55,200 (7.2%)	75	659	734
Uplands	31,600 (2.0%)	40	356	396	7,600 (0.7%)	11	94	105	4,500 (0.6%)	6	54	60
Total	**1,563,900 (100.0%)**	**2,000**	**17,600**	**19,600**	**1,037,600 (100.0%)**	**1,464**	**12,883**	**14,347**	**766,100 (100%)**	**1,040**	**9,152**	**10,192**

[1] This represents the total area available for leasing under the given alternative.

J.2 Fish and Aquatic Species

Table J-8
Winter Water Volumes (acre-feet) of Lakes in the 1002 Area at Different Ice Thickness Levels

Lake No.	Surface Area (acres)	Maximum Depth (feet)	Ice Thickness (Average Measurement Date)								Fish Observed
			0 feet	1 foot (Oct 31)	2 feet (Nov 13)	3 feet (Dec 11)	4 feet (Jan 4)	5 feet (Feb 20)	6 feet (April 5)	7 feet (April 16)[a]	
1[b]	33	1.5	57	24	0	0	0	0	0	0	NS[c]
2	131	13.1	912	784	668	564	465	372	284	204	NS
3[d]	0	0	0	0	0	0	0	0	0	0	NS
4	100	4.8	235	143	67	16		0	0	0	NS
5	58	6.8	279	222	167	117	72	34	9	0	NS
6	94	12.1	824	730	637	543	449	358	272	196	Yes
7	113	10	720	607	494	381	273	171	89	35	Yes
8	44	3.8	93	55	25	4	0	0	0	0	Yes
9	23	2.9	44	22	4	0	0	0	0	0	No
10	32	5.1	120	89	57	29	8	<1	0	0	No
11	22	4.3	75	53	31	11	<1	0	0	0	No
12	31	7.7	122	91	60	34	17	8	3	<1	Yes
13	40	3.1	85	45	11	<1	0	0	0	0	Yes
14	46	13.4	328	282	236	190	146	111	79	51	No
15	96	8.2	379	283	187	97	37	9	3	<1	No
16	257	3.8	668	427	221	67	0	0	0	0	NS
17	100	7.4	342	246	162	95	46	16	2	0	NS
18[b]	32	2	74	42	18	0	0	0	0	0	NS
19[b]	181	2	419	238	102	0	0	0	0	0	NS
20	81	9.2	457	377	301	230	167	110	59	18	NS
21	56	4.2	128	77	37	10	0	0	0	0	NS
22	77	9.3	352	276	206	145	95	54	20	3	NS
23	35	10.7	240	206	173	142	112	85	61	40	NS
24	133	7.5	709	578	457	345	240	141	50	7	NS
25	131	2.3	182	67	3	0	0	0	0	0	Yes
26	64	8.3	321	258	199	144	94	50	13	0	NS
27	303	17.9	3,212	2,009	1,706	1,414	1,138	878	639	432	Yes
28	79	3.4	216	141	72	14	0	0	0	0	NS
29	300	7.5	1,190	914	688	497	321	162	36	<1	NS
30[b]	0	0	0	0	0	0	0	0	0	0	NS
31	104	8.7	557	452	348	249	161	90	39	10	Yes
32	34	10.9	208	174	142	112	84	59	36	18	NS
33	29	6.3	94	66	39	17	5		0	0	NS

Lake No.	Surface Area (acres)	Maximum Depth (feet)	Ice Thickness (Average Measurement Date)								Fish Observed
			0 feet	1 foot (Oct 31)	2 feet (Nov 13)	3 feet (Dec 11)	4 feet (Jan 4)	5 feet (Feb 20)	6 feet (April 5)	7 feet (April 16)[a]	
34	1,533	9	9,285	7,753	6,220	4,756	3,416	2,220	1,169	340	NS
35	89	8.4	523	435	351	273	200	131	69	18	NS
36	1,316	11	9,198	7,882	6,565	5,305	4,138	3,067	2,097	1,282	NS
37	342	8.3	1,804	1,462	1,120	793	500	245	70	10	Yes
38	44	7.8	250	206	164	124	85	50	19	3	NS
39	58	4.9	224	167	112	62	23	0	0	0	NS
40	26	3.5	58	33	9	<1	0	0	0	0	No
41	30	5.9	116	85	56	28	2	0	0	0	NS
42	96	5.9	441	346	250	159	79	20	0	0	No
43[b]	0	0	0	0	0	0	0	0	0	0	NS
44	21	2.7	44	25	8	0	0	0	0	0	NS
45	51	8	295	244	193	142	93	55	27	6	No
46	56	8.8	373	317	260	205	152	104	62	29	No
47	75	4.6	274	199	124	54	7	0	0	0	No
48	32	8.4	155	124	95	69	47	29	15	6	NS
49	53	5.7	195	142	92	48	17	2	0	0	No
50	36	7.2	181	145	111	78	48	23	7	0	NS
51	155	6.4	624	469	325	203	101	31	1	0	Yes
52	69	7.9	417	348	280	212	148	88	33	4	Yes
53	17	6.7	89	72	56	40	25	12	3	0	NS
54	83	4.1	263	180	97	28	<1	0	0	0	No
55	36	5.9	166	131	96	64	36	12	0	0	NS
56[b]	28	2.5	65	37	17	0	0	0	0	0	NS
57	59	6.9	304	246	189	136	87	43	13	0	NS
58	31	8.4	156	126	98	73	50	29	12	2	NS
59	24	10.5	117	94	72	53	37	23	11	3	NS
60	50	7.9	280	231	183	137	92	52	20	3	NS
61	24	7.8	125	102	80	59	40	23	8	1	NS
62	84	3.9	248	164	83	17	0	0	0	0	Yes
63	48	7.7	269	222	177	137	95	58	25	5	NS
64	128	8. 1	766	638	510	382	259	151	66	13	Yes
65	87	8.6	477	390	302	215	141	89	49	16	Yes
66	43	6.5	193	150	109	70	34	7	0	0	NS
67	190	3.6	530	340	168	21	0	0	0	0	Yes
68	65	8.9	393	327	262	197	137	82	38	8	Yes
69	33	8.1	173	140	109	80	52	28	7	0	NS
70[b]	20	2	46	26	11	0	0	0	0	0	NS
71	43	8.2	190	147	106	69	40	19	4	0	NS
72	33	9.1	68	41	22	12	7	4	2	1	NS

Lake No.	Surface Area (acres)	Maximum Depth (feet)	Ice Thickness (Average Measurement Date)								Fish Observed
			0 feet	1 foot (Oct 31)	2 feet (Nov 13)	3 feet (Dec 11)	4 feet (Jan 4)	5 feet (Feb 20)	6 feet (April 5)	7 feet (April 16)[a]	
73	168	8.6	788	620	453	299	174	76	25	7	Yes
74	69	11	429	361	292	223	158	98	46	11	Yes
75	102	8.7	679	576	474	371	270	174	88	23	Yes
76	63	11.6	454	392	329	267	206	149	98	53	Yes
77	26	8.7	105	80	56	35	19	8	2	0	NS
78	36	8.7	149	113	79	49	24	9	2	1	NS
79	97	3.3	216	119	31	<1	0	0	0	0	Yes
80	164	8.5	1,045	881	717	558	412	280	159	53	Yes
81	41	6.7	155	115	77	44	19	5	1	0	NS
82	32	5.5	96	65	35	12	2	0	0	0	NS
83	32	7.9	184	153	122	92	64	39	16	3	NS
84	46	7.5	262	215	169	127	90	57	28	4	Yes
85	31	8.2	140	109	80	53	28	8	1	0	NS
86	41	7.1	226	185	144	106	70	36	10	<1	Yes
87	33	6.8	128	96	66	41	19	4	0	0	NS
88	27	5.6	75	49	26	10	2	0	0	0	NS
89	60	7.8	375	315	254	196	141	91	48	10	Yes
90	36	6.9	187	151	115	81	50	24	5	0	Yes
91[b]	77	1.5	77	33	0	0	0	0	0	0	NS
92	68	3.6	148	81	20	0	0	0	0	0	NS
93	58	8.2	261	203	145	92	50	20	6	1	Yes
94	181	7.7	1,003	823	642	475	330	200	79	8	No
95	29	3.5	79	50	24	4	0	0	0	0	NS
96	89	5.9	284	195	112	49	15	2	0	0	Yes
97	99	7.8	610	511	412	313	218	131	56	7	Yes
98	33	8.3	165	132	101	71	44	20	6	1	NS
99	38	7.9	195	157	121	88	58	32	12	2	NS
100	43	1.7	25	2	0	0	0	0	0	0	No
101	29	5.7	130	100	73	47	24	6	0	0	NS
102	30	7.4	131	101	73	47	23	7	1	0	NS
103	35	6.8	147	113	81	52	29	13	4	0	NS
104	50	6.2	226	176	127	80	41	11	<1	0	No
105	34	5.8	112	81	53	29	9	2	0	0	NS
106	36	5.7	84	52	26	10	2	0	0	0	NS
107	55	6.8	207	152	102	62	33	11	1	0	No
108[b]	20	2	46	26	11	0	0	0	0	0	NS
109	142	9.2	952	810	669	527	390	262	147	49	Yes
110	54	4.8	179	125	71	24	<1	0	0	0	No
111	25	4.8	76	52	29	9	1	0	0	0	NS

Lake No.	Surface Area (acres)	Maximum Depth (feet)	Ice Thickness (Average Measurement Date)								Fish Observed
			0 feet	1 foot (Oct 31)	2 feet (Nov 13)	3 feet (Dec 11)	4 feet (Jan 4)	5 feet (Feb 20)	6 feet (April 5)	7 feet (April 16)[a]	
112	88	3.3	189	102	34	2	0	0	0	0	No
113	26	3.8	75	50	27	8	0	0	0	0	NS
114[b]	0	0	0	0	0	0	0	0	0	0	NS
115	41	7.5	221	180	139	99	64	33	11	<1	Yes
116	45	7.9	148	103	58	22	6	3	1	<1	Yes
117	25	3.1	48	24	6	<1	0	0	0	0	Yes
118	18	2.7	32	15	4	0	0	0	0	0	NS
119	68	24.8	819	751	683	615	548	484	422	363	Yes
Total	**NA**	**NA**	**55,379**	**43,359**	**33,962**	**25,061**	**17,755**	**11,702**	**6,797**	**3,366**	**NA**

Source: Trawicki et al. 1991

Notes: NA (not applicable); NS (not sampled). Highlighted rows indicate lakes that contain some level of liquid water in April (i.e., lakes that do not freeze to the bottom). One acre foot equals 325,851 gallons.

[a] Seven feet of ice was reported only during one year of record.

[b] Lake was too shallow for fathometer readings. Volumes are estimated based on surface area from U.S. Geological Survey topographic maps and maximum depth estimates.

[c] Lake was not sampled for fish.

[d] Lake is directly connected to the Beaufort Sea.

J.3 BIRDS

Table J-9
Status, Abundance, and Conservation Listings of Bird Species on the Arctic Refuge Coastal Plain

Species Group: Waterbirds			Conservation Listings							
Common Name	**Scientific Name**	**Status and Abundance[a]**	**ESA[b]**	**USFWS BCC[c]**	**BLM[d]**	**ADFG[e]**	**US SCPP[f]**	**PIF[g]**	**AUD[h]**	**IUCN[i]**
Greater white-fronted goose	*Anser albifrons*	Breeder: uncommon Migrant: common (spring, fall)	—	—	—	—	—	—	—	—
Snow goose	*A. caerulescens*	Visitor: rare (summer) Migrant: common (spring), abundant (fall)	—	—	—	—	—	—	—	—
Ross's goose	*A. rossii*	Migrant: casual (spring), possible (fall)	—	—	—	—	—	—	—	—
Brant	*Branta bernicla*	Breeder: uncommon Migrant: common (coast)	—	—	—	—	—	—	Y	—
Cackling goose	*B. hutchinsii*	Breeder: common Migrant: common (spring, fall)	—	—	—	—	—	—	Y	—
Trumpeter swan	*Cygnus buccinator*	Breeder and visitor: casual	—	—	—	—	—	—	—	—
Tundra swan	*C. columbianus*	Breeder: common	—	—	W	—	—	—	—	—
Northern shoveler	*Spatula clypeata*	Possible breeder: uncommon Visitor: uncommon	—	—	—	—	—	—	—	—
Gadwall	*Mareca strepera*	Visitor: casual	—	—	—	—	—	—	—	—
Eurasian wigeon	*M. penelope*	Visitor: casual	—	—	—	—	—	—	—	—
American wigeon	*M. americana*	Migrant: uncommon	—	—	—	—	—	—	—	—
Mallard	*Anas platyrhynchos*	Breeder: rare (inland), uncommon (rest of coastal plain)	—	—	—	—	—	—	—	—
Northern pintail	*A. acuta*	Breeder and migrant: common	—	—	—	—	—	—	—	—
Green-winged teal	*A. crecca*	Breeder: uncommon (inland), rare (coast) Migrant: rare (coast)	—	—	—	—	—	—	Y	—
Canvasback	*Aythya valisineria*	Visitor: casual	—	—	—	—	—	—	—	—
Greater scaup	*A. marila*	Breeder: rare (inland) Visitor: uncommon (coast) Migrant: uncommon (coast)	—	—	—	—	—	—	R	—
Lesser scaup	*A. affinis*	Breeder: rare (inland) Visitor: rare (inland)	—	—	—	—	—	—	—	—

Species Group: Waterbirds			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Steller's eider	*Polysticta stelleri*	Visitor: rare (coast)	T	—	S	A	—	—	R	VU
Spectacled eider	*Somateria fischeri*	Breeder: rare (coast) Visitor: uncommon (coast)	T	—	S	A	—	—	R	NT
King eider	*S. spectabilis*	Breeder: fairly common (coast) Migrant: uncommon (coast)	—	—	—	—	—	—	Y	—
Common eider	*S. mollissima*	Breeder: common (barrier islands) Migrant: common (coast)	—	—	—	—	—	—	—	NT
Harlequin duck	*Histrionicus histrionicus*	Breeder: rare (inland)	—	—	—	—	—	—	—	—
Surf scoter	*Melanitta perspicillata*	Possible breeder: uncommon (inland) Migrant: uncommon (coast)	—	—	—	—	—	—	—	—
White-winged scoter	*M. degland*	Possible breeder: rare (inland) Migrant: common (coast)	—	—	—	—	—	—	—	—
Black scoter	*M. americana*	Migrant: uncommon (coast)	—	—	—	A	—	—	R	NT
Long-tailed duck	*Clangula hyemalis*	Breeder: common Migrant: abundant (coast) in fall	—	—	—	—	—	—	—	VU
Common goldeneye	*Bucephala clangula*	Visitor: rare	—	—	—	—	—	—	—	—
Smew	*Mergellus albellus*	Visitor: accidental	—	—	—	—	—	—	—	—
Common merganser	*Mergus merganser*	Visitor: casual (inland)	—	—	—	—	—	—	—	—
Red-breasted merganser	*M. serrator*	Breeder: fairly common (inland), rare (coast) Migrant: fairly common (coast)	—	—	—	—	—	—	—	—
Horned grebe	*Podiceps auritus*	Possible breeder: uncommon (inland) Visitor: casual	—	—	—	—	—	—	—	VU
Red-necked grebe	*P. grisegena*	Visitor: casual	—	—	—	—	—	—	R	—
Sandhill crane	*Antigone canadensis*	Breeder: rare Summer resident: uncommon	—	—	—	—	—	—	—	—
Red-throated loon	*Gavia stellata*	Breeder: fairly common (coast) Migrant: fairly common (coast)	—	C	S	A	—	—	—	—
Pacific loon	*G. pacifica*	Breeder: common Migrant: common (coast)	—	—	—	—	—	—	—	—
Common loon	*G. immer*	Visitor: rare (coast)	—	—	—	—	—	—	—	—
Yellow-billed Loon	*G. adamsii*	Migrant: uncommon (coast), rare (inland)	—	C	S	A	—	—	R	NT

Species Group: Shorebirds			Conservation Listings							
Common Name	**Scientific Name**	**Status and Abundance[a]**	**ESA[b]**	**USFWS BCC[c]**	**BLM[d]**	**ADFG[e]**	**US SCPP[f]**	**PIF[g]**	**AUD[h]**	**IUCN[i]**
Black-bellied plover	*Pluvialis squatarola*	Breeder: rare Migrant: rare (coast) to fairly common (coast in fall)	—	—	—	—	MC	—	—	—
American golden-plover	*P. dominica*	Breeder: common	—	—	W —	A	HC	—	R	—
Semipalmated plover	*Charadrius semipalmatus*	Breeder: uncommon (barrier islands) and fairly common (inland) Visitor: rare	—	—	—	—	—	—	—	—
Killdeer	*C. vociferus*	Visitor: casual	—	—	—	A	MC	—	—	—
Eurasian dotterel	*C. morinellus*	Visitor: casual	—	—	—	—	—	—	—	—
Upland sandpiper	*Bartramia longicauda*	Breeder: fairly common (inland)	—	—	—	A	—	—	—	—
Whimbrel	*Numenius phaeopus*	Breeder: rare (inland) Visitor: uncommon (coast)	—	C	S	A	HC	—	Y	—
Black-tailed godwit	*Limosa limosa*	Visitor: accidental	—	—	—	—	—	—	—	NT
Hudsonian godwit	*L. haemastica*	Visitor: casual	—	C[j]	S	A	HC	—	Y	—
Bar-tailed godwit	*L. lapponica*	Possible breeder: uncommon	—	C	S	A	GC	—	R	NT
Ruddy turnstone	*Arenaria interpres*	Breeder: fairly common (coast), uncommon (inland)	—	—	—	—	MC	—	—	—
Red knot	*Calidris canutus*	Migrant: rare	—	C	S	A	GC	—	R	NT
Ruff	*C. pugnax*	Visitor: casual	—	—	—	—	—	—	—	—
Sharp-tailed sandpiper	*C. acuminata*	Migrant: casual (coast)	—	—	—	—	—	—	R	—
Stilt sandpiper	*C. himantopus*	Breeder: uncommon Migrant: uncommon (fall)	—	—	—	—	—	—	—	—
Red-necked stint	*C. ruficollis*	Visitor: casual (coast)	—	—	—	—	—	—	—	NT
Sanderling	*C. alba*	Breeder: rare Migrant: rare (coast in spring), uncommon (coast in fall)	—	—	—	A	MC	—	—	—
Dunlin	*C. alpina*	Breeder: uncommon (coast) Migrant: uncommon (coast in fall)	—	C	S	A	HC[k]	—	R	—
Baird’s sandpiper	*C. bairdii*	Breeder: uncommon	—	—	—	—	—	—	—	—
Least sandpiper	*C. minutilla*	Visitor: rare	—	—	—	—	—	—	—	—
White-rumped sandpiper	*C. fuscicollis*	Breeder: rare Migrant: rare (spring), uncommon (fall)	—	—	—	—	—	—	—	—

Species Group: Shorebirds			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Buff-breasted Sandpiper	*C. subruficollis*	Breeder: uncommon Migrant: uncommon	—	C	S	A	HC	—	R	NT
Pectoral sandpiper	*C. melanotos*	Breeder: abundant Migrant: abundant (coast in fall)	—	—	—	A	HC	—	R	—
Semipalmated sandpiper	*C. pusilla*	Breeder: abundant (coast), common (inland) Migrant: common (coast in fall)	—	—	—	A	HC	—	—	NT
Western sandpiper	*C. mauri*	Possible breeder: rare Migrant: uncommon on coast	—	—	—	A	MC	—	Y	—
Long-billed dowitcher	*Limnodromus scolopaceus*	Breeder: uncommon Visitor: fairly common (summer) Migrant: common on coast	—	—	—	—	MC	—	—	—
Wilson's snipe	*Gallinago delicata*	Possible breeder: rare Visitor: rare	—	—	—	—	—	—	—	—
Spotted sandpiper	*Actitis macularius*	Breeder: uncommon (inland)	—	—	—	A	—	—	—	—
Wandering tattler	*Tringa incana*	Breeder: uncommon (inland)	—	—	—	—	—	—	Y	—
Lesser yellowlegs	*T. flavipes*	Visitor: casual	—	C[l]	—	A	HC	—	R	—
Wilson's phalarope	*Phalaropus tricolor*	Visitor: accidental	—	—	—	—	—	—	—	—
Red-necked phalarope	*P. lobatus*	Breeder: common Migrant: common to abundant (coast)	—	—	—	—	MC	—	—	—
Red phalarope	*P. fulicarius*	Breeder: fairly common (coast east to Jago Delta), uncommon (rest of coastal plain) Migrant: uncommon (coast in fall)	—	—	—	—	MC	—	—	—

Species Group: Larids			Conservation Listings							
Common Name	**Scientific Name**	**Status and Abundance[a]**	**ESA[b]**	**USFWS BCC[c]**	**BLM[d]**	**ADFG[e]**	**US SCPP[f]**	**PIF[g]**	**AUD[h]**	**IUCN[i]**
Pomarine jaeger	*Stercorarius pomarinus*	Breeder: occasionally common (coast) Visitor: common (summer) Migrant: common (spring)	—	—	—	—	—	—	—	—
Parasitic jaeger	*St. parasiticus*	Breeder: uncommon Summer resident: common	—	—	—	—	—	—	—	—
Long-tailed jaeger	*St. longicaudus*	Breeder: fairly common (inland), rare (coast) Summer resident: common	—	—	—	—	—	—	—	—
Black-legged kittiwake	*Rissa tridactyla*	Visitor: rare (coast mostly offshore)	—	—	—	—	—	—	R	VU
Ivory gull	*Pagophila eburnea*	Migrant: rare	—	—	—	—	—	—	R	NT
Sabine's gull	*Xema sabini*	Breeder: uncommon (coast) Migrant: uncommon (coast)	—	—	—	—	—	—	—	—
Bonaparte's gull	*Chroicocephalus philadelphia*	Visitor: casual	—	—	—	—	—	—	—	—
Ross's gull	*Rhodostethia rosea*	Migrant: rare (coast)	—	—	—	—	—	—	Y	—
Short-billed gull	*Larus brachyrhynchus*	Breeder: rare Visitor: rare	—	—	—	—	—	—	—	—
Herring gull	*L. argentatus*	Visitor and migrant: rare	—	—	—	—	—	—	—	—
Thayer's gull	*L. thayeri*	Visitor: rare	—	—	—	—	—	—	—	—
Slaty-backed gull	*L. schistisagus*	Visitor: casual (coast)	—	—	—	—	—	—	—	—
Glaucous-winged gull	*L. glaucescens*	Visitor: casual (coast)	—	—	—	—	—	—	—	—
Glaucous gull	*L. hyperboreus*	Breeder: common (coast), uncommon (inland) Summer resident: abundant (coast)	—	—	—	—	—	—	—	—
Caspian tern	*Hydroprogne caspia*	Visitor: accidental	—	—	—	—	—	—	—	—
Arctic tern	*Sterna paradisaea*	Breeder: uncommon (coast), rare (inland) Summer resident: common	—	C	—	—	—	—	—	—

Species Group: Raptors and Owls			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Osprey	*Pandion haliaetus*	Visitor: accidental	—	—	—	—	—	—	—	—
Bald eagle	*Haliaeetus leucocephalus*	Visitor: casual	—	—	—	—	—	—	—	—
Northern harrier	*Circus hudsonius*	Possible breeder: uncommon (inland) Summer resident: uncommon	—	—	—	A	—	—	—	—
Sharp-shinned hawk	*Accipiter striatus*	Visitor: casual	—	—	—	—	—	—	—	—
Northern goshawk	*A. gentilis*	Visitor: casual (inland)	—	—	—	—	—	—	—	—
Rough-legged hawk	*Buteo lagopus*	Breeder: uncommon (inland) Visitor: rare (coast)	—	—	—	—	—	—	—	—
Golden eagle	*Aquila chrysaetos*	Breeder: rare (inland) Visitor: fairly common	—	—	W	A	—	—	—	—
Snowy owl	*Bubo scandiacus*	Breeder: common (in high microtine rodent years) to rare	—	C	—	A	—	C	—	VU
Short-eared owl	*Asio flammeus*	Breeder: common (in high microtine rodent years) to uncommon	—	C	W	A	—	—	—	—
American kestrel	*Falco sparverius*	Visitor: casual	—	—	—	A	—	—	—	—
Merlin	*F. columbarius*	Possible breeder: rare Visitor: rare	—	—	—	—	—	—	—	—
Gyrfalcon	*F. rusticolus*	Permanent resident and breeder: uncommon (inland) Visitor: rare on coast	—	—	W	A	—	—	—	—
Peregrine falcon	*F. peregrinus*	Breeder: rare Visitor: uncommon	—	—	—	—	—	—	—	—

Species Group: Landbirds			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Willow ptarmigan	*Lagopus lagopus*	Permanent resident and breeder: uncommon (coast), common to abundant (inland)	—	—	—	—	—	—	—	—
Rock ptarmigan	*L. muta*	Permanent resident: common Breeder: common	—	—	—	—	—	—	—	—
Common nighthawk	*Chordeiles minor*	Visitor: casual	—	—	—	—	—	—	—	—
Rufous hummingbird	*Selasphorus rufus*	Visitor: accidental	—	C	W	A	—	C	R	NT
Belted kingfisher	*Megaceryle alcyon*	Visitor: casual	—	—	—	A	—	—	—	—
Hammond's flycatcher	*Empidonax hammondii*	Visitor: accidental	—	—	—	—	—	—	—	—
Eastern phoebe	*Sayornis phoebe*	Visitor: accidental	—	—	—	—	—	—	—	—
Say's phoebe	*S. saya*	Visitor: rare	—	—	—	—	—	—	—	—
Eastern kingbird	*Tyrannus tyrannus*	Visitor: accidental	—	—	—	—	—	—	—	—
Northern shrike	*Lanius borealis*	Possible breeder: rare (inland) Visitor: rare (inland)	—	—	—	—	—	—	—	—
Gray jay	*Perisoreus canadensis*	Visitor: casual	—	—	—	—	—	—	—	—
Common raven	*Corvus corax*	Permanent resident: uncommon Possible breeder: rare	—	—	—	—	—	—	—	—
Horned lark	*Eremophila alpestris*	Breeder: rare (inland) Visitor: rare (rest of coastal plain)	—	—	—	A	—	—	—	—
Tree swallow	*Tachycineta bicolor*	Visitor: casual	—	—	—	A	—	—	—	—
Violet-green Swallow	*T. thalassina*	Visitor: casual	—	—	—	—	—	—	R	—
Bank swallow	*Riparia riparia*	Visitor: casual	—	—	W	A	—	—	R	—
Cliff swallow	*Petrochelidon pyrrhonota*	Possible breeder: rare Visitor: rare	—	—	—	—	—	—	—	—
Barn swallow	*Hirundo rustica*	Visitor: casual	—	—	—	A	—	—	—	—
American dipper	*Cinclus mexicanus*	Permanent resident: uncommon (inland) Breeder: uncommon (inland)	—	—	—	—	—	—	—	—
Bluethroat	*Cyanecula svecica*	Breeder: rare (inland)	—	—	—	—	—	—	—	—
Northern wheatear	*Oenanthe oenanthe*	Visitor: rare	—	—	—	—	—	—	—	—
Gray-cheeked thrush	*Catharus minimus*	Visitor: rare	—	—	—	—	—	—	—	—
Hermit thrush	*C. guttatus*	Visitor: accidental	—	—	—	—	—	—	—	—
American robin	*Turdus migratorius*	Breeder: uncommon (inland) Visitor: rare (coast)	—	—	—	—	—	—	—	—

Species Group: Landbirds			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Varied thrush	*Ixoreus naevius*	Visitor: casual	—	—	C	A	—	—	—	—
Cedar waxwing	*Bombycilla cedrorum*	Visitor: accidental	—	—	—	—	—	—	—	—
Eastern yellow wagtail	*Motacilla tschutschensis*	Breeder: fairly common	—	—	—	—	—	—	—	—
American pipit	*Anthus rubescens*	Breeder: rare Migrant: uncommon (fall)	—	—	—	A	—	—	—	—
Common redpoll	*Acanthis flammea*	Breeder: common	—	—	—	A	—	—	—	—
Hoary redpoll	*A. hornemanni*	Breeder: common	—	—	—	—	—	—	—	—
Pine siskin	*Spinus pinus*	Visitor: casual	—	—	—	A	—	—	—	—
Lapland longspur	*Calcarius lapponicus*	Breeder: abundant	—	—	—	—	—	—	—	—
Smith's longspur	*C. pictus*	Visitor: rare	—	C	S	A	—	—	—	—
Snow bunting	*Plectrophenax nivalis*	Breeder: common (coast)	—	—	—	A	—	—	—	—
Northern waterthrush	*Parkesia noveboracensis*	Visitor: casual	—	—	—	—	—	—	—	—
Orange-crowned warbler	*Leiothlypis celata*	Visitor: casual	—	—	—	A	—	—	R	—
Yellow warbler	*Setophaga petechia*	Breeder: rare (inland) Visitor: rare (coast)	—	—	—	A	—	—	—	—
Yellow-rumped warbler	*S. coronata*	Visitor: casual	—	—	—	—	—	—	—	—
Wilson's warbler	*Cardellina pusilla*	Visitor: rare	—	—	—	A	—	—	—	—
American tree sparrow	*Spizelloides arborea*	Breeder: common (inland): Visitor: rare (coast)	—	—	—	—	—	—	—	—
Chipping sparrow	*Spizella passerina*	Visitor: casual	—	—	—	A	—	—	—	—
Clay-colored sparrow	*S. pallida*	Visitor: accidental	—	—	—	—	—	—	—	—
Savannah sparrow	*Passerculus sandwichensis*	Breeder: common	—	—	—	A	—	—	—	—
Fox sparrow	*Passerella iliaca*	Breeder: rare (inland) Visitor: rare (coast)	—	—	—	A	—	—	—	—
White-throated sparrow	*Zonotrichia albicollis*	Visitor: casual	—	—	—	—	—	—	—	—
White-crowned sparrow	*Z. leucophrys*	Breeder: uncommon (inland) Visitor: rare (coast)	—	—	—	A	—	—	—	—
Dark-eyed junco	*Junco hyemalis*	Visitor: rare	—	—	—	—	—	—	—	—
Red-winged blackbird	*Agelaius phoeniceus*	Visitor: casual	—	—	—	A	—	—	—	—
Rusty blackbird	*Euphagus carolinus*	Visitor: casual	—	—	—	A	—	—	—	VU
Brown-headed cowbird	*Molothrus ater*	Visitor: casual	—	—	—	—	—	—	—	—

Species Group: Seabirds			Conservation Listings							
Common Name	Scientific Name	Status and Abundance[a]	ESA[b]	USFWS BCC[c]	BLM[d]	ADFG[e]	US SCPP[f]	PIF[g]	AUD[h]	IUCN[i]
Thick-billed murre	*Uria lomvia*	Migrant: rare (coast)	—	—	—	—	—	—	—	—
Kittlitz's murrelet[m]	*Brachyramphus brevirostris*	Visitor: rare (offshore)	—	C	S	A	—	—	R	NT
Black guillemot	*Cepphus grylle*	Breeder: rare (coast) Summer resident: uncommon (coast)	—	—	—	—	—	—	—	—
Least auklet	*Aethia pusilla*	Visitor: casual (coast)	—	—	—	—	—	—	—	—
Horned puffin	*Fratercula corniculata*	Visitor: rare (coast)	—	—	—	—	—	—	R	—
Tufted puffin	*F. cirrhata*	Visitor: casual (coast)	—	C[m]	—	—	—	—	R	—
Northern fulmar	*Fulmarus glacialis*	Visitor: rare (offshore)	—	—	—	—	—	—	—	—
Short-tailed shearwater	*Ardenna tenuirostris*	Visitor: rare (coast mostly offshore)	—	—	—	—	—	—	—	—

[a]Status and abundance from the bird occurrence information for the Arctic Refuge Coastal Plain presented in USFWS (2015, in Appendix F) and Pearce et al. (2018).
[b]Endangered Species Act listings for Alaska (USFWS and NMFS 2014). T = Threatened.
[c] USFWS Birds of Conservation Concern (USFWS 2008). C = Bird of Conservation Concern from USFWS.
[d] BLM Special Status Species List (BLM 2019). S = Sensitive Species; W = Watchlist Species.
[e] ADFG Alaska Wildlife Action Plan list of Species of Greatest Conservation Need (ADFG 2015). A = At-risk Species.
[f] Shorebirds of Conservation Concern (U.S. Shorebird Conservation Plan Partnership 2016). GC = Greatest concern; HC = High concern; MC = Moderate concern.
[g] Partners in Flight Landbird Conservation Plan Species of Continental Concern (Rosenberg et al. 2016). C = Birds of Continental Concern.
[h] Audubon Watchlist Species (Warnock 2017a and 2017b). R = Red-list species; Y = Yellow-list species.
[i] IUCN Red List of Threatened Species (IUCN 2018). EN = Endangered; VU = Vulnerable; NT = Near Threatened.
[j]Listed as a species of conservation concern for Bird Conservation Regions 2 and 5 only.
[k]Listed at the regional not national level.
[l]Listed as a species of conservation concern for Bird Conservation Regions 4 and 5 only.
[m]Source: Kuletz and Labunski 2017.

Table J-10
Birds on the Arctic Refuge Coastal Plain Listed as Canadian Wildlife Species At Risk

Species Group	Common Name	*Scientific Name*	Status
Waterbirds	Horned grebe	*Podiceps auritus* (western population)	S
Shorebirds	Red knot	*Calidris canutus* ssp. *roselaari*	T
	Buff-breasted sandpiper	*Tryngites subruficollis*	S
	red-necked phalarope	*Phalaropus lobatus*	S
Larids	Ivory gull	*Pagophila eburnea*	E
	Ross's gull	*Rhodostethia rosea*	T
Raptors and owls	Short-eared owl	*Asio flammeus*	S
	Peregrine falcon*	*Falco peregrinus* ssp. *anatum/tundrius*	S
Landbirds	Common nighthawk	*Chordeiles minor*	T
	Bank swallow	*Riparia riparia*	T
	Barn swallow	*Hirundo rustica*	T
	Rusty blackbird	*Euphagus carolinus*	S

Source: COSEWIC 2018
S = Special Concern; T = Threatened; E = Endangered
*The *anatum/tundrius* subspecies of peregrine falcon was designated as "not at risk" by COSEWIC in 2017; however, it still retains special concern status under the Species At Risk Act (SARA)

Table J-11
Conservation Listings of Bird Species Occurring Along Marine Vessel Transit Route Between Dutch Harbor and the Program Area

Species Group: Waterbirds		Conservation Listings					
Common Name	**Scientific Name**	**ESA[a]**	**USFWS BCC[b]**	**BLM[c]**	**ADFG[d]**	**AUD[e]**	**IUCN[f]**
Emperor goose	*Anser canagicus*	—	—	W	A	Y	NT
Snow goose	*A. caerulescens*	—	—	—	—	—	—
Brant	*Branta bernicla*	—	—	—	—	Y	—
Cackling goose (Aleutian, Taverner's, minima)	*B. hutchinsii*	—	—	S	—	Y	—
Steller's eider	*Polysticta stelleri*	T	—	S	A	R	VU
Spectacled eider	*Somateria fischeri*	T	—	S	A	R	NT
King eider	*S. spectabilis*	—	—	—	—	Y	—
Common eider	*S. mollissima*	—	—	—	—	—	NT
Harlequin duck	*Histrionicus histrionicus*	—	—	—	—	—	—
Surf scoter	*Melanitta perspicillata*	—	—	—	—	—	—
White-winged scoter	*M. fusca*	—	—	—	—	—	—
Black scoter	*M. americana*	—	—	—	A	R	NT
Long-tailed duck	*Clangula hyemalis*	—	—	—	—	—	VU
Common goldeneye	*Bucephala clangula*	—	—	—	—	—	—
Barrow's goldeneye	*B. islandica*	—	—	—	—	—	—
Common merganser	*Mergus merganser*	—	—	—	—	—	—
Red-breasted merganser	*M. serrator*	—	—	—	—	—	—
Horned grebe	*Podiceps auritus*	—	—	—	—	—	VU
Red-throated loon	*Gavia stellata*	—	—	S	A	—	—
Arctic loon	*G. arctica*	—	—	—	—	—	—
Pacific loon	*G. pacifica*	—	—	—	—	—	—
Common loon	*G. immer*	—	—	—	—	—	—
Yellow-billed Loon	*G. adamsii*	—	C	S	A	R	NT

Species Group: Shorebirds		Conservation Listings					
Common Name	**Scientific Name**	**ESA[a]**	**USFWS BCC[b]**	**BLM[c]**	**ADFG[d]**	**AUD[e]**	**IUCN[f]**
Red-necked phalarope	*Phalaropus lobatus*	—	—	—	—	—	—
Red phalarope	*P. fulicarius*	—	—	—	—	—	—
Black oystercatcher	*Haematopus bachmani*	—	C	—	A	—	—
Semipalmated plover	*Charadrius semipalmatus*	—	—	—	—	—	—
Ruddy turnstone	*Arenaria interpres*	—	—	—	—	—	—
Rock sandpiper	*Calidris ptilocnemis*	—	C	S	—	Y	—
Least sandpiper	*C. minutilla*	—	—	—	—	—	—
Pectoral sandpiper	*C. melanotos*	—	C	—	A	R	—
Wandering tattler	*Tringa incana*	—	—	—	—	Y	—

Species Group: Larids		Conservation Listings					
Common Name	**Scientific Name**	**ESA[a]**	**USFWS BCC[b]**	**BLM[c]**	**ADFG[d]**	**AUD[e]**	**IUCN[f]**
Pomarine jaeger	*Stercorarius pomarinus*	—	—	—	—	—	—
Parasitic jaeger	*S. parasiticus*	—	—	—	—	—	—
Long-tailed jaeger	*S. longicaudus*	—	—	—	—	—	—
Black-legged kittiwake	*Rissa tridactyla*	—	—	—	—	R	VU
Red-legged kittiwake	*R. brevirostris*	—	C	—	A	R	VU
Ivory gull	*Pagophila eburnea*	—	—	—	—	R	NT
Sabine’s gull	*Xema sabini*	—	—	—	—	—	—
Bonaparte’s gull	*Chroicocephalus philadelphia*	—	—	—	—	—	—
Ross’s gull	*Rhodostethia rosea*	—	—	—	—	Y	—
Mew gull	*Larus canus*	—	—	—	—	—	—
Ring-billed gull	*L. delawarensis*	—	—	—	—	—	—
Herring gull	*L. argentatus*	—	—	—	A	—	—
Iceland gull	*L. glaucoides*	—	—	—	—	—	—
Slaty-backed gull	*L. schistisagus*	—	—	—	—	—	—
Glaucous-winged gull	*L. glaucescens*	—	—	—	—	—	—
Glaucous gull	*L. hyperboreus*	—	—	—	—	—	—
Aleutian tern	*Onychoprion aleuticus*	—	C	S	A	R	VU
Caspian tern	*Hydroprogne caspia*	—	C	—	—	—	—
Arctic tern	*Sterna paradisaea*	—	C	—	A	—	—

Species Group: Seabirds		Conservation Listings					
Common Name	**Scientific Name**	**ESA[a]**	**USFWS BCC[b]**	**BLM[c]**	**ADFG[d]**	**AUD[e]**	**IUCN[f]**
Dovekie	*Alle alle*	—	—	—	—	—	—
Common murre	*Uria aalge*	—	—	—	—	—	—
Thick-billed murre	*U. lomvia*	—	—	—	—	—	—
Black guillemot	*Cepphus grylle*	—	—	—	—	—	—
Pigeon guillemot	*C. columba*	—	—	—	—	—	—
Marbled murrelet	*Brachyramphus marmoratus*	—	C	S	A	R	EN
Kittlitz's murrelet	*B. brevirostris*	—	C	S	A	R	NT
Ancient murrelet	*Synthliboramphus antiquus*	—	C	—	A	—	—
Cassin's auklet	*Ptychoramphus aleuticus*	—	C[g]	—	A	—	NT
Parakeet auklet	*Aethia psittacula*	—	—	—	—	—	—
Least auklet	*A. pusilla*	—	—	—	—	—	—
Whiskered auklet	*A. pygmaea*	—	C	—	—	Y	—
Crested auklet	*A. cristatella*	—	—	—	—	—	—
Rhinoceros auklet	*Cerorhinca monocerata*	—	—	—	—	—	—
Horned puffin	*Fratercula corniculata*	—	—	—	—	R	—
Tufted puffin	*F. cirrhata*	—	C[g]	—	—	R	—
Laysan albatross	*Phoebastria immutabilis*	—	C	—	A	—	NT
Black-footed albatross	*P. nigripes*	—	C	—	A	—	NT
Short-tailed albatross	*P. albatrus*	E	—	—	A	R	VU
Northern fulmar	*Fulmarus glacialis*	—	—	—	—	—	—
Short-tailed shearwater	*Ardenna tenuirostris*	—	—	—	—	—	—
Sooty shearwater	*A. grisea*	—	—	—	—	—	NT
Fork-tailed storm-petrel	*Oceanodroma furcata*	—	—	—	—	—	—
Leach's storm-petrel	*O. leucorhoa*	—	—	—	—	—	VU
Double-crested cormorant	*Phalacrocorax auritus*	—	—	—	—	Y	—
Red-faced cormorant	*P. urile*	—	C	—	A	R	—
Pelagic cormorant	*P. pelagicus*	—	C	—	A	—	—

[a]Endangered Species Act listings for Alaska (USFWS and NMFS 2014); E = Endangered; T = Threatened
[b] USFWS Birds of Conservation Concern (USFWS 2008). C = Bird of Conservation Concern from USFWS
[c] BLM Special Status Species List (BLM 2019). S = Sensitive Species; W = Watchlist Species
[d] ADFG Alaska Wildlife Action Plan list of Species of Greatest Conservation Need (ADFG 2015). A = At-Risk Species
[e] Audubon Watchlist Species (Warnock 2017a and 2017b). R = Red-list species; Y = Yellow-list species
[f] IUCN Red List of Threatened Species (IUCN 2018). EN = Endangered; VU = Vulnerable; NT = Near Threatened
[g]Listed as a species of conservation concern for Bird Conservation Region 5 only.

Table J-12
Crosswalk of Ecotypes Mapped in Northwest Alaska to Land Cover Types Mapped in the ANWR Program Area[b]

Marcot Ecotype	Primary ANWR Land Cover Type	Secondary ANWR Land Cover Type
Alpine acidic barrens	Barrens	Partially vegetated
Alpine acidic dryas dwarf shrub	Dryas dwarf shrub	—
Alpine alkaline barrens	Barrens	Partially vegetated
Alpine alkaline dryas dwarf shrub	Dryas dwarf shrub	—
Alpine ericaceous dwarf shrub	Ericaceous dwarf shrub	Snowbed
Alpine lake	Water	—
Alpine mafic barrens	Barrens	Partially vegetated
Alpine snowfields and glaciers	Snow/Ice	—
Alpine wet sedge meadow	Wet sedge meadow tundra	Snowbed
Coastal barrens	Barrens	Partially vegetated
Coastal brackish sedge-grass meadow	Salt marsh	—
Coastal crowberry dwarf shrub	Ericaceous dwarf shrub	—
Coastal dunegrass meadow	—	—
Coastal water	Water	—
Human modified barrens	Barrens	Partially vegetated
Lacustrine barrens	Barrens	Partially vegetated
Lacustrine bluejoint meadow	—	—
Lacustrine wet sedge meadow	Wet sedge meadow tundra	Wet sedge meadow tundra with moist inclusions
Lacustrine willow shrub	—	—
Lowland alder tall shrub	—	—
Lowland barrens-burned	—	—
Lowland birch forest	—	—
Lowland birch-ericaceous-willow low shrub	Low and dwarf birch shrub	—
Lowland black spruce forest	—	—
Lowland ericaceous shrub bog	Ericaceous dwarf shrub	Low and dwarf birch shrub
Lowland lake	Water	—
Lowland sedge fen	Wet sedge meadow tundra	Wet sedge meadow tundra with moist inclusions
Lowland sedge-dryas meadow	Moist sedge-dryas tundra	Moist sedge-shrub tundra with wet inclusions
Lowland spruce-birch forest	—	—
Lowland willow low shrub	Low and dwarf birch shrub	Moist sedge-willow tundra
Riverine alder-willow tall shrub	Low and tall riverine willow shrub	—
Riverine barrens	Barrens	Partially vegetated
Riverine birch-willow low shrub	Low and tall riverine willow shrub	—
Riverine dryas dwarf shrub	Dryas dwarf shrub	Moist sedge-shrub tundra with wet inclusions
Riverine poplar forest	Poplar forest	—
Riverine water	Water	—
Riverine wet sedge meadow	Wet sedge meadow tundra	Wet sedge meadow tundra with moist inclusions

Marcot Ecotype	Primary ANWR Land Cover Type	Secondary ANWR Land Cover Type
Riverine white spruce-poplar forest	—	—
Riverine white spruce-willow forest	—	—
Riverine willow low shrub	Low and tall riverine willow shrub	—
Shadow/Indeterminate	—	—
Upland alder-willow tall shrub	—	—
Upland aspen forest	—	—
Upland barrens-burned	—	—
Upland barrens-landslides	Barrens	Partially vegetated
Upland barrens-thermokarst	Barrens	Partially vegetated

[a] Ecotypes in northwest Alaska from Marcot et al. (2015).
[B] Land cover types on the Refuge Coastal Plain from Macander et al. (2020).

Table J-13
Categorical Habitat-use Rankings for Bird Species Occurring Regularly[a] on the Arctic Refuge Coastal Plain

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Waterbirds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater white-fronted goose	0	1	2	2	1	2	1	1	0	0	2	0	1	1	1	3	1	3	3	3
Snow goose	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	3
Brant	0	0	1	0	0	1	0	0	0	0	3	0	0	0	3	3	0	1	1	3
Cackling goose	0	1	1	0	0	2	1	0	0	0	2	0	1	1	1	3	1	3	3	3
Tundra swan	0	1	2	2	1	2	1	1	0	0	1	0	1	1	1	3	2	3	3	3
Northern shoveler	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	3	2	3	3	3
American wigeon	0	1	0	0	1	1	1	0	0	0	1	0	0	0	1	3	2	3	3	3
Mallard	0	1	0	0	0	1	1	0	0	0	1	0	0	0	1	3	2	3	3	3
Northern pintail	0	0	0	0	0	1	1	0	0	0	3	0	0	0	0	3	2	3	3	3
Green-winged teal	0	1	0	0	1	1	1	0	0	0	3	0	0	0	1	3	2	3	3	3
Greater scaup	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	3	1	3	3	3
Lesser scaup	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	1	3	3	3
Steller’s eider	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	3
Spectacled eider	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	3
King eider	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	3
Common eider	1	0	1	0	0	0	0	0	1	0	3	0	0	0	3	0	0	0	0	0
Harlequin duck	0	2	0	0	1	0	1	0	0	0	0	0	0	0	1	0	3	0	0	1

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Surf scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	2
White-winged scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	3
Black scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	2
Long-tailed duck	0	1	1	0	0	2	1	0	0	0	2	0	0	0	3	3	2	3	3	3
Common goldeneye	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	1	0	0	
Red-breasted merganser	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	3	3	1	1	2
Horned grebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
Sandhill crane	0	2	3	1	0	2	2	1	0	0	1	0	1	1	0	0	0	3	3	2
Red-throated loon	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	3	2	3	3	3
Pacific loon	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	2	3	3	3
Common loon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	2	1	1	3
Yellow-billed loon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	2	1	1	2
Shorebirds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Black-bellied plover	1	3	1	1	0	2	2	1	1	0	2	0	1	1	0	0	0	3	3	1
American golden-plover	1	3	2	1	0	3	3	1	1	0	2	1	3	3	0	0	0	2	2	1
Semipalmated plover	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1
Upland sandpiper	0	0	0	0	0	1	1	0	0	0	0	0	3	3	0	0	0	0	0	0
Whimbrel	0	3	2	1	0	3	3	1	0	0	1	1	3	3	0	0	0	1	1	1
Bar-tailed godwit	0	3	1	1	0	3	3	1	0	0	1	1	3	3	0	0	0	1	1	1
Ruddy turnstone	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0
Red knot	0	0	0	0	0	1	1	0	0	0	0	0	2	2	0	0	0	1	1	1
Stilt sandpiper	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dunlin	0	1	1	0	0	1	1	0	0	0	2	0	0	0	0	0	0	3	3	1
Baird's sandpiper	1	3	1	0	0	2	2	0	1	0	1	0	0	0	0	0	0	1	1	0
Least sandpiper	0	2	1	1	1	2	2	0	0	0	1	0	3	3	0	0	0	2	2	1
White-rumped sandpiper	0	0	0	0	0	2	1	0	0	0	2	0	0	0	0	1	0	2	2	0
Buff-breasted sandpiper	0	1	1	0	0	1	1	0	0	0	1	0	1	1	0	0	0	1	1	0
Pectoral sandpiper	0	2	1	0	0	2	2	0	0	0	2	0	3	3	0	0	0	3	3	1
Semipalmated sandpiper	0	2	2	0	0	3	2	0	0	0	3	0	2	2	0	0	0	2	2	1
Western sandpiper	0	3	2	0	0	3	3	0	0	0	1	0	3	3	0	0	0	2	2	1
Long-billed dowitcher	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	3	2
Wilson's snipe	0	1	2	2	1	2	1	2	0	0	2	2	2	2	0	0	0	2	2	2
Spotted sandpiper	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Wandering tattler	1	2	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Red-necked phalarope	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	3	1	3	3	3
Red phalarope	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	2	2	3
Larids	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pomarine jaeger	0	0	1	0	0	1	0	0	0	0	2	0	0	0	3	0	0	2	2	0
Parasitic jaeger	0	2	1	0	0	2	2	0	0	0	2	0	2	2	1	0	0	2	2	0
Long-tailed jaeger	0	2	1	2	0	2	2	1	0	0	1	1	2	2	1	0	0	2	2	0
Black-legged kittiwake	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Ivory gull	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Sabine's gull	1	0	1	0	0	1	0	0	1	0	3	0	0	0	2	3	2	3	3	2
Ross's gull	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Short-billed gull	1	0	2	1	2	0	0	0	1	0	3	0	0	0	3	3	2	3	3	2
Herring gull	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Thayer's gull	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Glaucous gull	1	1	1	0	1	1	1	0	1	0	3	0	1	1	3	3	2	3	3	2
Arctic tern	1	0	1	0	0	0	0	0	1	0	3	0	0	0	3	3	2	3	3	3
Raptors and Owls	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northern harrier	0	3	0	1	1	3	3	2	0	0	0	1	2	2	0	0	0	1	1	0
Rough-legged hawk	0	1	1	1	1	2	2	2	0	0	0	2	3	3	0	0	0	0	0	0
Golden eagle	0	1	1	1	1	2	2	2	0	0	0	2	3	3	0	0	0	0	0	0
Snowy owl	0	2	1	1	1	3	2	1	0	0	1	1	3	3	0	0	0	2	2	0
Short-eared owl	0	3	2	1	1	3	3	1	0	0	2	1	3	3	0	0	0	2	2	0
Merlin	0	2	2	2	2	2	2	1	0	0	0	1	2	2	0	0	0	0	0	0
Gyrfalcon	0	1	0	1	1	1	1	2	0	0	0	2	1	1	0	0	0	0	0	0
Peregrine falcon	0	2	1	1	1	2	2	1	0	0	1	1	2	2	0	0	0	1	1	0
Landbirds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Willow ptarmigan	0	0	1	2	3	2	1	3	0	0	0	3	3	3	0	0	0	0	0	0
Rock ptarmigan	0	3	0	2	2	1	1	2	0	0	0	2	2	2	0	0	0	0	0	0
Say's phoebe	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Northern shrike	0	0	1	1	2	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Common raven	1	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0
Horned lark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cliff swallow	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0
American dipper	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0
Bluethroat	0	1	0	2	3	0	0	3	0	0	0	3	2	2	0	0	0	0	0	0
Northern wheatear	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Gray-cheeked thrush	0	0	0	1	2	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0
American robin	0	1	1	1	2	0	0	1	0	2	0	1	1	1	0	0	0	0	0	0
Eastern yellow wagtail	0	1	0	2	2	1	1	2	0	0	0	2	3	3	0	0	0	0	0	0
American pipit	0	2	0	0	0	2	2	0	0	0	0	0	2	2	0	0	0	0	0	0
Common redpoll	0	0	1	3	3	0	0	3	0	0	0	3	1	1	0	0	0	0	0	0
Hoary redpoll	0	0	1	3	3	0	0	3	0	0	0	3	1	1	0	0	0	0	0	0
Lapland longspur	0	3	2	1	0	3	3	1	0	0	2	1	3	3	0	0	0	2	2	0
Smith’s longspur	0	2	0	0	1	1	1	1	0	0	0	1	3	3	0	0	0	1	1	0
Snow bunting	1	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
Yellow warbler	0	1	0	1	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Wilson’s warbler	0	0	0	1	2	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
American tree sparrow	0	0	1	3	3	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0
Savannah sparrow	0	3	1	3	2	3	3	3	0	0	0	3	3	3	0	0	0	2	2	0
Fox sparrow	0	0	1	1	2	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
White-crowned sparrow	0	0	1	3	3	0	0	3	0	1	0	3	1	1	0	0	0	0	0	0

Species	Land Cover Class/Habitat-use Ranking[b,c]																			
	Barrens	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Low and Tall Riverine Willow Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Partially Vegetated	Poplar Forest	Salt Marsh	Sedge-Willow Tundra in Drainage Tracks	Shrub Tussock Tundra	Tussock Tundra	Coastal Water	Lowland Lake	Riverine Water	Wet Sedge Meadow Tundra	Wet Sedge Meadow Tundra with Moist Inclusions	Freshwater Marsh
Dark-eyed junco	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Seabirds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thick-billed murre	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Kittlitz's murrelet[n]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Black guillemot	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0
Horned puffin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Northern fulmar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Short-tailed shearwater	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Total med-high rank	**0**	**24**	**12**	**14**	**17**	**29**	**22**	**14**	**0**	**4**	**28**	**13**	**27**	**27**	**15**	**26**	**19**	**37**	**37**	**35**
Total no-low rank	**95**	**71**	**84**	**82**	**78**	**67**	**73**	**81**	**95**	**91**	**68**	**82**	**68**	**68**	**80**	**70**	**76**	**59**	**59**	**69**

[a] Species not occurring annually (casual visitors and accidentals) are not included because those species occur singly or in very low numbers and they do not breed in the area, resulting in negligible impacts from development.
[b] 0 = not used, not important for that species; 1 = low use, rarely occurring or occurring in low numbers annually; 2 = medium use, regularly occurring, regular use in moderate numbers; 3 = high use, regularly occurring, regular use in high numbers.
[c] Habitat-use rankings from Marcot et al. (2015). For the Freshwater Marsh land cover class, which is not represented in Marcot et al.'s ecotypes, rankings were derived using professional judgment based on over 20 years of tundra breeding bird observations on the North Slope of Alaska.
[d] Dash indicates the species was not assessed by Marcot et al. (2015).

Table J-14
Bird Species for Which Moist Tundra Habitats are Ranked as High or Medium Value During the Breeding Season[a] and Would be Expected to Experience Greater Impacts from Development on the Arctic Refuge Coastal Plain

Species	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Shrub Tussock Tundra	Tussock Tundra
Waterbirds	—	—	—	—	—	—	—	—
Greater white-fronted goose	—	X[b]	X	X	—	—	—	—
Cackling goose	—	—	—	X	—	—	—	—
Tundra swan	—	X	X	X	—	—	—	—
Long-tailed duck	—	—	—	X	—	—	—	—
Sandhill crane	X	X	—	X	X	—	—	—
Shorebirds	—	—	—	—	—	—	—	—
Black-bellied plover	X	—	—	X	X	—	—	—
American golden-plover	X	X	—	X	X	—	X	X
Upland sandpiper	—	—	—	—	—	—	X	X
Whimbrel	X	X	—	X	X	—	X	X
Bar-tailed godwit	X	—	—	X	X	—	X	X
Baird's sandpiper	X	—	—	X	X	—	—	—
White-rumped sandpiper	—	—	—	X	—	—	—	—
Pectoral sandpiper	X	—	—	X	X	—	X	X
Semipalmated sandpiper	X	X	—	X	X	—	X	X
Western sandpiper	X	X	—	X	X	—	X	X
Wilson's snipe	—	X	X	X	—	X	X	X
Wandering tattler	X	—	—	—	—	—	—	—
Larids	—	—	—	—	—	—	—	—
Parasitic jaeger	X	—	—	X	X	—	X	X
Long-tailed jaeger	X	—	X	X	X	—	X	X
Short-billed gull	—	X	—	—	—	—	—	—
Raptors and owls	—	—	—	—	—	—	—	—
Golden eagle	—	—	—	X	X	X	X	X
Northern harrier	X	—	—	X	X	X	X	X
Rough-legged hawk	—	—	—	X	X	X	X	X

Species	Dryas Dwarf Shrub	Ericaceous Dwarf Shrub	Low and Dwarf Birch Shrub	Moist Sedge-Dryas Tundra	Moist Sedge-Shrub Tundra with Wet Inclusions	Moist Sedge-Willow Tundra	Shrub Tussock Tundra	Tussock Tundra
Snowy owl	X	—	—	X	X	—	X	X
Short-eared owl	X	X	—	X	X	—	X	X
Merlin	X	X	X	X	X	—	X	X
Gyrfalcon	—	—	—	—	—	X	—	—
Peregrine falcon	X	—	—	X	X	—	X	X
Landbirds	—	—	—	—	—	—	—	—
Willow ptarmigan	—	—	X	X	—	X	X	X
Rock ptarmigan	X	—	X	—	—	X	X	X
Bluethroat	—	—	X	—	—	X	X	X
Eastern yellow wagtail	—	—	X	—	—	X	X	X
American pipit	X	—	—	X	X	—	X	X
Common redpoll	—	—	X	—	—	X	—	—
Hoary redpoll	—	—	X	—	—	X	—	—
Lapland longspur	X	X	—	X	X	—	X	X
Smith's longspur	X	—	—	—	—	—	X	X
American tree sparrow	—	—	X	—	—	X	—	—
White-crowned sparrow	—	—	X	—	—	X	—	—
Savannah sparrow	—	—	X	X	X	X	X	X

[a] Habitat rankings from Marcot et al. (2015) cross-walked to the land cover (habitat) types on the Coastal Plain from Macander et al. (2020) are listed in Table J-17. Species not known to breed on the Coastal Plain and species known to use moist tundra habitats in riverine/floodplain areas are omitted because development in riverine habitats is restricted by lease stipulation.

[b] An “X” indicates a high use or medium use habitat ranking, “—" indicate a low-use or not-used ranking.

Table J-15
Acreages of Habitat Types Available in All Areas Open to Leasing under Alternative B and Estimated to Occur in a Hypothetical Development Area[a], by Hydrocarbon Potential (HCP)

Habitat Type	High HCP		Medium HCP		Low HCP	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Barrens	231.39	17.27	5,167.77	247.99	2,857.72	189.24
Dryas dwarf shrub	8,605.83	642.41	1,738.84	83.44	2,978.29	197.23
Ericaceous dwarf shrub	68.18	5.09	361.08	17.33	2,217.73	146.86
Freshwater marsh	186.73	13.94	131.53	6.31	21.03	1.39
Low and dwarf birch shrub	3,676.01	274.41	14,033.01	673.42	27,779.85	1,839.63
Low and Tall Riverine Willow Shrub	601.82	44.93	4,156.64	199.47	10,603.62	702.19
Moist sedge-dryas tundra	15,684.75	1,170.84	30,282.61	1,453.21	20,277.72	1,342.83
Moist sedge-shrub tundra with wet inclusions	58,573.01	4,372.37	193,419.15	9,281.83	40,210.41	2,662.81
Moist sedge-willow tundra	47,180.36	3,521.93	32,151.49	1,542.89	22,722.15	1,504.70
Partially vegetated	27,346.61	2,041.38	9,013.52	432.54	7,473.47	494.91
Poplar forest	0.00	0.00	0.00	0.00	1.63	0.11
Salt marsh	1,245.04	92.94	215.63	10.35	213.74	14.15
Sedge-willow tundra in drainage tracks	12,464.69	930.47	15,989.02	767.28	39,994.89	2,648.53
Shrub tussock tundra	24,150.56	1,802.80	63,070.64	3,026.65	116,604.99	7,721.79
Snow/Ice	63.27	4.72	195.02	9.36	181.88	12.04
Snowbed	1,688.15	126.02	3,022.91	145.06	1,000.24	66.24
Tussock tundra	92,502.33	6,905.14	143,034.03	6,863.94	107,182.89	7,097.84
Water	56,935.31	4,250.12	43,102.88	2,068.43	7,511.00	497.39
Wet sedge meadow tundra	54,706.68	4,083.76	69,935.86	3,356.09	50,729.82	3,359.42
Wet sedge meadow tundra with moist inclusions	17,407.96	1,299.47	29,473.81	1,414.39	16,621.13	1,100.68
Total	**423,318.69**	**31,600.00**	**658,794.46**	**31,600.00**	**477,184.21**	**31,600.00**

Moist tundra habitats are in bold.
[a] Proportions of habitats in a hypothetical oil development area of a maximum of 31,600 acres assumed to be the same as in all areas open to leasing (see text).

Table J-16
Estimated Numbers of Waterbirds and Larids[a] in All Areas Open to Leasing and in a Hypothetical Development Area under Alternative B, by Hydrocarbon Potential (HCP)

Habitat Type	High HCP		Medium HCP		Low HCP[b]	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Cackling/Canada goose	32.9	16.2	1.3	0.1	0.0	0.0
Glaucous gull	15.6	7.7	10.7	1.2	0.2	0.2
Greater white-fronted goose	6.3	3.1	111.3	12.6	4.2	4.2
Unidentified scaup	3.2	1.6	4.7	0.5	1.0	1.0
Red-throated loon	3.0	1.5	0.0	0.0	0.0	0.0
Tundra swan	2.9	1.4	15.0	1.7	1.7	1.7
Long-tailed duck	2.8	1.4	12.2	1.4	1.2	1.2
Pacific loon	1.6	0.8	9.0	1.0	1.3	1.3
King eider	1.5	0.7	4.0	0.4	0.0	0.0
Northern pintail	0.3	0.1	6.5	0.7	0.0	0.0
Jaegers[c]	0.0	0.0	31.3	3.5	0.0	0.0
Arctic tern	0.0	0.0	1.1	0.1	0.2	0.2
Brant	0.0	0.0	0.0	0.0	0.0	0.0
Spectacled eider	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-billed loon	0.0	0.0	0.0	0.0	0.0	0.0
Sabine's gull	0.0	0.0	0.0	0.0	0.0	0.0
Total	**70.1**	**34.5**	**211.2**	**23.7**	**9.8**	**9.8**

[a] Numbers estimated from the density polygons for each species or species group calculated by Amundson et al. (2019) that occur within the USFWS ACP Aerial Breeding Waterfowl Survey area on the Arctic Refuge Coastal Plain.
[b] The estimated area of effects on birds for a hypothetical development under Alternative B (31,600 acres) is greater than the portion of the ACP Aerial Breeding Waterfowl Survey area that occurs in the Low HCP area, so a hypothetical development area would encompass all density polygons and the numbers of birds in the area open to leasing and in a hypothetical development area would be the same.
[c] All jaeger species were combined and treated as jaegers by Amundson et al. (2019).

Table J-17
Acreages of Habitat Types Available in All Areas Open to Leasing under Alternative C and Estimated to Occur in a Hypothetical Development Area[a], by Hydrocarbon Potential (HCP)

Habitat Type	High HCP		Medium HCP		Low HCP	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Barrens	4,540.31	249.84	4,524.53	194.59	1,036.06	303.65
Dryas dwarf shrub	8,392.96	461.84	1,403.89	60.38	2,116.55	620.32
Ericaceous dwarf shrub	68.18	3.75	342.68	14.74	726.49	212.92
Freshwater marsh	186.39	10.26	104.82	4.51	1,196.55	350.68
Low and dwarf birch shrub	3,676.01	202.28	11,808.90	507.86	2,463.70	722.06
Low and tall riverine willow shrub	599.67	33.00	3,163.65	136.06	17.46	5.12
Moist sedge-dryas tundra	15,216.37	837.31	26,637.21	1,145.58	7,295.35	2,138.12
Moist sedge-shrub tundra with wet inclusions	56,592.94	3,114.13	149,706.77	6,438.42	1,342.81	393.55
Moist sedge-willow tundra	46,573.90	2,562.81	28,099.04	1,208.45	2,567.17	752.39
Partially vegetated	26,650.71	1,466.50	6,996.97	300.92	2,164.46	634.36
Salt marsh	1,245.04	68.51	215.63	9.27	9.01	2.64
Sedge-willow tundra in drainage tracks	12,442.81	684.69	15,548.84	668.71	11,076.81	3,246.39
Shrub tussock tundra	24,150.56	1,328.93	57,635.16	2,478.71	25,652.14	7,518.12
Snow/Ice	61.63	3.39	180.35	7.76	34.61	10.14
Snowbed	1,640.28	90.26	2,533.76	108.97	371.95	109.01
Tussock tundra	91,299.16	5,023.90	117,727.80	5,063.11	12,987.55	3,806.39
Water	56,860.89	3,128.87	40,359.33	1,735.73	4,387.94	1,286.02
Wet sedge meadow tundra	53,202.16	2,927.55	48,294.49	2,077.00	2,246.35	658.36
Wet sedge meadow tundra with Moist inclusions	16,958.62	933.18	22,560.04	970.24	1,230.94	360.76
Total	**420,358.62**	**23,131.00**	**537,843.88**	**23,131.00**	**78,923.91**	**23,131.00**

Moist tundra habitats are in bold.
[a] Proportions of habitats in a hypothetical oil development area of a maximum of 23,131 acres assumed to be the same as in all areas open to leasing (see text).

Table J-18
Estimated Numbers of Waterbirds and Larids[a] in All Areas Open to Leasing and in a Hypothetical Development Area under Alternative C, by Hydrocarbon Potential (HCP)

Habitat Type	High HCP		Medium HCP		Low HCP[b]	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Cackling/Canada goose	32.9	11.8	1.3	0.1	0.0	0.0
Glaucous gull	15.6	5.6	10.7	1.1	0.2	0.2
Greater white-fronted goose	6.3	2.3	111.3	11.3	4.2	4.2
Unidentified scaup	3.2	1.2	4.7	0.5	1.0	1.0
Red-throated Loon	3.0	1.1	0.0	0.0	0.0	0.0
Tundra swan	2.9	1.0	15.0	1.5	1.7	1.7
Long-tailed duck	2.8	1.0	12.2	1.2	1.2	1.2
Pacific loon	1.6	0.6	9.0	0.9	1.3	1.3
King eider	1.5	0.5	4.0	0.4	0.0	0.0
Northern pintail	0.3	0.1	6.5	0.7	0.0	0.0
Jaegers[c]	0.0	0.0	31.3	3.2	0.0	0.0
Arctic tern	0.0	0.0	1.1	0.1	0.2	0.2
Brant	0.0	0.0	0.0	0.0	0.0	0.0
Spectacled eider	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-billed loon	0.0	0.0	0.0	0.0	0.0	0.0
Sabine's gull	0.0	0.0	0.0	0.0	0.0	0.0
Total	**70.1**	**25.2**	**207.1**	**21.0**	**9.8**	**9.8**

[a] Numbers estimated from the density polygons for each species or species group calculated by Amundson et al. (2019) that occur within the USFWS ACP Aerial Breeding Waterfowl Survey area on the Arctic Refuge Coastal Plain.
[b] The estimated area of effects on birds for a hypothetical development under Alternative C (23,131 acres) is greater than the portion of the ACP Aerial Breeding Waterfowl Survey area that occurs in the Low HCP area, so a hypothetical development area would encompass all density polygons and the numbers of birds in the area open to leasing and in a hypothetical development area would be the same.
[c] All jaeger species were combined and treated as jaegers by Amundson et al. (2019).

Table J-19
Acreages of Habitat Types Available in All Areas Open to Leasing under Alternative D and Estimated to Occur in a Hypothetical Development Area[a], by Hydrocarbon Potential (HCP)

Habitat Type	High HCP		Medium HCP		Low HCP[b]	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Barrens	4,533.02	188.61	3,569.56	158.03	1.00	1.00
Dryas dwarf shrub	7,877.28	327.76	1,248.52	55.27	0.00	0.00
Ericaceous dwarf shrub	68.18	2.84	279.72	12.38	0.02	0.02
Freshwater Marsh	186.39	7.76	66.04	2.92	0.00	0.00
Low and dwarf birch shrub	3,617.42	150.51	8,828.29	390.85	1.15	1.15
Low and Tall Riverine Willow Shrub	586.25	24.39	1,868.43	82.72	0.00	0.00
Moist sedge-dryas tundra	14,762.52	614.24	16,644.73	736.89	2.51	2.51
Moist sedge-shrub tundra with wet inclusions	50,420.99	2,097.91	90,175.81	3,992.25	0.77	0.77
Moist sedge-willow tundra	38,238.38	1,591.01	20,169.42	892.94	1.03	1.03
Partially vegetated	26,191.49	1,089.77	4,985.27	220.71	9.13	9.13
Salt marsh	1,245.04	51.80	41.66	1.84	0.65	0.65
Sedge-willow tundra in drainage tracks	12,095.58	503.27	12,432.45	550.41	1.03	1.03
Shrub tussock tundra	24,150.56	1,004.85	36,771.75	1,627.96	0.01	0.01
Snow/Ice	61.63	2.56	137.49	6.09	1.00	1.00
Snowbed	1,535.68	63.90	1,845.74	81.71	0.00	0.00
Tussock tundra	85,589.57	3,561.19	95,491.19	4,227.58	0.02	0.02
Water	56,722.05	2,360.08	30,226.30	1,338.18	0.00	0.00
Wet sedge meadow tundra	51,232.75	2,131.68	31,747.51	1,405.52	1.15	1.15
Wet sedge meadow tundra with Moist inclusions	15,811.34	657.87	14,631.04	647.74	0.00	0.00
Total	**394,926.12**	**16,432.00**	**37,1160.91**	**16,432.00**	**17.30**	**17.30**

Moist tundra habitats are in bold.
[a] Proportions of habitats in a hypothetical oil development area of a maximum of 16,432 acres assumed to be the same as in all areas open to leasing (see text).
[b] Area available for leasing in the low HCP area is far below a hypothetical development area in size, so any development in that area is likely to encompass all acres of each habitat.

Table J-20
Estimated Numbers of Waterbirds and Larids[a] in All Areas Open to Leasing and in a Hypothetical Development Area under Alternative D, by Hydrocarbon Potential (HCP).

Habitat Type	High HCP		Medium HCP		Low HCP[b]	
	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area	All Areas Open to Leasing	Hypothetical Development Area
Greater white-fronted goose	6.3	1.6	111.3	11.8	0.0	0.0
Jaegers[c]	0.0	0.0	31.3	3.3	0.0	0.0
Tundra swan	2.9	0.7	15.0	1.6	0.0	0.0
Long-tailed duck	2.8	0.7	12.2	1.3	0.0	0.0
Glaucous gull	15.6	4.0	10.7	1.1	0.0	0.0
Pacific loon	1.6	0.4	9.0	1.0	0.0	0.0
Northern pintail	0.3	0.1	6.5	0.7	0.0	0.0
Unidentified scaup	3.2	0.8	4.7	0.5	0.0	0.0
King eider	1.5	0.4	4.0	0.4	0.0	0.0
Cackling/Canada goose	32.9	8.4	1.3	0.1	0.0	0.0
Arctic tern	0.0	0.0	1.1	0.1	0.0	0.0
Red-throated Loon	3.0	0.8	0.0	0.0	0.0	0.0
Brant	0.0	0.0	0.0	0.0	0.0	0.0
Spectacled eider	0.0	0.0	0.0	0.0	0.0	0.0
Yellow-billed loon	0.0	0.0	0.0	0.0	0.0	0.0
Sabine's gull	0.0	0.0	0.0	0.0	0.0	0.0
Total	**70.1**	**17.9**	**207.1**	**21.9**	**0.0**	**0.0**

[a] Numbers estimated from the density polygons for each species or species group calculated by Amundson et al. (2019) that occur within the USFWS ACP Aerial Breeding Waterfowl Survey area on the Arctic Refuge Coastal Plain.
[b] There are no bird density polygons that overlap with areas available for leasing in the low HCP area under Alternative D, so no birds are estimated to be affected in that area.
[c] All jaeger species were combined and treated as jaegers by Amundson et al. (2019).

J.4 Terrestrial Mammals

Table J-21
Terrestrial Mammal Species Known or Suspected to Occur in the Arctic National Wildlife Refuge (adapted from Appendix F in USFWS 2015)

English Name[a]	Scientific Name[a]	Present in Program Area
Cinereus shrew	*Sorex cinereus*	No
Pygmy shrew	*S. hoyi*	No
Dusky shrew	*S. monticolus*	No
Tundra shrew	*S. tundrensis*	Yes
Barren ground shrew	*S. ugyunak*	Yes
Holarctic least shrew	*S. minutissimus*	Yes
Collared lemming	*Dicrostonyx groenlandicus*	Yes
Brown lemming	*Lemmus trimucronatus*	Yes
Long-tailed vole	*Microtus longicaudus*	No
Singing vole	*M. miurus*	Yes
Root (tundra) vole	*M. oeconomus*	Yes
Meadow vole	*M. pennsylvanicus*	No
Taiga vole	*M. xanthognathus*	No
Northern red-backed vole	*Myodes rutilus*	No
Common muskrat	*Ondatra zibethicus*	Unknown; expanding range
Northern bog lemming	*Synaptomys borealis*	No
Alaska marmot	*Marmota broweri*	No
Arctic ground squirrel	*Urocitellus parryii*	Yes
Red squirrel	*Tamiasciurus hudsonicus*	No
North American porcupine	*Erethizon dorsatum*	No
American beaver	*Castor canadensis*	No; range is expanding northward
Snowshoe hare	*Lepus americanus*	Rare; range is expanding northward
Wolverine	*Gulo gulo*	Yes
North American river otter	*Lontra canadensis*	Rare
American marten	*Martes americana*	No
Ermine	*Mustela erminea*	Yes
Least weasel	*M. nivalis*	Yes
American mink	*Neovison vison*	No
Canada lynx	*Lynx canadensis*	Rare
Wolf	*Canis lupus*	Yes
Coyote	*C. latrans*	Rare
Arctic fox	*Vulpes lagopus*	Yes
Red Fox	*V. vulpes*	Yes
American black bear	*Ursus americanus*	No
Brown (grizzly) bear	*U. arctos*	Yes
Moose	*Alces americanus*	Yes
Caribou	*Rangifer tarandus*	Yes
Dall's sheep	*Ovis dalli*	No; nearby in mountains to south
Muskox	*Ovibos moschatus*	Yes

[a]Sources: MacDonald and Cook (2009), with taxonomic and nomenclatural updates from Bradley et al. (2014)

Table J-22
Acres in Different Levels of Use (Percent of Years Caribou Present) by Parturient Porcupine Caribou During Calving, by Different Lease Restriction Categories, Alternatives, and Areas of Expected Oil Potential

PCH Calving Table

Alternative	Lease Type	Percent of Years Present	Oil Potential: High	Medium	Low	Total
B	No surface occupancy	<20	104,900	15,000	900	120,800
		20–30	3,500	14,600	3,100	21,200
		30–40	0	10,800	500	11,300
		>40	0	51,700	83,800	135,500
	Timing limitations	<20	0	100	0	100
		20–30	0	300	500	800
		30–40	0	8,400	8,900	17,300
		>40	0	241,200	323,700	564,900
	Standard terms and conditions only	<20	263,900	69,100	1,900	334,900
		20–30	19,300	76,300	31,000	126,600
		30–40	0	114,900	10,400	125,300
		>40	0	26,100	1,800	27,900
C	No sale/no surface occupancy	<20	7,300			7,300
		20–30			200	200
		30–40			1,000	1,000
		>40		120,600	391,100	511,700
	No surface occupancy	<20	197,600	44,200	2,800	244,600
		20–30	22,400	57,100	27,400	106,900
		30–40		68,200	15,800	84,000
		>40		184,900	17,300	202,200
	Timing limitations	<20	32,400	26,500	0	58,900
		20–30	0	21,600	7,100	28,700
		30–40	0	27,900	3,000	30,900
		>40	0	4,500	900	5,400
	Standard Terms and Conditions Only	<20	131,500	13,500		145,000
		20–30	400	12,500		12,900
		30–40	0	38,000		38,000
		>40	0	8,900		8,900
D	No sale	<20	32,800	9,200	2,800	44,800
		20–30		8,400	34,600	43,100
		30–40		42,000	19,800	61,700
		>40		221,500	409,300	630,800
	No surface occupancy	<20	319,100	69,800		388,900
		20–30	22,800	78,600		101,400
		30–40		80,500		80,500
		>40		83,300		83,300
	Controlled surface use	<20	1,300	5,100		6,400
		20–30		1,100		1,100
		30–40		900		900
		>40		7,500		7,500
	Timing Limitations	<20	100			100
		20–30				0
		30–40				0
		>40		1,700		1,700
	Standard terms and conditions only	<20	2,800	0		2,800
		20–30		3,100		3,100
		30–40		10,800		10,800
		>40		4,900		4,900

Source: BLM GIS 2018

Table J-23
Acres within Different Levels of Use (percent of years caribou present) by Porcupine Caribou during Post-calving, by Different Lease Restriction Categories, Alternatives, and Areas of Expected Oil Potential

PCH Post-calving Table

Acres		Percent of Years Present	Oil Potential			
Alternative	**Lease Type**		**High**	**Medium**	**Low**	**Total**
B	No surface occupancy	<20	82,900	4,900	700	88,500
		20–30	11,500	18,700	400	30,600
		30–40	11,700	38,500	5,700	55,900
		>40	2,200	30,000	81,500	113,700
	Timing limitations	<20		29,000	4,800	33,800
		20–30		61,100	14,100	75,200
		30–40		86,800	16,100	102,900
		>40		73,200	298,100	371,300
	Standard terms and conditions only	<20	112,000	54,000	0	166,000
		20–30	77,300	84,400	1,800	163,500
		30–40	69,800	106,300	35,400	211,500
		>40	24,100	41,600	7,900	73,600
C	No sale	<20		1,800	3,600	5,400
		20–30	4,600	13,200	14,400	32,200
		30–40	2,800	58,600	11,900	73,300
		>40		47,000	362,400	409,400
	No surface occupancy	<20	124,000	67,800	1,900	193,700
		20–30	41,500	100,200	2,000	143,700
		30–40	49,600	121,300	37,000	207,900
		>40	4,800	65,000	22,300	92,100
	Controlled surface use	<20				
		20–30		2,700		2,700
		30–40	10,900	45,100	8,300	64,300
		>40	21,500	32,600	2,700	56,800
	Standard terms and conditions only	<20	70,900	18,200		89,100
		20–30	42,800	48,000		90,800
		30–40	18,200	6,600		24,800
		>40		0	0	0
D	No sale	<20		58,500	5,500	64,000
		20–30	20,600	44,400	16,300	81,300
		30–40	12,200	87,600	57,200	157,000
		>40		90,500	387,500	478,000
	No surface occupancy	<20	194,800	28,900		223,700
		20–30	65,600	96,100		161,700
		30–40	68,000	136,200		204,200
		>40	26,100	50,900		77,000
	Controlled surface use	<20				0
		20–30		4,200		4,200
		30–40	1,100	7,100		8,200
		>40	200	3,300		3,500
	Timing limitations	<20				0
		20–30		1,700		1,700
		30–40	100			100
		>40				0
	Standard terms and conditions only	<20	100	500		600
		20–30	2,700	17,700		21,600
		30–40	100	700		800
		>40				0

Source: BLM GIS 2018

Table J-24
Acres within Different Calving use and Predicted Calving Areas (Defined by Severson et al. 2021) for the Porcupine Caribou Herd, by Different Lease Restriction Categories, Alternatives, and Areas of Expected Oil Potential

PCH Calving Table

Acres		Years of Use or Prediction	Oil Potential			
Alternative	Lease Type		High	Medium	Low	Total
B	No surface occupancy	2012–2018			17,500	17,500
		2030–2039		9,400	38,900	48,300
		2040–2049	3,500	12,100	54,100	69,700
		2050–2059	3,800	13,000	57,200	74,000
	Timing limitations	2012–2018			59,200	59,200
		2030–2039		11,100	109,500	120,600
		2040–2049		39,900	193,800	233,700
		2050–2059		16,500	197,400	213,900
	Standard terms and conditions only	2012–2018			0	0
		2030–2039		50,000	5,100	55,100
		2040–2049	23,800	36,600	6,800	67,200
		2050–2059	39,800	71,400	7,800	119,000
C	No sale	2012–2018			76,700	76,700
		2030–2039		4,800	135,600	140,400
		2040–2049		14,800	242,600	257,400
		2050–2059		7,400	249,900	257,300
	No surface occupancy	2012–2018			0	0
		2030–2039		30600	15600	46,200
		2040–2049	13800	59500	9300	82,600
		2050–2059	27100	65900	9700	102,700
	Controlled surface use	2012–2018				0
		2030–2039		35,100	2,300	37,400
		2040–2049	3,500	14,200	2,800	20,500
		2050–2059	5,600	25,400	2,800	33,800
	Standard terms and conditions only	2012–2018			0	0
		2030–2039		0	0	0
		2040–2049	10,000	0	0	10,000
		2050–2059	10,800	2,300	0	13,100
D	No sale	2012–2018		0	76,700	76,700
		2030–2039		39,600	153,600	193,200
		2040–2049	100	39,500	254,800	294,400
		2050–2059		39,500	262,400	301,900
	No surface occupancy	2012–2018		0		0
		2030–2039		30,500		30,500
		2040–2049	26,900	45,300		72,200
		2050–2059	43,100	57,400		100,500
	Controlled surface use	2012–2018				0
		2030–2039		400		400
		2040–2049	400	3,700		4,100
		2050–2059	400	2,400		2,800
	Timing limitations	2012–2018				
		2030–2039				
		2040–2049				
		2050–2059	100	1,700		1,800
	Standard terms and conditions only	2012–2018				
		2030–2039				
		2040–2049		100		100
		2050–2059				0

Source: Severson et al. 2021

Table J-25
Acres within Different Post-calving use and Predicted Post-calving Areas (Defined by Severson et al. 2021) for the Porcupine Caribou Herd, by Different Lease Restriction Categories, Alternatives, and Areas of Expected Oil Potential

PCH Post-calving Table						
Acres		Years of Use or Prediction	Oil Potential			
Alternative	Lease Type		High	Medium	Low	Total
B	No surface occupancy	2012–2018	9,800	54,100	49,500	113,400
		2030–2039	2,200	42,100	50,000	94,300
		2040–2049	12,700	64,500	60,700	137,900
		2050–2059	11,600	70,400	55,100	137,100
	Timing limitations	2012–2018		73,100	145,300	218,400
		2030–2039		56,800	119,000	175,800
		2040–2049		114,200	211,700	325,900
		2050–2059		140,400	194,700	335,100
	Standard terms and conditions only	2012–2018	79,700	158,800	18,800	257,300
		2030–2039	15,600	148,700	45,400	209,700
		2040–2049	110,300	168,400	42,200	320,900
		2050–2059	112,000	169,300	42,000	323,300
C	No sale	2012–2018	700	43,800	179,900	224,400
		2030–2039		28,500	141,400	169,900
		2040–2049	3,000	86,400	254,800	344,200
		2050–2059	3,200	85,000	237,400	325,600
	No surface occupancy	2012–2018	37,600	151,200	27,100	215,900
		2030–2039	8,800	131,100	62,000	201,900
		2040–2049	43,000	164,400	49,000	256,400
		2050–2059	42,000	197,900	43,600	283,500
	Controlled surface use	2012–2018	21,800	74,100	6,700	102,600
		2030–2039	8,900	80,100	11,000	100,000
		2040–2049	28,900	80,500	10,800	120,200
		2050–2059	30,700	80,500	10,800	122,000
	Standard terms and conditions only	2012–2018	29,400	16,900		46,300
		2030–2039	0	7,800		7,800
		2040–2049	48,200	16,000		64,200
		2050–2059	47,700	16,700		64,400
D	No Sale	2012–2018	6,600	104,400	213,600	324,600
		2030–2039	0	92,200	214,400	306,600
		2040–2049	11,900	159,200	314,600	485,700
		2050–2059	12,100	159,700	291,900	463,700
	No surface occupancy	2012–2018	82,700	174,900		257,600
		2030–2039	17,700	147,900		165,600
		2040–2049	110,400	179,400		289,800
		2050–2059	109,900	205,900		315,800
	Controlled surface use	2012–2018	100	6,400		6,500
		2030–2039	100	7,400		7,500
		2040–2049	800	8,600		9,400
		2050–2059	1,600	14,500		16,100
	Timing limitations	2012–2018				0
		2030–2039				0
		2040–2049				0
		2050–2059				0
	Standard terms and conditions only	2012–2018	100	300		400
		2030–2039				0
		2040–2049				0
		2050–2059				0

Source: Severson et al. 2021

Table J-26
Estimated Percentage of Central Arctic Caribou Herd Seasonal Range (Based on the Utilization Distribution of Kernel Density Estimate) by Different Lease Restriction Categories, Alternatives, and Oil Potential

CAH Acres of Seasonal Range Table						
Percent of CAH		Season	Oil Potential			
Alternative	Lease Type		High	Medium	Low	Total
B	No surface occupancy	Post-calving	0.90	0.03	0.05	0.98
		Mosquito	3.27	0.23	0.06	3.56
		Oestrid fly	1.08	0.30	0.13	1.51
		Late summer	0.31	0.08	0.11	0.50
	Timing limitations	Post-calving		0.05	0.17	0.22
		Mosquito		0.25	0.18	0.43
		Oestrid fly		0.41	0.39	0.80
		Late summer		0.09	0.31	0.40
	Standard terms and conditions only	Post-calving	1.67	0.13	0.03	1.83
		Mosquito	6.22	0.97	0.12	7.31
		Oestrid fly	3.07	1.20	0.14	4.41
		Late summer	0.96	0.32	0.07	1.34
C	No sale	Post-calving	0.05	0.05	0.21	0.30
		Mosquito	0.28	0.08	0.20	0.56
		Oestrid fly	0.10	0.18	0.44	0.73
		Late summer	0.02	0.06	0.38	0.46
	No surface occupancy	Post-calving	1.44	0.09	0.03	1.56
		Mosquito	5.34	0.85	0.14	6.32
		Oestrid fly	2.15	1.14	0.19	3.48
		Late summer	0.61	0.25	0.10	0.96
	Controlled surface use	Post-calving	0.11	0.06	0.01	0.18
		Mosquito	0.63	0.30	0.02	0.94
		Oestrid fly	0.31	0.38	0.03	0.72
		Late summer	0.06	0.13	0.02	0.21
	Standard terms and conditions only	Post-calving	0.97	0.02		0.99
		Mosquito	3.24	0.22		3.46
		Oestrid fly	1.59	0.20		1.79
		Late summer	0.58	0.04		0.62
D	No sale	Post-calving	0.22	0.09	0.24	0.55
		Mosquito	1.20	0.30	0.36	1.86
		Oestrid fly	0.44	0.52	0.66	1.62
		Late summer	0.11	0.16	0.49	0.75
	No surface occupancy	Post-calving	2.31	0.12		2.44
		Mosquito	8.06	1.07		9.14
		Oestrid fly	3.61	1.31		4.92
		Late summer	1.15	0.31		1.46
	Controlled surface use	Post-calving	0.01	0.01		0.01
		Mosquito	0.03	0.04		0.07
		Oestrid fly	0.02	0.05		0.06
		Late summer	0.00	0.01		0.01
	Timing limitations	Post-calving		0.00		0.00
		Mosquito		0.00		0.00
		Oestrid fly		0.00		0.00
		Late summer		0.00		0.00
	Standard terms and conditions only	Post-calving	0.03	0.00		0.03
		Mosquito	0.19	0.03		0.22
		Oestrid fly	0.08	0.03		0.11
		Late summer	0.01	0.00		0.01

Source: BLM GIS 2018
[a] High, medium, and low density areas based on 50 percent, 75 percent, and 95 percent kernel density contours respectively

Table J-27
Porcupine Caribou Calving and Post-Calving in the Program Area

Percent of Years that Calving Caribou Are Present	Area (Acres)	Percent of Coastal Plain
<20	443,000	30.1
20–30	148,600	10.1
30–40	153,900	10.4
>40	728,200	49.4

Percent of Years that Post-Calving Caribou are Present	Area (acres)	Percent of Coastal Plain
<20	269,100	18.3
20–30	269,300	18.3
30–40	370,300	25.2
>40	558,500	38.1

Source: BLM and USFWS GIS 2022

Table J-28
Central Arctic Herd Female Caribou Annual Use of the Program Area During June-August[a]

Year	Number of Collared Animals	Percent of Animals Using Program Area	Average Percent of Days in Program Area per Animal	Percent of all collar-days in Program Area [c]
2003[b]	23	52	8	4
2004	45	89	11	10
2005	31	55	7	4
2006	27	44	5	2
2007	1	100	16	16
2008	1	100	16	16
2009	13	100	25	25
2010	13	92	21	19
2011	11	82	16	13
2012	8	88	17	15
2013	8	75	16	12
2014	14	57	13	7
2015	15	47	7	3
2016	13	46	5	2
2017	13	38	9	3
2018	24	54	5	3
2019	37	38	7	3
2020	57	33	6	2
2021	50	16	4	1
2022	68	25	4	1

Source: ADF&G telemetry data.
[a] Collars active greater than 85 days and reporting locations greater than 75 days and locations within 30 days of first collaring were removed to reduce effects of collaring location on program area use.
[b] For example, in 2003, 23 female Central Arctic Herd caribou were collared June–August, 52 percent were in the program area at least once and the average percent of days animals were in the program area for those 23 animals was 8 percent.
[b] Collar-day = one animal collared for one day.

J.5 MARINE MAMMALS

J.5.1 Standard Mitigation Measures for Polar Bears Under MMPA Incidental Take Regulations (ITRs)

The current Marine Mammal Protection Act (MMPA) Incidental Take Regulations (86 FR42982; 50 CFR 18.126-128) for the Alaska Beaufort Sea describe mitigation, monitoring, and reporting requirements. Oil and gas industry operators are required to use them in the coastal region of the central Beaufort Sea that abuts, but does not include, the program area. The Beaufort Sea ITRs encompass a large portion of the range of the Southern Beaufort Sea (SBS) stock of polar bears, so it is expected that the new ITRs to be promulgated for the program area are likely to include the same or similar requirements. The general mitigation, monitoring, and reporting requirements for oil and gas industry operators are described below.

A) Mitigation measures for all holders of letters of authorization (LOAs)

- Implement policies and procedures to conduct activities in a manner that minimizes adverse impacts on polar bears, their habitat, and their availability for subsistence uses
- Use adaptive management practices, such as temporal and spatial activity restrictions in response to the presence polar bears or bears engaged in a biologically significant activity, to avoid interactions with, and minimize impacts on, the bears and their availability for subsistence uses
- Cooperate with the USFWS and other designated federal, state, and local agencies to monitor and mitigate the impacts of industry activities on polar bears
- Designate trained and qualified personnel to monitor for the presence of polar bears, to initiate mitigation measures, and to monitor, record, and report the effects of industry activities on polar bears
- Provide personnel with polar bear awareness training
- Have an approved polar bear safety, awareness, and interaction plan on file with the USFWS and on-site; it must include the following:
  - The type of activity and where and when the activity will occur (i.e., a plan of operation)
  - A food, waste, and other bear attractants management plan
  - Personnel training policies, procedures, and materials
  - Site-specific polar bear interaction risk evaluation and mitigation measures
  - Polar bear avoidance and encounter procedures
  - Polar bear observation and reporting procedures
- Contact affected subsistence communities and hunter organizations to discuss potential conflicts

B) Mitigation measures for onshore activities

- To limit disturbance around known polar bear dens:
  - Attempt to locate polar bear dens—Holders of an LOA seeking to carry out onshore activities during the denning season (November–April) must conduct two surveys for occupied polar bear dens in all denning habitat within 1.6 km (1 mi) of proposed activities using aerial infrared (AIR) imagery. All observed or suspected polar bear dens must be reported to the USFWS before beginning activities under the LOA.
    - o The first survey should be conducted between 25 November and 15 December and the second between 5 and 31 December. For areas of proposed seismic surveys, there

must be a third survey conducted with AIR technology between 15 December and 15 January.

  - o AIR surveys will be conducted under clear, calm conditions during darkness or civil twilight and not during daylight hours. Flight crews will record and report environmental parameters including air temperature, dew point, wind speed and direction, cloud ceiling, and percent humidity, and a flight log will be provided to the Service within 48 hours of the flight.
  - o A scientist with experience in the in-air interpretation of AIR imagery will be on board the survey aircraft to analyze the AIR data in real-time. The data (infrared video) will be made available for viewing by the Service immediately upon return of the survey aircraft to the base of operations.

- − Observe the exclusion zone around known polar bear dens—Operators must observe a 1.6-km (1-mile) operational exclusion zone around all putative polar bear dens during the denning season (November–April) or until the female and cubs leave the areas. Should previously unknown occupied dens be discovered within 1 mile of activities, work must cease and the USFWS must be contacted for guidance. It will evaluate these instances on a case-by-case basis to determine the appropriate action. Potential actions range from cessation or modification of work to conducting additional monitoring. The holder of the authorization must comply with any additional measures specified.
- − Use the den habitat map developed by the USGS—This measure ensures that the locations of potential polar bear dens are considered when conducting activities in the coastal areas of the Beaufort Sea.
- − Polar bear den restrictions—Restrict the timing of activities to limit disturbance around dens, including putative and known dens

C) Mitigation measures for operational and support vessels

- Operational and support vessels must be staffed with dedicated marine mammal observers to alert crew members of the presence of polar bears and to initiate mitigation responses.
- Vessel operators must maintain the maximum distance possible from concentrations of polar bears. No vessel operator should approach within a 805-m (0.5-mile) radius of polar bears observed on land or ice.
- Vessel operators must avoid areas of active or anticipated polar bear subsistence hunting activity, as determined through community consultations.
- The USFWS may require trained marine mammal monitors on the site of the activity or onboard any vessel or vehicles to monitor the impacts of industry’s activity on polar bears.

D) Mitigation measures for aircraft

- Operators of support aircraft should conduct their activities at the maximum distance possible from concentrations of polar bears.
- Aircraft operations will maintain an altitude of 1,500 ft above ground level when safe and operationally possible.
- Aircraft will not be operated at an altitude lower than 1,500 feet within 0.5 miles of polar bears observed on ice or land. Helicopter operators may not hover or circle above such areas or within

0.5 miles of such areas. When weather conditions do not allow a 1,500-foot flying altitude, operators will take precautions to avoid flying directly over or within 0.5 miles of these areas.

- Plan all aircraft routes to minimize any potential conflict with known subsistence polar bear hunting activity.

E) Mitigation measures for the subsistence use of polar bears

Holders of LOAs must minimize adverse impacts on the availability of polar bears for subsistence uses.

- Community consultation—Applicants must consult with potentially affected communities and appropriate subsistence-user organizations to discuss potential conflicts with subsistence polar bear hunting caused by the location, timing, and methods of operations and support activities.
- Plan of cooperation (POC)—If conflicts arise, the applicant must address conflict avoidance issues through a POC, where the holder of an LOA will be required to develop and implement a USFWS-approved POC.

F) Mitigation measures for sound-producing offshore activities

Any offshore activity expected to produce pulsed underwater sounds with received sound levels ≥160 dB re 1 µPa will be required to establish and monitor acoustically verified mitigation zones surrounding the sound source and to implement mitigation measures, as follows:

- Mitigation zones—A polar bear mitigation zone is required where the received pulsed sound level would be ≥190 dB re 1 µPa.
- Mitigation measures:
  - Ramp-up procedures—For all sound sources, including sound-source testing, the following sound ramp-up procedures must be used to allow polar bears to depart the mitigation zones:
    - Visually monitor the ≥190 dB re 1 µPa mitigation zones and adjacent waters for polar bears for at least 30 minutes before initiating ramp-up procedures. If no polar bears are detected, ramp-up procedures may begin. Do not initiate ramp-up procedures when mitigation zones are not observable.
  - Power-down procedures—Immediately power down a sound source when one or more polar bears are observed or detected in the area delineated by the pulsed sound ≥190 dB re 1 µPa polar bear mitigation zone.
  - Shutdown procedures—If the power-down operation cannot reduce the received pulsed sound level to <190 dB re 1 µPa, the operator must immediately shut down the sound source.

G) Monitoring requirements

- Develop and implement a site-specific, USFWS-approved marine mammal monitoring and mitigation plan to monitor and evaluate the effectiveness of mitigation measures and the effects of activities on polar bears and the subsistence use of this species.
- Provide trained, qualified, and USFWS-approved on-site observers to carry out monitoring and mitigation activities identified in the marine mammal monitoring and mitigation plan.
- Cooperate with the USFWS and other designated federal, state, and local agencies to monitor the impacts of industry activities on polar bears. Where information is insufficient to evaluate the potential effects of activities on polar bears, and the subsistence use of this species, holders of an

LOA may be required to participate in joint monitoring or research efforts to address these information needs and ensure the least practicable impact on these resources.

H) Reporting requirements

Holders of an LOA must report the results of monitoring and mitigation activities to the USFWS.

- In-season monitoring reports:
  - Activity progress reports—Notify the USFWS at least 48 hours before beginning activities; provide the USFWS with weekly progress reports of any significant changes in activities or locations; and notify the USFWS within 48 hours after activities end.
  - Polar bear observation reports—Report all observations of polar bears and potential polar bear dens during any industry activity. Information in the observation report must include the following:
    - Date, time, and location of observation
    - Number of bears
    - Sex and age of bears (if known)
    - Observer name and contact information\Weather, visibility, sea state, and sea-ice conditions at the time of observation
    - Estimated closest distance of bears from personnel and facilities
    - Industry activity at time of sighting
    - Possible attractants present
    - Bear behavior
    - Description of the encounter
    - Duration of the encounter
    - Mitigation actions taken
- Notification of LOA incident report—Report all LOA incidents during any industry activity. Reports must include all information specified for an observation report, a complete detailed description of the incident, and any other actions taken.
- Final report—The results of monitoring and mitigation identified in the marine mammal monitoring and mitigation plan must be submitted to the USFWS for review within 90 days of the LOA expiration. Information in the final report must include the following:
  - Copies of all observation reports submitted under the LOA
  - A summary of the observation reports
  - A summary of monitoring and mitigation, including areas, total hours, total distances, and distribution
  - Analysis of factors affecting the visibility and detectability of polar bears during monitoring
  - Analysis of the effectiveness of mitigation measures
  - Analysis of the distribution, abundance, and behavior of polar bears observed
  - Estimates of take in relation to the specified activities

J.5.2 Estimated Number of Maternal Polar Bear Dens likely to occur Annually in the Coastal Plain Program Area

Biometricians at the USGS Alaska Science Center developed a Bayesian hierarchical model of annual abundance of polar bear dens within the 1002 area using data collected in 1982–2015 (Patil et al. 2022). The analysis used location records of 287 dens associated with females that were initially captured and radio-tagged within the boundary of the Southern Beaufort Sea (SBS) subpopulation. Of the 122 dens located on land, 31 dens were in the 1002 area, including one located on a barrier island. For each year, the observed number of dens ($Ndens\_obs_i$), the number of dens detected on land including barrier islands ($Ldens\_obs_i$), and the number of land dens within the 1002 area (1002_obs_i) were used to estimate:

- Probability of a den occurring on land (*pLand*)
- Probability of a den occurring in the 1002 area (*pAreas*)
- Probability of a den occurring on a barrier island within the 1002 area (*pBarrisl_1002*)

A series of equations was used to estimate the annual probabilities:

$Ldens\ obs_i\_$ ~ binomial(p = *pLand*, n = $Ndens\_obs_i$)

1002_obs_i ~ multinomial(p = *pAreas*, n = $Ldens\ obs_i$)

BI dens_1002 ~ binomial (p = *pBarrisl*_1002, n = $Ldens\_1002_i$)

Den abundance modelling also required estimating several demographic parameters using data from previous long-term studies. The total population size of the SBS subpopulation (*Nbears*) was estimated to be stable from 2006 to at least 2015, with a mean = 908 bears and standard deviation = 163.8 bears (Bromaghin et al. 2015). That same mark-recapture study also provided information on the total number of bears captured in each year 2001–2010 (*Nbears_obsi*) and the number of adult females captured in each year (*NAFC0_obsi*). An analysis of denning propensity and den success based on temperature data from satellite-collared denning bears (USFS Alaska Science Center 2018) provided the number of successful dens per year ($Ndens\_success_i$) and the total number of dens per year ($Ndens\_obs_i$). These numbers were used to estimate:

- Probability that a bear in the SBS subpopulation was an adult female with cubs of the year (*pAFC0*; Bromaghin 2015)
- Probability of denning success (*pDensuccess*; USGS Alaska Science Center 2018)

The expected number of adult females with cubs (*NAFC0*) was estimated from a binomial process

$Nbears \sim \text{Normal}(\mu = 908, \sigma = 163.8) NAFC0 \sim \text{binomial}(p = pAFC0, n = Nbears)$

The number of failed dens was modeled as a negative binomial process where p = *pDensuccess* and the value was constrained not to exceed the number of adult females that did not have age zero cubs. The expected number of dens per year was the sum of the estimated number of failed and successful dens:

Number of failed dens ~ negative binomial(*pDensuccess, NAFC0*) bounded [0, *Nbears* – *pAFC0*]

Number of dens per year in population = Number of failed dens + *NAFC0*

The number of dens on land was modeled as a binomial process, where *p* = *pLand*, and the number of land dens in the 1002 region as a multinomial process, where p = *pAreas*.

> Number of dens on land ~ binomial(p = *pLand, n* = Number of dens per year in population)
>
> Number of land dens in 1002 region ~ multinomial(p = *p1002*, m = Number of dens on land)

Finally, the number of dens on barrier islands was modeled as a binomial process, where p = the probability of occurring on a barrier island in the 1002 region:

> Number of dens on barrier islands ~ binomial(*p* = *pBarrisl, n* = Number of dens on land)
>
> Number of barrier island dens in 1002 region ~ multinomial(p = *p1002*, n = Number of dens on barrier islands)

The model ran with 3 chains for 50,000 iterations, discarding the first 5,000 iterations as a burn-in period. The best model included random annual variation in *pLand* and a fixed effect of time-block indicating that the average probability of denning on land was 23% lower in 1982–1999 (posterior median = 0.32, posterior credible interval [0.2, 0.48]) than in 2000–2015 (posterior median = 0.56, posterior credible interval [0.5, 0.71]). The probability of a den occurring on a barrier island in the 1002 area was 0.1 [0.04, 0.2]. The probability of a bear being an adult female with cubs of the year had a posterior median value of 9.4% [7.7%, 11.3%] and the posterior median of den success was 0.69 [0.54, 0.82].

The median estimated number of polar bear dens on land annually in the 1002 region was 14 dens with a posterior credible interval [5,30].

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Appendix K

Fish and Aquatic Species

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Appendix K. Fish and Aquatic Species

K.1 Freshwater Fish

Many of the resident freshwater fish discussed below have at least some ability to tolerate brief periods of saline waters (USFWS 2015). Additional freshwater species not listed here, such as slimy sculpin, lake trout, and arctic char, have been reported in other parts of the Arctic National Wildlife Refuge (Arctic Refuge), and may be present (but not yet confirmed) in waters of the program area (BLM 2020). **Table K-1** summarizes habitat use and life history information for common species in the program area.

Round whitefish is a relatively small, benthic invertebrate feeding whitefish found in clearwater rivers and lakes in northern latitudes of North America and northeast Asia. The vast majority of round whitefish are resident freshwater fish, but some may tolerate brief periods in brackish waters. In the program area, these fish are found only in the Canning River. They are relatively less migratory in behavior than other whitefish. They are a minor component of subsistence catch due to low density.

Arctic grayling live in lakes and streams throughout northern North America and Asia and are found abundantly throughout the Arctic Refuge Coastal Plain. They exhibit very limited salinity tolerance. Adults feed on aquatic and terrestrial invertebrates and are capable of extensive annual movements between overwintering sites and summer feeding habitats. Though they constitute a minor subsistence component, recreational fishing for arctic grayling is likely common for residents of Kaktovik.

Burbot is large freshwater cod that inhabits deep areas of rivers and lakes throughout the circumpolar north (Evenson 1990; USFWS 2015). In the program area, burbot are found in waters along the Canning River (Smith and Glesne 1983; USFWS 2015). Burbot feed on insect larvae and other invertebrates as juveniles but move to a fish diet around age 4.

Ninespine stickleback are found throughout northern waters of North America. In the Arctic Refuge it is found in lakes, rivers and streams and is tolerant of saline waters up to 20 parts per thousand. This small, relatively short-lived species is present in large numbers throughout its range. Ninespine stickleback feed on small crustaceans and insects. They themselves are a major prey item for many larger species of fish as well as birds. Ninespine stickleback overwinter in freshwater habitats in the program area.

K.2 Anadromous Fish

There are at least nine species of anadromous fish in the program area. Most use this area and adjacent coastal waters seasonally for foraging or migration to other habitats. Pacific salmon are at the northern portion of their range in the project area, though their numbers appear to be increasing with warming trends in the region. Whitefish are common in the program area and are extremely important to subsistence communities. Dolly Varden are the only sport/subsistence fish that overwinters in the program area and its numbers are therefore limited by available spawning and overwintering habitat. For brevity, some of the following species are discussed within the context of family groups with similar life histories.

Pacific salmon (*Oncorhynchus* spp.) are represented by three primary species that have been reported in coastal waters adjacent to the program area: pink salmon, chum salmon, and Chinook salmon. Chinook salmon have not been reported in streams in the area, but several reports of chum salmon have been noted in the Canning River (Smith and Glesne 1983; USFWS 2015). Pink salmon are found in the Staines and Canning River complex. Pink salmon feed on plankton, larval fishes, fish eggs, and aquatic invertebrates. Juveniles of chum and Chinook salmon consume copepods and amphipods before switching to a diet of fish as sub-adults and adults whereupon they reach large sizes (Bradford et al. 2009; Horne-Brine et al. 2009; Salo 1991). All spawn in freshwater streams where the young emerge from gravel and disperse to the sea; almost immediately for chum and pink salmon and after a period of a year or more for Chinook salmon (Salo 1991; USFWS 2015). Depending on the species, each salmon spends between 1 and 5 years at sea before returning to freshwater to spawn and die.

Whitefish (***Coregonus* spp.**) are important subsistence fishes and, in addition to the mostly freshwater round whitefish, are represented by four anadromous species found either in Arctic Refuge Coastal Plain streams or in the adjacent coastal waters: humpback whitefish, least cisco, broad whitefish, and arctic cisco. Each species displays a different degree of freshwater and saline water reliance during their life. All are relatively long-lived (up to 20 years and older). Because waters of the program area do not support overwintering or spawning habitat sufficient for these species, they are found only in the adjacent coastal waters as they migrate or forage.

Humpback whitefish are medium sized, benthic invertebrate-feeding fish that are found in rivers lakes and estuaries in Asia and North America. In the Arctic Refuge Coastal Plain, they are only rarely documented in adjacent nearshore waters as they forage during summer months. Though they are rarely targeted for subsistence, they are a common bycatch species.

Least cisco are a relatively small, nearshore and pelagic-feeding whitefish that is found in Arctic and sub-Arctic environments of Asia and North America. They are common in estuaries, rivers, and lakes in northern Alaska, but are only found in coastal waters in or adjacent to the Arctic Refuge Coastal Plain during summer months as they forage before returning to deeper overwintering and spawning waters to the west or east (Seigle 2003; USFWS 2015). Least cisco may undertake extensive spawning, overwintering, and foraging migrations annually. As with humpback whitefish, they are caught mostly incidentally during subsistence activities and are commonly a source of dog food.

Broad whitefish are a relatively large, primarily benthic-feeding fish that is very important in subsistence activities in northern Alaska, including in coastal waters adjacent to the program area. The species may exhibit freshwater resident or anadromous behavior, but those found near the program area during summer are overwintering and spawning elsewhere.

Arctic cisco are a relatively small, pelagic-feeding species found in nearly all arctic waters. In Alaska, the evidence suggests that arctic cisco originate and later spawn in waters of the Mackenzie River drainage (Zimmerman et al. 2013; USFWS 2015). Arctic cisco are found foraging in Beaufort Sea coastal waters and overwintering in brackish waters of large rivers such as the Colville River to the west and Mackenzie River to the east. This is a fully anadromous species not known to reside in freshwaters. They are a prized subsistence species known for high fat content and good taste (Moulton et al. 2010).

Rainbow Smelt is a small schooling fish that spawns in freshwater but can be found extensively in nearshore brackish and marine waters throughout the Arctic Coastal Plain. They feed on a varied diet of crustacea, plankton, and various other aquatic invertebrates, as well as fish eggs and small fish. They are relatively short-lived (6 years) but can be highly migratory. It is unknown how common these fish are in the program area, but they are known to have spawning populations in the Colville, Sag, Kuk, and Mackenzie Rivers (Craig 1984).

Dolly Varden is a coldwater species found in the higher latitude waters of North America, as well as Russia, Japan, and Korea. They are found widely within the northern portion of the Arctic Refuge and in several rivers of the Arctic Refuge Coastal Plain and adjacent coastal waters and can display resident and anadromous forms. In the Program Area, spawning populations are documented in the Canning, Hulahula (Brown et al. 2014; USFWS 2015), and Aichilik rivers (USFWS 2015). Isolated resident populations are found in springs and lakes in the Canning (McCart and Craig 1973; USFWS 2015), Sadlerochit (USFWS 2015), and Jago (USFWS 2015) river drainages. Resident species are typically smaller and live shorter lives while anadromous forms are larger and longer-lived (Underwood et al. 1996; USFWS 2015). Anadromous forms typically migrate to brackish, nearshore waters of the Arctic Refuge Coastal Plain at ages 2–5 from their overwintering habitats in deep pools and spring-fed areas of the Arctic Refuge Coastal Plain rivers (Underwood et al. 1996; Fechhelm et al. 1997; USFWS 2015). They are a highly migratory species who feed on mysid shrimp and amphipods, exhibiting little piscivory. They are the primary species targeted in subsistence fisheries by Kaktovik residents on the Hulahula River and in coastal areas during summer.

K.3 COASTAL MARINE FISH

Although adult and juvenile stages of several species of marine fishes may use coastal and lagoon waters adjacent to the Program Area, this section focuses on the four most commonly observed species. Additional species likely to occur in marine waters are described in the National Petroleum Reserve-Alaska Integrated Activity Plan/Environmental Impact Statement (BLM 2020).

Arctic cod are distributed throughout the entirety of the northern polar basin and may be the most abundant and widely distributed fish in the Beaufort Sea. They are common and often abundant in nearshore coastal waters adjacent to the Arctic Refuge Coastal Plain. They inhabit cold, saline waters, but are tolerant of fluxes in temperature, salinity, and are found nearshore, offshore, and even in the lower reaches of large rivers. They are typically a small to medium sized species. They are common in nearshore coastal waters in summer and fall before moving into full-scale marine waters during winter. Arctic cod prey on amphipods, copepods, and mysid shrimp and are themselves common prey for marine mammals, birds, and fish (Craig et al. 1984; Frost and Lowry 1984; USFWS 2015). They are incidentally harvested during subsistence activities along the Beaufort Sea coast, including near Kaktovik.

Saffron cod are found throughout the North Pacific and in the Arctic Ocean. They are common and widely distributed in the Beaufort Sea and along the Arctic Refuge Coastal Plain. They are found from coastal lagoons to offshore marine waters and some lower reaches of large rivers. They range from medium to large in size and feed on mysid shrimp, amphipods, and decapods, with some piscivory upon reaching larger sizes (Ellis 1962; USFWS 2015).

Fourhorn sculpin are found throughout the circumpolar north including the Beaufort Sea coastline, and waters adjacent to the Arctic Refuge Coastal Plain where they are typically very abundant. They feed on mysids, amphipods, isopods, and small fish.

Arctic flounder are found in coastal marine waters of much of the Artic and sub-Arctic of North America and Siberia. They are commonly found in nearshore waters of the Beaufort Sea, including the waters adjacent to the Arctic Refuge Coastal Plain. They are a relatively medium sized species, which remain near to shorelines and lagoons but are sometimes found in lower river reaches (Bendock 1979; USFWS 2015). They feed on amphipods, mollusks, crustaceans, and small fish.

Table K-1
Life History Attributes for Fish Species that May Use the Program Area

Species	Lifespan (Years)	Age at Maturity (Years)	Spawning Behavior	Spawning in Program Area?	Habitat Use in Program Area	Feeding Behavior in Program Area	Subsistence Use in Arctic Coastal Plain
Arctic cisco	~20	7–8	Semiannual; fall	No	Migration and foraging in coastal marine waters during summer; not likely to overwinter in program area	Pelagic invertebrates	Extensive
Arctic cod	6–7	2–3	Annual to semiannual; fall	Likely	Common in coastal marine waters for spawning and rearing	Amphipods, copepods, and mysid shrimp	Limited
Arctic flounder	9–12	4–5	Annual to semiannual	Likely	Common during summer in marine waters; lower river deltas	Amphipods, mollusks, crustacea, and small fish	Limited
Arctic grayling	up to 18	4–8	Annual to semiannual; spring	Yes	Summer in some freshwater streams; limited use of marine waters; present in the program area throughout the year	Aquatic and terrestrial invertebrates	Limited
Broad whitefish	>20	5–8	Annual to semiannual: fall	No	Summer migration and foraging in freshwater and coastal marine waters	Benthic invertebrates	Extensive
Burbot	>20	6–7	Semiannual; winter	Probably	Present throughout year in the Canning River, but not elsewhere in program area	Insect larvae and other invertebrates as juveniles; fish diet as adults	Extensive
Chinook salmon	4–7	4–7	Once; summer/fall	No	Rare in coastal marine waters for migration and foraging	Copepods/amphipods (early) and fish (later)	Limited
Chum salmon	3–6	3–6	Once; summer/fall	No	Foraging in coastal waters; migration in Canning and Staines rivers	Copepods/amphipods (early) and fish (later)	Limited

Species	Lifespan (Years)	Age at Maturity (Years)	Spawning Behavior	Spawning in Program Area?	Habitat Use in Program Area	Feeding Behavior in Program Area	Subsistence Use in Arctic Coastal Plain
Dolly varden	Resident = 7; Anadromous = 10	Resident = 2–4; Anadromous = 4–8	Semiannual; fall	Yes	Common during summer in freshwater streams and springs and coastal marine waters; spawning and overwintering in freshwater springs	Resident = Dipteran larvae and macroinvertebrates; Anadromous = Mysids, amphipods, and fish	Extensive
Fourhorn sculpin	up to 14	3–9	Annual to semiannual	Likely	Common in summer and fall in coastal marine waters; lower river deltas	Mysid shrimp, amphipods, isopods, and fish	Limited
Humpback whitefish	>20	5–11	Annual to semiannual: fall	No	Summer migration and foraging in freshwater and coastal marine waters	Benthic invertebrates	Extensive
Least cisco	>25	3–7	Annual to semiannual; fall	Unknown	Summer migration and foraging in freshwater and coastal marine waters	Pelagic invertebrates and small fish	Limited
Ninespine stickleback	up to 5	1–2	Annual; summer	Yes	Nearly ubiquitous species that is common in freshwater and some brackish/coastal waters during summer; overwinters in freshwater; may spawn in fresh or brackish waters	aquatic and terrestrial insects, and crustacea	None
Pink salmon	2	2	Once: summer/fall	No	Migration in Canning and Staines rivers; coastal marine waters	Plankton, larval fishes, fish eggs, and aquatic invertebrates	Limited
Round whitefish	>20	3–8	Annual to semiannual	Probably	Common in Canning River throughout the year, including summer migration and foraging activities; also found in some brackish waters but not in other freshwaters of planning area	Benthic invertebrates	Limited

Species	Lifespan (Years)	Age at Maturity (Years)	Spawning Behavior	Spawning in Program Area?	Habitat Use in Program Area	Feeding Behavior in Program Area	Subsistence Use in Arctic Coastal Plain
Rainbow smelt	~6	2–6	Once; summer/fall	Unknown	Found in coastal marine waters; lower river deltas in summer/fall	Copepods, fish eggs, and algae as juveniles; decapods, mysid shrimp, copepod, amphipod, small fish, and other invertebrates as adults	Limited
Saffron cod	10–12	2–3	Annual to semiannual: fall	Likely	Common in coastal marine waters for spawning and rearing	Amphipods, copepods, decapods, mysid shrimp, and some fish	Limited

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Appendix L

Cultural Resources

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Appendix L. Cultural Resources

Table L-1
Documented Alaska Heritage Resources Survey (AHRS) Sites in Program Area

AHRS #	Site Name	Period	Resource Description
BRL-00001	Elupak ("Old Village")	Prehistoric	Sod house ruins
BRL-00004	Igluqpaaluk	Historic	—
BRL-00005	Uqsruqtalik	Historic	Camp, hunting, sod houses, cabins, ice cellars
BRL-00007	Naalagiagvik	Prehistoric, Historic, Protohistoric	Settlement, sod houses, burials
BRL-00009	—	Historic	Burials
BRL-00012	—	Historic	Residential, cabin, log, sod house
BRL-00013	—	Historic	—
BRL-00017	Uqsruqtalik	Historic	Burials
BRL-00018	Kapiluuraq	Historic	Camp, fishing, sod house
BRL-00020	—	Historic	Residential, sod house
BRL-00021	—	Historic	—
BRL-00022	Puukak	Historic	Camp, sod houses, cemetery
BRL-00023	(Doe) BAR-M (AHRS) Barter Island	Historic	Defense, DEW Line
BRL-00044	Gravel structures, Barter Island Airfield	Historic	Defense, DEW Line, transportation
BRL-00051	Barter Island seawall	Historic	Military, seawall, defense, DEW Line
BRL-00052	Browers Camp	Historic, Modern	Camp, tent floors, drying racks, windbreaks
XDP-00001	Angun	Historic	Sod house ruins, foundations
XDP-00021	—	Historic	—
XDP-00022	—	Historic	—
XDP-00024	Atchalik	Historic	Sod house ruins, sod quarry, cache pots
XDP-00026	—	Historic	Burials
XDP-00027	—	Historic	Sod house ruins, sod quarry
XDP-00028	—	Historic	Burials, box coffins
XDP-00029	—	Historic	—
XDP-00030	—	Historic	—
XDP-00031	—	Prehistoric	Lithic scatter
XDP-00032	—	Prehistoric	—
XDP-00033	—	Historic	—
XDP-00034	—	Historic	—
XDP-00035	—	Prehistoric	—
XDP-00045	Beaufort Lagoon (AHRS) Demarcation Point	Historic	Defense, DEW Line
XDP-00046	Nuvagapak Jacobson and Wentworth's Traditional Land Use Inventory (TLUI) Site 32	—	—

AHRS #	Site Name	Period	Resource Description
XDP-00048	Nuvagapak reburial	Historic	Reburied human remains
XFI-00003	Anderson Point	Prehistoric	Settlement, bone and wood artifacts
XFI-00009	Brownlow Point, Agliguagruk	Historic	House ruins, burials
XFI-00011	Sanniqsaaluk	Historic	Cabin, ice cellar, camp
XFI-00013	—	Historic	Ice cellar
XFI-00014	—	Historic	Lookout tower
XFI-00015	—	Historic	Single dwelling, sod house
XFI-00016	—	Historic	Settlement, sod houses, sod quarry
XFI-00017	Kanigniivik	Historic	Burials
XFI-00018	—	Historic	Single dwelling, sod house, artifacts
XFI-00019	—	Historic	Single dwelling, sod house
XFI-00020	—	Historic	Single dwelling, sod house
XFI-00030	Flaxman Island-Brownlow Point Historic District	—	—
XFI-00033	Brownlow cemetery	Historic	Cemetery
XFI-00034	Brownlow southern grave	Historic	Isolated grave
XFI-00035	—	Prehistoric	Artifact scatter
XMM-00001	Camden Bay	Prehistoric	House pit, midden, organic artifacts
XMM-00004	—	Historic	Sod houses, cellar
XMM-00005	—	Historic	Sod house ruin
XMM-00006	—	Historic	Sod house ruin, ice cellar, tent frame remains
XMM-00007	—	Prehistoric	Tent ring
XMM-00008	—	Prehistoric	—
XMM-00009	—	Prehistoric	Tent ring, scattered stones of other features
XMM-00010	—	Prehistoric	—
XMM-00011	—	Prehistoric	—
XMM-00012	—	Prehistoric	Tent ring, hearth(?)
XMM-00013	—	Prehistoric	—
XMM-00014	—	Prehistoric	—
XMM-00015	—	Prehistoric	—
XMM-00016	—	Prehistoric	—
XMM-00017	—	Prehistoric	—
XMM-00018	—	Historic	Sod house ruins, log cabin, historic debris
XMM-00019	—	Historic	Sod house, quarry
XMM-00020	—	Prehistoric	—
XMM-00021	—	Historic	—
XMM-00022	—	Prehistoric	—
XMM-00023	—	Prehistoric	—
XMM-00024	—	Prehistoric	—
XMM-00025	—	Prehistoric	—
XMM-00026	—	Prehistoric	—
XMM-00027	—	Prehistoric	—
XMM-00028	—	Prehistoric	Tent ring, scattered stones of other features
XMM-00029	—	Historic	—
XMM-00030	—	Prehistoric	—

AHRS #	Site Name	Period	Resource Description
XMM-00031	—	Historic	—
XMM-00032	—	Historic	—
XMM-00033	—	Historic	—
XMM-00034	—	Prehistoric	—
XMM-00035	—	Prehistoric, Historic	—
XMM-00037	—	Prehistoric	—
XMM-00038	—	Prehistoric	Tent rings
XMM-00039	—	Historic	—
XMM-00040	—	Historic	—
XMM-00041	—	Historic	Fish camp, tent rings(?)
XMM-00042	—	Historic	Settlement, winter, reindeer herding
XMM-00043	—	Historic	Settlement, winter, reindeer herding
XMM-00044	—	Historic	—
XMM-00045	—	Historic	Cemetery
XMM-00046	—	Historic	—
XMM-00114	(Doe) Camden Bay (AHRS) POW-D	Historic	Building, structure, defense, DEW Line
XMM-00117	Sivugag	—	—

Source: (ADNR OHA 2023)
— = no information provided in AHRS database. Information provided in this table is verbatim from the AHRS database.

Table L-2
Documented Traditional Land Use Inventory (TLUI) Sites in Program Area

TLUI #	Site Name	Resource Description
TLUIXMM039	Katakturuk	Viewing area
TLUIXMM036	Aanalaaq	House ruins, cabin, and graves
None Given	Aanaalaaq	None given
TLUIXMM033	Salliġutchich	Reindeer herding area
TLUIXMM032	Nuvugaq	House and ice cellar ruins
TLUIXMM032	Nuvugaq	Another reference name is Saluksa, used by Indians; ruins and trapping and duck hunting area
None Given	Nuvugaq	None given
None Given	Nuvugaq Sigluaq	None given
TLUIXMM028	1st Fish Hole	Fishing area
TLUIXMM027	Sivugaq	Landmark and resting place along trail
TLUIXMM005	Iqalugliuraq	House ruins and fishing area
TLUIXMM001	Niaquqtuġvik	None given
TLUIXFI027	Agliġuaġruk Cemetery	Cemetery
TLUIXFI017	Kunagrak	House ruin
TLUIXFI015	Salliġutchit	House ruins, fishing area, and hunting and camping area
None Given	Salliġutchit	None given
TLUIXFI013	Sanniqsaaluk	House ruins and graves
TLUIXFI012	Aanalaaq	House ruins, cabin, and graves
None Given	Aanalaaq	House ruins, cabin, and graves
None Given	Aanalaaq	House ruin
None Given	Aanalaaq	None given
None Given	Aanalaaq	None given
TLUIXFI011	Kaŋiŋiivik	House ruins and graves
TLUIXFI010	Kayutak	House ruins
TLUIXFI009	Tigutaaq	House ruins and grave
TLUIXFI008	Agliġuaġruk	Trading post and graves
TLUIXDP010	Igluġruatchiat	House ruin and graves
None Given	Igluġruatchiat graves	Grave
None Given	Igluġruatchiat grave	Grave
TLUIXDP009	Imaiġeauraq	House ruins, ice cellar ruins, and graves
TLUIXDP008	Annŋun	House ruins and oil seep
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
None Given	Annŋun	House ruin
TLUIXDP007	Atchalik	House ruins and fishing area
None Given	Atchalik	House ruin
None Given	Atchalik	None given
None Given	Atchalik	None given
None Given	Atchalik	None given
None Given	Atchalik	House ruin

TLUI #	Site Name	Resource Description
TLUIBRL012	Uqsruqtalik	House ruins, cabin, and graves
TLUIBRL011	Puukak	House ruins
None Given	Puukak	None given
None Given	Puukak	None given
TLUIBRL(44)	Kapiłġuurak	House ruin and ice cellar ruins
None Given	Kapiłġuurak (2)	House ruin
None Given	Uqsruqtalik Ijuvvivik	None given
None Given	Nuvugapak	House ruins
None Given	None Given	Disturbed grave
None Given	None Given	Grave
None Given	None Given	None given

Source: (IHLC 2023)

Table L-3
Documented Place Names in Program Area

Place Name #	USGS Name	Name	Translation	Type	Origin
1	Barter Island	Łeerideedal	we meet	Island	Gwich'in
2	Canning River	Vyàhk'it Gwinjik	snare place river	Stream	Gwich'in
3	Coastal Plain	Iizhik Gwats’an Gwandaii Goodlit	The Sacred Place Where Life Begins	Locale	Gwich'in
4	Collinson Point	Iñupiaq: Nuvuġaq, Gwich'in: Sallute	Iñupiaq: point on land or on an open lead	Locale	Iñupiaq, Gwich'in
5	1st Fish Hole	—	—	Site	Iñupiaq
6	Aichilik River	—	—	Stream	Iñupiaq
7	Akootchook House Site	Tikluk	—	Site	Iñupiaq
8	Akutoktak River	—	food mixture of seal oil, caribou fat, and snow	Stream	Iñupiaq
9	Anderson Point	Aanalaaq	—	Site	Iñupiaq
10	Angun Lagoon	Anŋun	—	Lagoon	Iñupiaq
11	Angun Point	Anŋun	—	Site	Iñupiaq
12	Angun River	—	—	Stream	Iñupiaq
13	Arctic Creek	—	—	Site	Iñupiaq
14	Arey Island	Naalagiagvik	—	Island	Iñupiaq
15	Arey Lagoon	Aŋayuqaksrakuvik	place to keep old man	Bay	Iñupiaq
16	Bernard Spit	Tapkak	—	Site	Iñupiaq
17	Brooks Range	Gwashrał/Gwazhał	—	Locale	Gwich’in
18	Brownlow Point	Agliġuaġruk	—	Site	Iñupiaq
19	Egaksrak Entrance	—	—	Channel	Iñupiaq
20	Egaksrak Lagoon	—	—	Lagoon	Iñupiaq
21	Egaksrak River	—	—	Stream	Iñupiaq
22	Ekaluakat River	—	—	Stream	Iñupiaq
23	Flaxman Island	Sirak	—	Island	Iñupiaq
24	Griffin Point	Uqsruqtalik	—	Site	Iñupiaq
25	Humphrey Point	Imiagnaurak	—	Site	Iñupiaq
26	Herschel Island	Chuu Choo Vee	shore of big water	Locale	Gwich’in
27	Igilatvik Creek	—	place where parts of a house are found	Stream	Iñupiaq
28	Itkilyariak Creek	—	indian's route	Stream	Iñupiaq

Place Name #	USGS Name	Name	Translation	Type	Origin
29	Itkilyariak Valley	—	indian's route	Valley	Iñupiaq
30	Kajutakrok Creek	—	—	Stream	Iñupiaq
31	Kaktovik	Qaaktugvik	—	Village	Iñupiaq
32	Kaktovik (1st location)	Qaaktuġvik	—	Village	Iñupiaq
33	Kaktovik (2nd location)	Qaaktuġvik	—	Village	Iñupiaq
34	Kaktovik (3rd location)	Qaaktuġvik	—	Village	Iñupiaq
35	Kaktovik Lagoon	Uqpillaq	willowless lake	Lagoon	Iñupiaq
36	Katakturak	Katakturak	a narrow place, many falls	Site	Iñupiaq
37	Katakturuk River	Katakturak	a narrow place, many falls	Stream	Iñupiaq
38	Kimikpaurauk River	Iġġiguq	big hill	Stream	Iñupiaq
39	Kingak Hill	—	nose	Summit	Iñupiaq
40	Kogotpak River	—	—	Stream	Iñupiaq
41	Kongakut River	Ch'ùhnjik	Charcoal Riber	River	Gwich'in
42	Konganevik Point	Kaŋiññiivik	—	Site	Iñupiaq
43	Kuvritovik Entrance	—	—	Channel	Iñupiaq
44	Manning Point	Qikiqtaq	island	Site	Iñupiaq
45	Martin Point	Tapqauraq	—	Site	Iñupiaq
46	Matsutnak River	—	—	Stream	Iñupiaq
47	Nataroarok Creek	—	—	Stream	Iñupiaq
48	Nelsaluk	—	—	Locale	Iñupiaq
49	Nelsaluk Pass	—	—	Channel	Iñupiaq
50	Niguanak Ridge	—	attempt to see animals	Ridge	Iñupiaq
51	Niguanak River	—	attempt to see animals	Stream	Iñupiaq
52	Nularvik River	—	camping place	Stream	Iñupiaq
53	Nuvagapak Entrance	Tikiġayuġruaq	big point	Channel	Iñupiaq
54	Nuvagapak Lagoon	Tikiġayuġruaq	big point	Lagoon	Iñupiaq
55	Nuvagapak Point	Nuvagapaq	—	Site	Iñupiaq
56	Nuwuak (historical)	Siŋik	point of land	Locale	Iñupiaq
57	Okerokovik River	—	place where there is a blubber cache	Stream	Iñupiaq
58	Okerokovik River	—	place where there is a blubber cache	Stream	Iñupiaq
59	Okpilak River	—	no willows	Stream	Iñupiaq
60	Okpirourak Creek	—	a few willows	Stream	Iñupiaq
61	Oruktalik Entrance	—	—	Channel	Iñupiaq

Place Name #	USGS Name	Name	Translation	Type	Origin
62	Oruktalik Lagoon	—	—	Lagoon	Iñupiaq
63	Pipsuk Bight	—	—	Bay	Iñupiaq
64	Pipsuk Point	Pipsuk	—	Site	Iñupiaq
65	Pokok Bay	—	—	Lagoon	Iñupiaq
66	Pokok Creek	—	—	Stream	Iñupiaq
67	Pokok Lagoon	—	—	Lagoon	Iñupiaq
68	Sadlerochit River	—	area outside of the mountains	Stream	Iñupiaq
69	Sadlerochit Spring	Salliġutchich	—	Site	Iñupiaq
70	Sikrelurak River	—	place where ice is found	Stream	Iñupiaq
71	Siksik River	Siksrik	ground squirrel	Stream	Iñupiaq
72	Tamayariak River	—	route where some people were lost	Stream	Iñupiaq
73	Tapkaurak Entrance	—	little narrow spit	Channel	Iñupiaq
74	Tapkaurak Lagoon	—	little narrow spit	Lagoon	Iñupiaq
75	Tapkaurak Point	—	little narrow spit	Cape	Iñupiaq
76	Tapkaurak Spit	—	—	Site	Iñupiaq
77	—	Aaquaksrakuvik	place to keep old woman	Site	Iñupiaq
78	—	Aġviġuraq	little whale	Site	Iñupiaq
79	—	Aġviġuraq	little whale	Site	Iñupiaq
80	—	Aniġaġaniq	place to be outside	Site	Iñupiaq
81	—	Aniġaġaniq	place to be outside	Site	Iñupiaq
82	—	Aŋayuqaksrakuvik	place to keep old man	Site	Iñupiaq
83	—	Aŋayuqaksrakuvik	place to keep old man	Site	Iñupiaq
84	—	Aŋayuqaksrakuvik	place to keep old man	Site	Iñupiaq
85	—	Atchalik	place with skin tents	Site	Iñupiaq
86	—	Iglugruatchiat	—	Site	Iñupiaq
87	—	Igluqpaaluk	—	Site	Iñupiaq
88	—	Igluqpauraq	little big house	Site	Iñupiaq

Place Name #	USGS Name	Name	Translation	Type	Origin
89	—	Kanugrak	—	Site	Iñupiaq
90	—	Kaŋi	end	Site	Iñupiaq
91	—	Kaŋi	end	Site	Iñupiaq
92	—	Kayutak	—	Site	Iñupiaq
93	—	Name not known	—	Site	Iñupiaq
94	—	Name not known	—	Site	Iñupiaq
95	—	Name not known	—	Mouth	Iñupiaq
96	—	Name not known	—	Site	Iñupiaq
97	—	Name not known	—	Village	Iñupiaq
98	—	Name not known	—	Village	Iñupiaq
99	—	Name not known	—	Site	Iñupiaq
100	—	Name not known	—	Site	Iñupiaq
101	—	Name not known	—	Site	Iñupiaq
102	—	Name not known	—	Site	Iñupiaq
103	—	Name not known	—	Site	Iñupiaq
104	—	Name not known	—	Site	Iñupiaq
105	—	Niaquqtuġuiqsaaġvik	place where the heads are eaten for the last time	Site	Iñupiaq
106	—	Nuvuġaq	point on land or on an open lead	Site	Iñupiaq
107	—	Nuvuġaq	point on land or on an open lead	Site	Iñupiaq
108	—	Nuvuġaq	point on land or on an open lead	Site	Iñupiaq
109	—	Nuvuġaq	point on land or on an open lead	Site	Iñupiaq
110	—	Nuvuġaq	point on land or on an open lead	Site	Iñupiaq
111	—	Paaqta	Pass by and meet	Site	Iñupiaq
112	—	Patkotak	Paul Patkutaq's place	Site	Iñupiaq
113	—	Pukak	—	Site	Iñupiaq
114	—	Qayyaaq	kayak	Site	Iñupiaq

Place Name #	USGS Name	Name	Translation	Type	Origin
115	—	Sallitchit Iqaluitch	most northernly fish hole	Site	Iñupiaq
116	—	Sanniqsaaluk	—	Site	Iñupiaq
117	—	Siiqsiññiq	glacier	Site	Iñupiaq
118	—	Sivugaq	first	Site	Iñupiaq
119	—	Tapqauraq	little sand spit	Site	Iñupiaq
120	—	Tapqauraq	little sand spit	Village	Iñupiaq
121	—	Tiaŋuraq	named after Danny Gordon, Sr. (his Eskimo name)	Site	Iñupiaq
122	—	Tigutaaq	—	Site	Iñupiaq
123	—	Uqpillam Paaŋa	—	Site	Iñupiaq
124	—	Uqpillaq	willowless lake	Site	Iñupiaq
125	—	Uqpillaq	willowless lake	Site	Iñupiaq
126	—	Uqpillaq	willowless lake	Site	Iñupiaq
127	—	Uqsruqtalik	place with some oil	Village	Iñupiaq
128	—	Uqsruqtalik	place with some oil	Village	Iñupiaq
129	—	Yaigum Tapqaŋa	Jago spit	Site	Iñupiaq

Source: (Smith 2017; Gilbert, Williams, Fields, Williams, Flitt, Savage, Francis, John, Salmon, Salmon, Tritt, Martin, Herbert, Frank, Frank, James, Alexander, and Roberts 2017; Pedersen, Coffing, and Thompson 1985; Jacobson and Wentworth 1982; Nielson 1977; Gwich'in Steering Committee 2004)

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Appendix M

Subsistence Uses and Resources

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Appendix M. Subsistence Uses and Resources

M.1 KAKTOVIK

M.1.1 Harvest Data

Table M-1
Kaktovik Subsistence Harvest Estimates[5] by Resource Category, All Resources Study Years

Study Year	Resource	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[1]	Total Pounds[2]	Average HH Pounds	Per Capita Pounds	
1985	All Resources	100	93	91	83	100	—	61,663	1,163	328	100.0
	Salmon	2	0	0	0	2	0	0	0	0	0.0
	Non-Salmon Fish	100	86	81	45	93	6,866	11,403	215	61	18.5
	Large Land Mammals	100	79	71	71	100	288	35,331	667	188	57.3
	Small Land Mammals	60	52	52	31	24	427	160	3	1	0.3
	Marine Mammals	88	69	57	41	86	174	10,762	203	57	17.5
	Migratory Birds	83	76	71	48	57	964	3,388	64	18	5.5
	Upland Game Birds	86	74	69	45	43	867	607	11	3	1.0
	Vegetation	24	17	2	5	21	—	13	<1	<1	<0.1
1986	All Resources	100	89	87	83	100	—	84,060	1,501	433	100.0
	Non-Salmon Fish	96	75	72	66	87	4,416	6,951	124	36	8.3
	Large Land Mammals	98	68	62	57	98	198	24,908	445	128	29.6
	Small Land Mammals	47	45	40	19	30	183	39	1	<1	<0.1
	Marine Mammals	96	64	60	64	96	—	49,723	888	256	59.2
	Migratory Birds	—	—	—	—	—	273	1,673	30	9	2.0
	Upland Game Birds	87	62	62	47	55	1,012	708	13	4	0.8
	Eggs	2	2	2	0	2	4	1	<1	<1	<0.1
	Vegetation	49	21	21	11	40	—	58	1	<1	0.1
1992a	All Resources	96	89	89	83	92	—	170,939	2,713	886	100.0
	Salmon	26	9	9	11	19	50	105	2	1	0.1
	Non-Salmon Fish	94	83	81	70	68	18,415	22,847	363	118	13.4
	Large Land Mammals	96	70	57	62	83	212	28,705	456	149	16.8
	Small Land Mammals	47	43	38	21	19	213	162	3	1	0.1
	Marine Mammals	89	64	40	70	87	-	115,645	1,836	599	67.7
	Migratory Birds	83	62	51	47	70	970	2,702	43	14	1.6
	Upland Game Birds	85	60	57	47	49	769	539	9	3	0.3
	Eggs	23	15	13	15	15	56	8	<1	<1	<0.1
	Vegetation	77	72	70	23	40	—	227	4	1	0.1

Study Year	Resource	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[1]	Total Pounds[2]	Average HH Pounds	Per Capita Pounds	
1992b[3]	All resources	—	—	—	—	—	—	180,970	—	—	100.0
	Salmon	—	—	—	—	—	20	123	—	—	0.1
	Non-salmon fish	—	66	—	—	—	19,641	32,941	—	—	18.2
	Large land mammals	—	—	—	—	—	195	24,763	—	—	13.7
	Small land mammals	—	—	—	—	—	51	13	—	—	<0.1
	Marine mammals	—	—	—	—	—	77	120,287	—	—	66.5
	Migratory birds	—	64	—	—	—	773	2,362	—	—	1.3
	Upland game birds	—	—	—	—	—	400	257	—	—	0.1
	Eggs	—	—	—	—	—	32	5	—	—	<0.1
	Vegetation	—	50	—	—	—	56	219	—	—	0.1
1994–95	All resources	—	—	—	—	—	—	126,893	—	—	100.0
	Salmon	—	—	—	—	—	1	6	—	—	<0.1
	Non-salmon fish	—	—	—	—	—	4,425	7,934	—	—	6.3
	Large land mammals	—	—	—	—	—	119	17,007	—	—	13.4
	Small land mammals	—	—	—	—	—	59	18	—	—	<0.1
	Marine mammals	—	—	—	—	—	46	100,725	—	—	79.4
	Migratory birds	—	—	—	—	—	411	1,102	—	—	0.9
	Upland game birds	—	—	—	—	—	119	119	—	—	0.1
2002–03	All resources	—	—	—	—	—	—	104,777	—	—	100.0
	Non-salmon fish	—	—	—	—	—	2,363	4,784	—	—	4.6
	Large land mammals	—	—	—	—	—	130	17,104	—	—	16.3
	Small land mammals	—	—	—	—	—	56	20	—	—	<0.1
	Marine mammals	—	—	—	—	—	30	80,877	—	—	77.2
	Migratory birds	—	—	—	—	—	536	1,585	—	—	1.5
	Upland game birds	—	—	—	—	—	370	370	—	—	0.4
	Eggs	—	—	—	—	—	30	5	—	—	<0.1
	Marine invertebrates	—	—	—	—	—	3	6	—	—	<0.1
	Vegetation	—	—	—	—	—	9	27	—	—	<0.1
2007	All resources	—	—	—	—	—	6,277	78,243	954	—	100.0
	Salmon	—	—	—	—	—	5	14	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	5,086	7,592	93	—	9.7
	Large land mammals	—	—	—	—	—	181	21,168	258	—	27.1
	Small land mammals	—	—	—	—	—	31	14	<1	—	<0.1
	Marine mammals	—	—	—	—	—	17	47,316	577	—	60.5
	Migratory birds	—	—	—	—	—	537	1,814	22	—	2.3
	Upland game birds	—	—	—	—	—	199	139	2	—	0.2
	Bird eggs	—	—	—	—	—	43	13	<1	—	<0.1
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	179	173	2	—	0.2

Study Year	Resource	Percent of Households: Use	Percent of Households: Try to Harvest	Percent of Households: Harvest	Percent of Households: Give	Percent of Households: Receive	Estimated Harvest: Number[1]	Estimated Harvest: Total Pounds[2]	Estimated Harvest: Average HH Pounds	Estimated Harvest: Per Capita Pounds	Percent of Total Harvest
2008	All resources	—	—	—	—	—	6,735	101,398	1,237	—	100.0
	Salmon	—	—	—	—	—	11	34	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	5,364	12,000	146	—	11.8
	Large land mammals	—	—	—	—	—	230	26,123	319	—	25.8
	Small land mammals	—	—	—	—	—	47	2	<1	—	<0.1
	Marine mammals	—	—	—	—	—	23	60,731	741	—	59.9
	Migratory birds	—	—	—	—	—	698	2,274	28	—	2.2
	Upland game birds	—	—	—	—	—	155	155	2	—	0.2
	Bird eggs	—	—	—	—	—	170	44	1	—	<0.1
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	36	36	<1	—	<0.1
2009	All resources	—	—	—	—	—	4,796	126,628	1,472	—	100.0
	Salmon	—	—	—	—	—	4	14	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	3,737	7,919	92	—	6.3
	Large land mammals	—	—	—	—	—	202	23,050	268	—	18.2
	Small land mammals	—	—	—	—	—	54	8	<1	—	0.0
	Marine mammals	—	—	—	—	—	22	93,638	1,089	—	73.9
	Migratory birds	—	—	—	—	—	397	1,632	19	—	1.3
	Upland game birds	—	—	—	—	—	287	287	3	—	0.2
	Bird eggs	—	—	—	—	—	0	0	0	—	0.0
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	93	82	1	—	0.1
2010	All resources	—	—	—	—	—	1,870	79,231	990	—	100.0
	Salmon	—	—	—	—	—	4	16	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	1,195	762	10	—	1.0
	Large land mammals	—	—	—	—	—	143	16,105	201	—	20.3
	Small land mammals	—	—	—	—	—	19	3	<1	—	<0.1
	Marine mammals	—	—	—	—	—	12	61,474	768	—	77.6
	Migratory birds	—	—	—	—	—	151	596	7	—	0.8
	Upland game birds	—	—	—	—	—	266	266	3	—	0.3
	Bird eggs	—	—	—	—	—	0	0	0	—	0.0
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	81	9	<1	—	<0.1
2010–11	All resources	100	96	94	84	100	13,138	202,958	2,388	707	100.0
	Salmon	19	7	6	9	14	59	288	3	1	0.1
	Non-salmon fish	96	83	76	69	84	10,799	27,198	320	95	13.4
	Large land mammals	94	56	47	51	93	511	68,458	805	239	33.7
	Small land mammals	29	23	17	13	16	150	302	4	1	0.1
	Marine mammals	99	91	89	69	97	59	103,108	1,213	359	50.8
	Migratory birds	73	51	40	40	67	788	2,547	30	9	1.3
	Upland game birds	60	43	37	29	40	710	710	8	3	0.4
	Bird eggs	1	1	1	1	0	7	5	0	0	0.0
	Marine invertebrates	1	0	0	0	1	0	0	0	0	0.0
	Vegetation	46	29	19	21	41	55	342	4	1	0.2

Study Year	Resource	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[1]	Total Pounds[2]	Average HH Pounds	Per Capita Pounds	
2011[4]	All resources	—	—	—	—	—	8,216	98,841	1,236	—	100.0
	Salmon	—	—	—	—	—	1	6	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	7,390	16,837	210	—	17.0
	Large land mammals	—	—	—	—	—	191	21,920	274	—	22.2
	Small land mammals	—	—	—	—	—	6	3	<1	—	<0.1
	Marine mammals	—	—	—	—	—	14	58,944	737	—	59.6
	Migratory birds	—	—	—	—	—	239	884	11	—	0.9
	Upland game birds	—	—	—	—	—	127	127	2	—	0.1
	Bird eggs	—	—	—	—	—	65	18	<1	—	<0.1
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	183	102	1	—	0.1
2012	All resources	—	—	—	—	—	5,806	133,258	1,666	—	100.0
	Salmon	—	—	—	—	—	7	32	<1	—	<0.1
	Non-salmon fish	—	—	—	—	—	4,948	9,556	119	—	7.2
	Large land mammals	—	—	—	—	—	169	20,099	251	—	15.1
	Small land mammals	—	—	—	—	—	39	2	<1	—	<0.1
	Marine mammals	—	—	—	—	—	9	102,278	1,278	—	76.8
	Migratory birds	—	—	—	—	—	434	1,089	14	—	0.8
	Upland game birds	—	—	—	—	—	0	0	0	—	0.0
	Bird eggs	—	—	—	—	—	0	0	0	—	0.0
	Marine invertebrates	—	—	—	—	—	—	—	—	—	—
	Vegetation	—	—	—	—	—	202	202	3	—	0.2

Sources: 1985, 1986 (ADFG 2018); 1992a (Pedersen 1995a); 1992b (Fuller and George 1999); 1994–95 (Brower, Olemaun, and Hepa 2000); 2002–03 (Bacon et al. 2009); 2007–12 (Harcharek, Kayotuk, George, and Pederson 2018); 2010–11 (Kofinas, BurnSilver, Magdanz, Stotts, and Okada 2016).

Notes: Sources: 2000–01, 2001-02 Pedersen and Linn 2005

[1]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[2]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.

[3]Due to a low response rate during the NSB 1992b survey, these data should be viewed with caution. Household participation for the 1992b study year is based on Table A5 in Fuller and George (1999); participation in migratory bird harvests includes waterfowl and eggs; participation in vegetation harvests includes only berries; participation in non-salmon fish harvests is for fish in general.

[4]The survey in 2011 consisted of only an 8-month survey, covering May through December 2011; therefore, estimates from 2011 may not be directly comparable with other years that covered an entire year. The estimated harvest numbers for the 1994-95 and 2002-03 data were derived by summing individual species in each resource category. Also, for those study years, total pounds were derived from conversion rates found at ADFG (2018) and total usable pounds for bowhead whales were calculated based on the method presented in (SRB&A and ISER 1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George, Philo, Suydam, Carroll, and Albert, n.d.

[5] The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

Table M-2
Kaktovik Subsistence Harvest Estimates[1] by Resource Category, Non-Comprehensive Study Years

Study Year	Resource	Percent of Households: Use	Try to Harvest	Harvest	Give	Receive	Estimated Harvest: Number	Total Pounds	Average HH Pounds	Per Capita Pounds
2000–01	Non-salmon fish	61	43	38	36	52	3,137	5,970	35	11
2001–02	Non-salmon fish	76	55	47	33	47	5,036	9,748	55	19

[1]The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

Table M-3
Kaktovik Subsistence Harvest Estimates[8] by Selected Species, All Study Years

Study Year	Resource[1]	Percent of Households: Use	Try to Harvest	Harvest	Give	Receive	Estimated Harvest: Number[2]	Total Pounds[3]	Average HH Pounds	Per Capita Pounds	Percent of Total Harvest
1981–82	Caribou	—	—	—	—	—	43	—	—	—	—
1982–83	Caribou	—	—	—	—	—	160	—	—	—	—
1983–84	Caribou	—	—	—	—	—	107	—	—	—	—
1985–86	Caribou	—	—	—	—	—	235	—	—	—	—
1985	Caribou	95	76	69	67	86	235	27,941	527	149	45.3
	Arctic char	100	86	81	41	69	3,075	8,611	162	46	14.0
	Ringed seal	69	50	45	26	45	151	6,360	120	34	10.3
	Dall sheep	79	29	21	21	74	47	4,622	87	25	7.5
	Bearded seal	62	43	33	29	57	21	3,776	71	20	6.1
	Geese	71	62	57	38	43	647	2,913	55	15	4.7
	Cisco	79	60	55	29	62	3,546	2,482	47	13	4.0
	Moose	45	7	7	5	38	4	1,893	36	10	3.1
	Muskox	43	5	2	2	43	1	748	14	4	1.2
	Polar bear	24	5	2	2	21	1	626	12	3	1.0
	Ptarmigan	86	74	69	45	43	867	607	11	3	1.0
1986	Bowhead whale	96	62	43	51	94	—	43,704	780	225	52.0
	Caribou	98	66	60	53	94	178	21,188	378	109	25.2
	Arctic char	94	70	70	62	77	1,768	4,951	88	25	5.9
	Bearded seal	75	34	26	23	64	17	2,936	52	15	3.5
	Ringed seal	72	40	38	28	60	44	1,851	33	10	2.2
	Dall sheep	75	15	9	9	68	17	1,710	31	9	2.0
	Cisco	85	53	53	45	79	2,402	1,682	30	9	2.0
	Muskox	68	4	4	4	66	2	1,413	25	7	1.7
	Geese	83	55	51	36	70	371	1,410	25	7	1.7
	Polar bear	15	6	4	4	13	2	1,182	21	6	1.4
1986–87	Caribou	—	—	—	—	—	201	—	—	—	—
1987–88	Caribou	—	—	55	—	—	185	22,229	383	104	—
1990[4]	Caribou	—	—	48	—	—	113	13,453	224	67	—
1991	Caribou	—	—	50	—	—	181	22,113	369	94	—

Study Year	Resource[1]	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[2]	Total Pounds[3]	Average HH Pounds	Per Capita Pounds	
1992a	Bowhead whale	87	53	6	62	85	—	108,160	1,717	560	63.3
	Caribou	96	70	55	53	75	158	19,136	304	99	11.2
	Arctic char	92	81	79	66	45	5,523	15,463	245	80	9.0
	Bering cisco[8]	77	62	62	57	45	8,103	5,672	90	29	3.3
	Dall sheep	70	36	28	32	64	44	4,379	70	23	2.6
	Bearded seal	75	47	28	32	60	24	4,246	67	22	2.5
	Muskox	53	21	9	17	51	5	3,179	50	16	1.9
	Geese	79	60	47	40	62	601	2,135	34	11	1.2
	Moose	36	11	6	9	32	4	2,011	32	10	1.2
	Ringed seal	47	30	26	28	36	42	1,689	27	9	1.0
1992b[5]	Bowhead whale	—	59	—	—	—	3	108,463	—	—	59.9
	Arctic char	—	—	—	—	—	7,937	22,224	—	—	12.3
	Caribou	—	66	—	—	—	136	15,926	—	—	8.8
	Arctic cisco	—	—	—	—	—	—	7,143	—	—	3.9
	Dall sheep	—	—	—	—	—	53	5,249	—	—	2.9
	Walrus	—	23	—	—	—	5	3,737	—	—	2.1
	Musk ox	—	—	—	—	—	6	3,588	—	—	2.0
	Bearded seal	—	62	—	—	—	17	2,998	—	—	1.7
	Beluga	—	—	—	—	—	2	2,761	—	—	1.5
	Grayling	—	—	—	—	—	3,299	2,639	—	—	1.5
	Geese	—	—	—	—	—	563	2,034	—	—	1.1
1994–95	Bowhead whale	—	—	—	—	—	3	88,688	—	—	69.9
	Caribou	—	—	—	—	—	78	10,608	—	—	8.4
	Bearded seal	—	—	—	—	—	21	8,820	—	—	7.0
	Dolly varden	—	—	—	—	—	1,875	6,188	—	—	4.9
	Dall sheep	—	—	—	—	—	30	3,120	—	—	2.5
	Muskox	—	—	—	—	—	9	2,655	—	—	2.1
	Arctic cisco	—	—	—	—	—	2,358	1,651	—	—	1.3
2000–01	Dolly varden	—	—	35	—	—	1,739	4,869	27	9	—
	Arctic cisco	—	—	91	—	—	1,361	953	32	9	—
	Lake trout	—	—	4	—	—	37	148	2	1	—
2001–02	Dolly varden	—	—	44	—	—	2,649	7,418	41	14	—
	Arctic cisco	—	—	38	—	—	2,187	1,531	19	7	—
	Lake trout	—	—	6	—	—	200	800	10	3	—
2002–03	Bowhead whale	—	—	—	—	—	3	75,515	—	—	72.1
	Caribou	—	—	—	—	—	112	15,232	—	—	14.5
	Arctic char	—	—	—	—	—	1,162	3,834	—	—	3.7
	Bearded seal	—	—	—	—	—	8	3,360	—	—	3.2
	Dall sheep	—	—	—	—	—	18	1,872	—	—	1.8
	Ringed seal	—	—	—	—	—	17	1,258	—	—	1.2
2007	Bowhead whale	—	—	—	—	—	3	40,833	498	—	52.2
	Caribou	—	—	—	—	—	181	21,168	258	—	27.1
	Beluga whale	—	—	—	—	—	6	5,934	72	—	7.6
	Dolly varden	—	—	—	—	—	1,658	4,643	57	—	5.9
	Arctic cisco	—	—	—	—	—	3,198	2,239	27	—	2.9
2008	Bowhead whale	—	—	—	—	—	3	57,482	701	—	56.7
	Caribou	—	—	—	—	—	185	21,586	263	—	21.3
	Dolly varden	—	—	—	—	—	3,921	10,980	134	—	10.8
	Dall sheep	—	—	—	—	—	45	4,425	54	—	4.4
	Polar bear	—	—	—	—	—	3	1,662	20	—	1.6
	Bearded seal	—	—	—	—	—	6	1,117	14	—	1.1

Study Year	Resource[1]	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[2]	Total Pounds[3]	Average HH Pounds	Per Capita Pounds	
2009	Bowhead whale	—	—	—	—	—	3	88,488	1029	—	69.9
	Caribou	—	—	—	—	—	170	19,872	231	—	15.7
	Dolly varden	—	—	—	—	—	2,449	6,857	80	—	5.4
	Bearded seal	—	—	—	—	—	15	2,915	34	—	2.3
	Dall sheep	—	—	—	—	—	29	2,886	34	—	2.3
	Beluga whale	—	—	—	—	—	2	1,450	17	—	1.1
	White-fronted geese	—	—	—	—	—	274	1,234	14	—	1.0
2010	Bowhead whale	—	—	—	—	—	3	53,167	665	—	67.1
	Caribou	—	—	—	—	—	115	13,458	168	—	17.0
	Beluga whale	—	—	—	—	—	8	8,075	101	—	10.2
	Dall sheep	—	—	—	—	—	16	1,612	20	—	2.0
	Black bear[6]	—	—	—	—	—	12	1,035	13	—	1.3
2010–11	Bowhead	97	90	89	60	94	3	78,662	925	274	38.8
	Caribou	94	53	46	51	93	429	58,305	686	203	28.7
	Dolly varden	94	79	76	64	77	6,333	20,898	246	73	10.3
	Beluga	76	30	26	30	74	15	10,318	121	36	5.1
	Bearded seal	57	28	17	24	54	24	10,165	120	35	5.0
	Dall sheep	76	14	14	0	73	78	8,089	95	28	4.0
	Broad whitefish	43	26	20	20	29	1,148	3,729	44	13	1.8
	Geese	70	49	40	37	60	701	2,272	27	8	1.1
	Moose	16	9	4	4	13	4	1,960	23	7	1.0
2011[7]	Bowhead whale	—	—	—	—	—	3	57,661	721	—	58.3
	Caribou	—	—	—	—	—	170	19,909	249	—	20.1
	Dolly varden	—	—	—	—	—	5,440	15,232	190	—	15.4
	Dall sheep	—	—	—	—	—	20	2,011	25	—	2.0
	Bering cisco[8]	—	—	—	—	—	1,093	1,093	14	—	1.1
	Bearded seal	—	—	—	—	—	5	1,016	13	—	1.0
2012	Bowhead whale	—	—	—	—	—	3	100,968	1,262	—	75.8
	Caribou	—	—	—	—	—	155	18,145	227	—	13.6
	Dolly varden	—	—	—	—	—	2,861	8,010	100	—	6.0
2014	Caribou	—	—	—	—	—	248	29,016	363	—	—
2015	Caribou	—	52	—	—	—	303	35,451	445	—	—
2016	Caribou	—	—	—	—	—	133	15,561	199	—	—
2017	Caribou	—	—	—	—	—	119	13,923	176	—	—
2018	Caribou	—	—	—	—	—	108	12,636	164	—	—
2019	Caribou	—	—	—	—	—	125	14,625	—	—	—

Sources: 1981–82, 1982–83 (Pedersen and Coffing 1984); 1983–84 (Coffing and Pedersen 1985); 1985–86, 1986–87, 1987–88 (Pedersen 1990); 1985, 1986, 1990, 1991, (ADFG 2018); 1992a (Pedersen 1995a); 1992b (Fuller and George 1999); 1994–95 (Brower et al. 2000); and 2000–01, 2001–02 (Pedersen and Linn 2005); 2002–03 (Bacon et al. 2009); 2007–12 (Harcharek et al. 2018); 2010–11 (Kofinas et al. 2016); 2014-2018 (Person, Kayotuk, and Olemaun 2019), 2019 ((NSB 2020).

Notes:

[1]Except in the case of ducks and geese, which are lumped into more general species categories, this table shows individual species, unless they are not available for a given study year.

[2]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[3]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.

[4]Per capita pounds may be underestimated.

[5]Data should be viewed with caution due to a low response rate. Household participation for the 1992b study year was based on Table A5 in Fuller and George (1999). Bearded seal participation rates include all species of seal.

[6]Probably misreported and should be brown bear (Akłaq).

[7]The survey in 2011 consisted of only an 8-month survey, covering May through December 2011; therefore, estimates from 2011 may not be directly comparable with other years that covered an entire year. For All Resources study years (1985, 1986, 1992a, 1992b, 1994–95, 2002–03), species are listed in descending order by percent of total harvest and are limited to species accounting

for at least 1.0 percent of the total harvest; for single-resource study years, species are listed in descending order by total estimated pounds (or total number harvested, in the case of salmon study years) and limited to the five top species. Years lacking “% of total harvest” data were not comprehensive (i.e., all resources) study years).
[8]Reports of Bering cisco harvests in 1992 and 2011 may be incorrect, as Bering cisco are rare in the Kaktovik area. The data are likely referencing Arctic cisco. The estimated harvest numbers for the 1994–95 and 2002–03 data were derived by summing individual species in each resource category. Also, for those study years, total pounds were derived from conversion rates found at (ADFG 2018) and total (usable) pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George et al., n.d.
[8] The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

M.1.2 Seasonal Round

Table M-4
Kaktovik Annual Cycle of Subsistence Activities

Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Freshwater non-salmon	X	X	X	X	X	X	X	X	X	X	X	X
Marine non-salmon	X	X	X	X	X	X	X	X	X		X	X
Salmon							X	X	X			
Caribou	X	X	X	X	X	X	X	X	X	X	X	X
Moose	X	X	X	X			X	X	X	X	X	X
Bear					X		X	X	X	X	X	
Sheep	X		X	X				X	X	X	X	X
Muskox	X	X	X					X		X	X	X
Furbearers	X	X	X	X	X			X		X	X	X
Small land mammals			X	X	X	X		X	X		X	
Marine mammals	X	X	X	X	X	X	X	X	X	X	X	X
Upland birds			X	X	X	X	X	X		X	X	
Waterfowl				X	X	X	X	X	X	X		
Eggs				X	X	X	X	X	X	X		
Marine invertebrates								X				
Plants and Berries							X	X	X			
Total number of resources categories by month	**8**	**7**	**10**	**11**	**10**	**8**	**11**	**16**	**12**	**11**	**11**	**8**

Sources: 2002–03 (Bacon et al. 2009); 1994–95 (Brower et al. 2000); 2004 (EDAW Inc., Consulting, Research, Callaway, Associates, and Economics 2008); 1992 (Fuller and George 1999); (Kofinas et al. 2016); pre-1989 (Pedersen, Haynes, and Wolfe 1991); 2000–01 (Pedersen and Linn 2005); 1996–2006 (SRB&A 2010); 2007–2012 (Harcharek et al. 2018)

X = Subsistence activity

M.1.3 Travel Method

Table M-5
Kaktovik Travel Method to Subsistence Use Areas

Resources	Boat	Snowmachine	Foot	Car/Truck	ATV
Arctic cisco	5	1	3	2	4
Burbot	5	4	4	0	0
Arctic char/dolly varden and broad whitefish	5	4	2	1	3
Broad whitefish	5	3	2	2	4
Caribou	5	4	3	0	2
Moose	5	0	0	0	0
Wolf and wolverine	4	5	0	0	0
Bowhead whale	5	0	0	0	0
Seals	5	4	0	0	0
Walrus	5	0	0	0	0
Geese	4	5	3	0	3
Eider	4	5	3	0	2
Total number of resources targeted	**12**	**9**	**7**	**3**	**6**

Sources: 1996–2006 (SRB&A 2010)
Note: For each resource, darker shades indicate greater use of that travel method and lighter shades indicate lesser use of a travel method. The shades have been given a value of 0–5, 0 being the lightest and 5 the darkest.

M.1.4 Resource Importance

Table M-6
Material and Cultural Importance of Subsistence Resources, Kaktovik

Resource Level	Resource[1]	Cultural Importance: Percent of Households: Try to Harvest	Cultural Importance: Percent of Households: Receive	Material Importance: Percent of Total Harvest
Major resources[2]	Bearded seal	38	59	2.6
	Bering cisco[3]	62	45	2.2
	Bowhead whale[6]	62	89	56.6
	Caribou	66	93	21.6
	Dall sheep	24	70	2.9
	Dolly varden and arctic char	79	67	7.4
	Ptarmigan	60	47	0.4
	Wood	64	21	—
Moderate resources[4]	Arctic cisco	17	16	1.2
	Arctic fox	14	1	—
	Arctic grayling	11	13	0.2
	Belukha/beluga	12	38	2.6
	Blueberry	20	22	<.1
	Broad whitefish	8	25	0.3
	Canada geese	48	46	0.3
	Common eider	19	15	0.1
	Cranberry	21	33	0.1
	King eider	13	10	<.1
	Lake trout	13	24	0.3
	Least cisco	9	13	0.1
	Long-tailed duck (oldsquaw)	22	17	<.1

Resource Level	Resource[1]	Cultural Importance: Percent of Households: Try to Harvest	Cultural Importance: Percent of Households: Receive	Material Importance: Percent of Total Harvest
Moderate resources[4] *(continued)*	Moose	8	37	1.3
	Muskox	8	40	1.5
	Polar bear	4	12	0.8
	Ringed seal	38	36	1.5
	Saffron cod	16	1	<.1
	Salmonberry/cloudberry	21	33	0.1
	Snow geese	17	9	<.1
	Squirrel	28	16	0.1
	Walrus	8	31	0.6
	White-fronted geese	30	26	0.5
	Wolf	11	2	—
	Wolverine	13	2	—
Minor resources[5]	Bird eggs	6	6	<.1
	Brown bear	3	6	0.2
	Halibut	1	9	0.2
	Humpback whitefish	—	5	<.1
	Red fox	9	1	—
	Spotted seal	9	5	0.2

Sources: 1981–82, 1982-83 (Pedersen and Coffing 1984); 1983–84 (Coffing and Pedersen 1985); 1985–86, 1986–87, 1987–88 (Pedersen 1990); 1985, 1986, 1990, 1991, (ADFG 2018); 1992a (Pedersen 1995a); 1992b (Fuller and George 1999); 1994–95 (Brower et al. 2000); and 2000–01, 2001–02 (Pedersen and Linn 2005); 2002–03 (Bacon et al. 2009); 2007–12 (Harcharek et al. 2018); 2010–11 (Kofinas et al. 2016); 2015 (SRB&A 2017a)

Notes:

[1]Resources that contributed an average of less than 1 percent of harvest, less than 5 percent attempting harvests, and less than 5 percent receiving harvests are categorized as minor and are not shown.

[2]Major resources contribute >9 percent total harvest, have ≥50 percent of households attempting harvest, or have ≥50 percent of households receiving a resource.

[3]Reports of Bering cisco harvests in 1992 and 2011 may be incorrect, as Bering cisco are rare in the Kaktovik area. The data are likely referencing Arctic cisco.

[4]Moderate resources contribute 2 to 9 percent of total harvest, have 11 to 49 percent of households attempting harvest, or have 11 to 49 percent of households receiving a resource.

[5]Minor resources contribute <2 percent of total harvest, have ≤10 percent of households attempting harvest, or have ≤10 percent of households receiving a resource.

[6]Averages include unsuccessful bowhead whale harvest years.

M.2 NUIQSUT

M.2.1 Harvest Data

Table M-7
Nuiqsut Subsistence Harvest Estimates[5] by Resource Category, All Resources Study Years

Study Year	Resource	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[1]	Total Pounds[2]	Average HH Pounds	Per Capita Pounds	
1985	All resources	100	98	98	95	100	—	160,035	2,106	399	100.0
	Salmon	60	43	40	23	23	441	1,366	18	3	0.9
	Non-salmon fish	100	93	93	83	75	67,712	69,243	911	173	43.3
	Large land mammals	98	90	90	80	70	536	67,621	890	169	42.3
	Small land mammals	65	63	58	23	13	688	245	3	1	0.2
	Marine mammals	100	48	23	30	100	59	13,355	176	33	8.3
	Migratory birds	90	90	85	60	55	1,733	6,626	87	17	4.1
	Upland game birds	88	88	88	58	13	1,957	1,370	18	3	0.9
	Bird eggs	25	25	23	8	10	262	40	1	<1	<0.1
	Vegetation	38	50	18	10	20	—	169	2	<1	0.1
1992[3]	All resources	—	—	—	—	—	—	150,195	—	—	100.0
	Salmon	—	—	—	—	—	6	65	—	—	0.0
	Non-salmon fish	—	74	—	—	—	36,701	51,890	—	—	34.5
	Large land mammals	—	—	—	—	—	299	41,386	—	—	27.6
	Small land mammals	—	—	—	—	—	46	1	—	—	0.0
	Marine mammals	—	—	—	—	—	49	52,865	—	—	35.2
	Migratory birds	—	—	—	—	—	1,105	3,655	—	—	2.4
	Upland game birds	—	—	—	—	—	378	265	—	—	0.2
	Eggs	—	—	—	—	—	25	4	—	—	<0.1
	Vegetation	—	32	—	—	—	—	66	—	—	<0.1
1993	All resources	100	94	90	92	98	—	267,818	2,943	742	100.0
	Salmon	71	45	36	39	47	272	1,009	11	3	0.4
	Non-salmon fish	97	79	79	87	90	71,626	89,481	983	248	33.4
	Large land mammals	98	76	74	82	92	691	87,306	959	242	32.6
	Small land mammals	53	45	42	27	18	599	84	1	<1	<0.1
	Marine mammals	97	58	37	79	97	113	85,216	936	236	31.8
	Migratory birds	87	74	73	63	65	2,238	3,540	39	10	1.3
	Upland game birds	60	45	45	42	26	973	681	7	2	0.3
	Eggs	40	21	19	15	23	346	104	1	<1	<0.1
	Vegetation	79	71	71	27	40	—	396	4	1	0.1
1994–95[4]	All resources	—	—	—	—	—	—	83,228	—	—	100.0
	Salmon	—	—	—	—	—	10	31	—	—	<0.1
	Non-salmon fish	—	—	—	—	—	15,190	46,569	—	—	56.0
	Large land mammals	—	—	—	—	—	263	32,686	—	—	39.3
	Small land mammals	—	—	—	—	—	42	0	—	—	0.0
	Marine mammals	—	—	—	—	—	25	1,504	—	—	1.8
	Migratory birds	—	—	—	—	—	569	2,289	—	—	2.8
	Upland game birds	—	—	—	—	—	58	58	—	—	0.1
	Vegetation	—	—	—	—	—	14	91	—	—	0.1

Study Year	Resource	Percent of Households: Use	Percent of Households: Try to Harvest	Percent of Households: Harvest	Percent of Households: Give	Percent of Households: Receive	Estimated Harvest: Number[1]	Estimated Harvest: Total Pounds[2]	Estimated Harvest: Average HH Pounds	Estimated Harvest: Per Capita Pounds	Percent of Total Harvest
1995–96	All resources	—	—	—	—	—	—	183,576	—	—	100.0
	Salmon	—	—	—	—	—	42	131	—	—	0.1
	Non-salmon fish	—	—	—	—	—	10,612	16,822	—	—	9.2
	Large land mammals	—	—	—	—	—	364	43,554	—	—	23.7
	Small land mammals	—	—	—	—	—	27	0	—	—	0.0
	Marine mammals	—	—	—	—	—	178	120,811	—	—	65.8
	Migratory birds	—	—	—	—	—	683	2,166	—	—	1.2
	Upland birds	—	—	—	—	—	19	13	—	—	<0.1
	Vegetation	—	—	—	—	—	12	78	—	—	<0.1
2000–01	All resources	—	—	—	—	—	—	183,246	—	—	100.0
	Salmon	—	—	—	—	—	10	75	—	—	<0.1
	Non-salmon fish	—	—	—	—	—	26,545	27,933	—	—	15.2
	Large land mammals	—	—	—	—	—	504	62,171	—	—	33.9
	Small land mammals	—	—	—	—	—	108	2	—	—	<0.1
	Marine mammals	—	—	—	—	—	31	87,929	—	—	48.0
	Migratory birds	—	—	—	—	—	1,192	5,108	—	—	2.8
	Upland birds	—	—	—	—	—	23	16	—	—	<0.1
	Vegetation	—	—	—	—	—	2	13	—	—	<0.1
2014	All resources	100	95	90	91	97	—	371,992	3,444	896	100.0
	Salmon	64	41	40	31	35	—	3,889	36	9	1.0
	Non-salmon fish	93	78	71	72	71	—	85,106	788	205	22.9
	Large land mammals	91	66	64	67	72	—	108,359	1,003	261	29.1
	Small land mammals	17	16	10	2	7	—	0	0	0	0.0
	Marine mammals	95	55	40	71	95	—	169,367	1,568	408	45.5
	Migratory birds	79	71	66	52	38	—	4,742	44	11	1.3
	Upland birds	16	12	12	9	5	—	78	1	<1	<0.1
	Vegetation	67	55	53	21	38	—	414	4	1	0.1

Sources: 1985 (ADFG 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995b); 1994–95 (Brower and Hepa 1998); 1995–96, 2000-01 (Bacon et al. 2009); 2014 (Brown, Braem, Mikow, Trainor, Slayton, Runfola, Ikuta, Kostick, McDevitt, Park, and Simon 2016).

Notes:

[1]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[2]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.

[3]The estimated pounds of moose harvested in 1992 is likely too high (Fuller and George 1999).

[4]The 1994–95 study year underrepresents the harvest of Arctic cisco and humpback whitefish (Brower and Hepa 1998). Nuiqsut did not successfully harvest a bowhead whale in 1994–95.

[5]The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

The estimated harvest numbers for the 1994–95, 1995–96, and 2000–01 data were derived by summing individual species in each resource category. Also for those study years, total pounds were derived from conversion rates found at ADFG (2018), and total usable pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George et al. n.d.

Table M-8
Nuiqsut Subsistence Harvest Estimates[6] by Selected Species, All Study Years

Study Year	Resource[1]	Percent of Households: Use	Try to Harvest	Harvest	Give	Receive	Estimated Harvest: Number[2]	Total Pounds[3]	Average HH Pounds	Per Capita Pounds	Percent of Total Harvest
1985	Caribou	98	90	90	80	60	513	60,021	790	150	37.5
	Cisco	98	75	73	65	60	46,478	29,354	386	73	18.3
	Broad whitefish	95	80	78	70	40	7,900	26,861	353	67	16.8
	Bowhead whale	100	23	5	8	100	0	7,458	98	19	4.7
	Moose	40	40	18	20	25	13	6,650	88	17	4.2
	White-fronted geese	90	90	85	55	48	1,340	6,028	79	15	3.8
	Arctic grayling	78	65	63	48	35	4,055	3,650	48	9	2.3
	Humpback whitefish	48	45	38	33	13	4,345	3,476	46	9	2.2
	Arctic char	75	63	60	33	35	1,060	2,969	39	7	1.9
	Burbot	75	60	60	43	33	669	2,675	35	7	1.7
	Bearded seal	48	25	15	15	35	15	2,675	35	7	1.7
	Ringed seal	53	25	18	23	40	40	1,676	22	4	1.0
1992	Bowhead whale	—	—	—	—	—	2	48,715	—	—	32.4
	Caribou	—	81	—	—	—	278	32,551	—	—	21.7
	Arctic cisco	—	—	—	—	—	22,391	22,391	—	—	14.9
	Broad whitefish	—	—	—	—	—	6,248	15,621	—	—	10.4
	Moose[4]	—	—	—	—	—	18	8,835	—	—	5.9
	Humpback whitefish	—	—	—	—	—	1,802	4,504	—	—	3.0
	Arctic char	—	—	—	—	—	1,544	4,324	—	—	2.9
	Bearded seal	—	—	—	—	—	16	2,760	—	—	1.8
	Arctic grayling	—	—	—	—	—	3,114	2,491	—	—	1.7
	Canada geese	—	—	—	—	—	319	1,437	—	—	1.0
1993	Caribou	98	74	74	79	79	672	82,169	903	228	30.7
	Bowhead whale	97	37	5	76	97	3	76,906	845	213	28.7
	Broad whitefish	90	66	66	65	66	12,193	41,455	456	115	15.5
	Arctic cisco	89	69	68	81	60	45,237	31,666	348	88	11.8
	Ringed seal	65	42	31	40	55	98	7,277	80	20	2.7
	Burbot	79	63	57	53	55	1,416	5,949	65	16	2.2
	Moose	69	47	10	29	63	9	4,403	48	12	1.6
	Arctic grayling	79	69	65	44	27	4,515	4,063	45	11	1.5
	Least cisco	63	52	47	36	27	6,553	3,277	36	9	1.2
1994–95[5]	Broad whitefish	—	—	—	—	—	3,237	37,417	—	—	45.0
	Caribou	—	—	—	—	—	258	30,186	—	—	36.3
	Arctic cisco	—	—	—	—	—	9,842	6,889	—	—	8.3
	Moose	—	—	—	—	—	5	2,500	—	—	3.0
	Geese unidentified	—	—	—	—	—	474	2,133	—	—	2.6
	Ringed seal	—	—	—	—	—	24	1,008	—	—	1.2
1995–96	Bowhead whale	—	—	—	—	—	4	110,715	—	—	60.3
	Caribou	—	—	—	—	—	362	42,354	—	—	23.1
	Broad whitefish	—	—	—	—	—	2,863	9,735	—	—	5.3
	Ringed seal	—	—	—	—	—	155	6,527	—	—	3.6
	Arctic cisco	—	—	—	—	—	5,030	3,521	—	—	1.9
	Bearded seal	—	—	—	—	—	17	2,974	—	—	1.6
	Least cisco	—	—	—	—	—	1,804	1,804	—	—	1.0
1999–00	Caribou	—	—	—	—	—	413	—	—	112	—

Study Year	Resource[1]	Percent of Households: Use	Percent of Households: Try to Harvest	Percent of Households: Harvest	Percent of Households: Give	Percent of Households: Receive	Estimated Harvest: Number[2]	Estimated Harvest: Total Pounds[3]	Estimated Harvest: Average HH Pounds	Estimated Harvest: Per Capita Pounds	Percent of Total Harvest
2000–01	Bowhead whale	—	—	—	—	—	4	86220	—	—	47.1
	Caribou	—	—	—	—	—	496	57,985	—	—	31.6
	Arctic cisco	—	—	—	—	—	18,222	12,755	—	—	7.0
	Broad whitefish	—	—	—	—	—	2,968	10,092	—	—	5.5
	White-fronted geese	—	—	—	—	—	787	3,543	—	—	1.9
	Moose	—	—	—	—	—	6	3,000	—	—	1.6
2002–03	Caribou	95	47	45	49	80	397	—	—	118	—
2003–04	Caribou	97	74	70	81	81	564	—	—	157	—
2004–05	Caribou	99	62	61	81	96	546	—	—	147	—
2005–06	Caribou	100	60	59	97	96	363	—	—	102	—
2006–07	Caribou	97	77	74	66	69	475	—	—	143	—
2010	Caribou	94	86	76	—	—	562	65,754	707	—	—
2011	Caribou	92	70	56	49	58	437	51,129	544	134	—
2012	Caribou	99	68	62	65	79	501	58,617	598	147	—
2013	Caribou	95	79	63	62	75	586	68,534	692	166	—
2014	Bowhead	93	29	21	57	91	5	148,087	1,371	357	39.8
	Caribou	90	66	64	67	59	774	105,193	974	253	28.3
	Broad whitefish	72	60	59	52	40	11,439	36,605	339	88	9.8
	Arctic cisco	83	52	48	59	53	46,277	32,394	300	78	8.7
	Bearded seal	67	38	22	40	62	13,846	13,846	128	33	3.7
	Least cisco	33	28	28	19	7	13,332	9,333	86	22	2.5
	Ringed seal	52	40	35	38	33	108	6,156	57	15	1.7
2015	Caribou	96	84	78	74	72	628	73,527	728	180	—
2016	Caribou	96	76	67	79	81	481	56,277	592	132	-
2017	Caribou	96	72	60	74	85	635	74,338	715	164	-
2018	Caribou	99	84	74	88	88	608	71,113	658	157	-
2019	Caribou	100	98	91	87	78	636	74,439	658	153	-
2020	Caribou	98	88	79	82	76	629	73,639	657	160	-

Sources: 1985 (ADFG 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995b); 1994–95 (Brower and Hepa 1998); 1995–96, 2000–01 (Bacon et al. 2009); 1999–00, 2002–2007 (Braem et al. 2011); 2010, 2011, 2012, 2013 (SRB&A 2012, 2013, 2014, 2015); 2014 (Brown et al. 2016); 2015 (SRB&A 2017b); 2016 (SRB&A 2018); 2017 (SRB&A 2019); 2018 (SRB&A 2020); 2019 (SRB&A 2021); 2020 (SRB&A 2022)

Notes:

[1]This table shows individual species unless they are not available for a given study year.

[2]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[3]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.

[4]The estimated pounds of moose harvested in 1992 is likely too high (Fuller and George 1999).

[5]The 1994–95 study year underrepresents the harvest of Arctic cisco and humpback whitefish (Brower and Hepa 1998); Nuiqsut did not successfully harvest a bowhead whale in 1994–95.

[6]The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

7 This study year had a low response rate due to COVID-19; thus, results and community wide estimates should be viewed with this in mind

Most of Nuiqsut's caribou harvests come from the Teshekpuk Herd and Central Arctic Herd; few Porcupine Caribou Herd caribou migrate into Nuiqsut's core harvesting area.

For All Resources study years (1985, 1992, 1993, 1994-95, 1995–96, 2000–01), species are listed in descending order by percent of total harvest and are limited to species accounting for at least 1.0 percent of the total harvest; for single-resource study years, species are listed in descending order by total estimated pounds (or total number harvested, in the case of salmon study years) and are limited to the five top species. Years lacking percent of total harvest data were not comprehensive study years for all resources. The estimated harvest numbers for the 1992, 1994–95, 1995–96 and 2000–01 data were derived by summing individual species in each resource category. Also, for those study years, total pounds were derived from conversion rates found at ADFG (2018). Total usable pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George et al. n.d. for the 2002–03, 2003–04, 2004–05, 2005–06, 2006–07, and 2010–11 study years, total pounds were derived from conversion rates from Braem et al. 2011.

M.2.2 Seasonal Round

Table M-9
Nuiqsut Annual Cycle of Subsistence Activities

Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Freshwater non-salmon												
Marine non-salmon												
Salmon												
Caribou												
Moose												
Bear												
Muskox												
Furbearers												
Small land mammals												
Marine mammals												
Upland birds												
Waterfowl												
Eggs												
Plants and berries												
Total number of resource categories by month	**6**	**5**	**6**	**7**	**9**	**10**	**10**	**12**	**11**	**10**	**8**	**8**

Sources: 1995–96, 2000–01 (Bacon et al. 2009); 2002–07 (Braem et al. 2011); 1994–95 (Brower and Hepa 1998); Pre-1979 (Brown 1979); 2014 (Brown et al. 2016); 2004 (EDAW Inc. et al. 2008); 1992 (Fuller and George 1999); 2001–2012 (Galginaitis 2014); 1988 (Hoffman, Libbey, and Spearman 1988); 1979 (Libbey, Spearman, and Hoffman 1979); 1995–2006 (SRB&A 2010); 2008–2020 (SRB&A 2022)

Limited activity and/or harvests | Moderate activity and/or harvests | High activity and/or harvests

M.2.3 Travel Method

Table M-10
Nuiqsut Travel Method to Subsistence Use Areas

Resources	Boat	Snowmachine	Foot	Car/Truck	ATV	Plane
Arctic cisco and burbot	3	5	2	4	0	0
Arctic char and dolly varden and broad whitefish	5	4	3	0	0	0
Caribou	5	4	0	2	4	0
Moose	5	0	4	0	0	0
Wolf and wolverine	4	5	0	0	0	4
Bowhead whale	5	0	0	0	0	0
Seals	5	4	0	0	0	0
Geese	4	5	3	1	2	0
Eider	5	4	0	0	0	0
Total number of resources targeted	**9**	**7**	**4**	**3**	**2**	**1**

Sources: 1995–2006 (SRB&A 2010), 2008–2020 () (SRB&A 2022)
Notes: For each resource, darker shades indicate greater use of that travel method; lighter shades indicate lesser use of a travel method. The shades have been given a value of 0–5, 0 being the lightest and 5 the darkest. Caribou based on SRB&A 2017; all others based on SRB&A 2010a.

M.2.4 Resource Importance

Table M-11
Material and Cultural Importance of Subsistence Resources, Nuiqsut

Resource Level	Resource	Cultural Importance		Material Importance
		Percent of Households		
		Trying to Harvest	Receiving	Percent of Total Harvest
Major resources[2]	Arctic cisco	61	57	8.8
	Arctic grayling	50	24	1.0
	Bearded seal	32	50	1.6
	Bowhead whale[5]	30	96	30.4
	Broad whitefish	69	49	15.5
	Burbot	51	35	1.0
	Caribou	76	77	29.9
	Cloudberry	55	29	0.0
	White fronted geese	62	36	1.4
	Wood	50	3.2	0.0
Moderate resources[3]	Arctic char	38	22	0.9
	Arctic fox	14	1	0.0
	Beluga	2	24	0.0
	Bird eggs	16	12	0.0
	Blueberries	29	16	0.0
	Brant	17	9	0.1
	Brown bear	14	18	0.2
	Canada geese	42	24	0.4
	Chum salmon	23	11	0.6
	Ground squirrel	45	8	0.1
	Humpback whitefish	26	9	1.0
	King eider	24	19	0.0
	Least cisco	40	17	1.1
	Long-tailed duck	8	13	0.0
	Moose	40	41	2.5

Resource Level	Resource	Cultural Importance: Percent of Households: Trying to Harvest	Cultural Importance: Percent of Households: Receiving	Material Importance: Percent of Total Harvest
Moderate resources[3] *(continued)*	Pink salmon	28	17	0.4
	Polar bear	7	29	0.2
	Ptarmigan	48	15	0.2
	Rainbow smelt	13	22	0.1
	Red fox	22	2	0.0
	Ringed seal	36	43	1.6
	Snow geese	19	7	0.0
	Spotted seal	13	5	0.1
	Walrus	7	43	0.2
	Wolf	18	6	0.0
	Wolverine	22	5	0.0
Minor resources[4]	Arctic cod	7	7	0.0
	Chinook salmon	2	9	0.0
	Coho salmon	3	5	0.0
	Common eider duck	7	3	0.1
	Cranberries	9	5	0.0
	Crowberries	7	2	0.0
	Dall sheep	-	9	0.0
	Dolly varden	10	3	0.4
	Lake trout	3	8	0.0
	Muskox	—	8	0.3
	Northern pike	7	7	0.0
	Northern pintail	5	1.6	0.0
	Round whitefish	5	1	0.1
	Saffron cod	7	—	0.0
	Sheefish	—	6	0.0
	Sockeye salmon	3	6	0.0
	Sourdock	5	7	0.0
	Weasel	5	—	0.0

Sources: 1985 (ADFG 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995b); 1994–95 (Brower and Hepa 1998); 1995–96, 2000–01 (Bacon et al. 2009); 1999–2000, 2002–07 (Braem et al. 2011); 2010, 2011, 2012, 2013 (SRB&A 2012, 2013, 2014, 2015); 2014 (Brown et al. 2016); 2015-2020(SRB&A 2022)

Notes:

[1]Resources that contributed an average of less than 1 percent of harvest, less than 5 percent attempting harvests, and less than 5 percent receiving harvests are categorized as minor and are not be shown.

[2]Major resources contribute >9 percent total harvest, have ≥50 percent of households attempting harvest, or have ≥50 percent of households receiving resource.

[3]Moderate resources contribute 2 to 9 percent of total harvest, have 11 to 49 percent of households attempting harvest, or have 11 to 49 percent of households receiving resource.

[4]Minor resources contribute <2 percent of total harvest, have ≤10 percent of households attempting harvest, or have ≤10 percent of households receiving resource.

[5]Averages include unsuccessful bowhead whale harvest years.

M.3 ARCTIC VILLAGE

M.3.1 Harvest Data

Table M-12
Arctic Village Subsistence Harvest Estimates[1] by Resource Category, Non-Comprehensive Study Years

Study Year	Resource	Percent of Households					Estimated Harvest			
		Use	Try to Harvest	Harvest	Give	Receive	Number	Total Pounds	Average HH Pounds	Per Capita Pounds
2000	Migratory Birds	87	46	52	37	39	437	820	16	6
2001	Non-salmon fish	63	—	63	24	28	4,754	9,923	102	34
2002	Non-salmon fish	80	—	42	21	42	7,676	18,416	181	67

Sources: 2000 (Andersen and Jennings 2001); 2001–02, 2002–03 (Adams et al. 2005)
[1] The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

Table M-13
Arctic Village Subsistence Harvest Estimates[4] by Selected Species, All Study Years

Study Year	Resource[1]	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number[2]	Total Pounds[3]	Average HH Pounds	Per Capita Pounds	
2000	Scoter	—	—	—	—	—	187	370	7	3	—
	Scaup	—	—	—	—	—	71	118	2	1	—
	Long-tailed duck (oldsquaw)	—	—	—	—	—	67	100	2	1	—
	Mallard	—	—	—	—	—	49	95	2	1	—
	White-fronted geese	—	—	—	—	—	10	43	1	<1	—
2001	Broad whitefish	12	—	12	8	5	990	3,958	39	14	—
	Humpback whitefish	17	—	17	10	7	1,685	3,538	38	12	—
	Grayling	47	—	47	13	20	1,257	1,257	13	4	—
	Northern pike	18	—	18	7	5	187	562	6	2	—
	Lake trout	9	—	9	2	0	212	212	4	1	—
2002	Humpback whitefish	28	—	10	4	20	3,987	8,373	84	30	—
	Broad whitefish	40	—	16	10	26	1,673	6,691	65	24	—
	Northern pike	20	—	18	11	2	598	1,793	18	7	—
	Grayling	32	—	29	8	5	857	857	9	3	—
	Unknown whitefish	2	—	1	0	1	188	328	3	1	—

Sources: 2000 (Andersen and Jennings 2001); 2001–02, 2002–03 (Adams et al. 2005)
Notes: For single-resource study years, species are listed in descending order by total estimated pounds and limited to the five top species. Years lacking percent of total harvest data were not comprehensive study years for all resources.
Notes:
[1]This table shows individual species unless they are not available for a given study year.
[2]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.
[3]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.
[4] The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

M.3.2 Seasonal Round

Table M-14
Arctic Village Annual Cycle of Subsistence Activities

Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish			High	High	High	High	Low to medium	High		High	High	
Caribou	High	High	High					High	High	High	High	High
Moose	Low to medium	Low to medium	High						High	Low to medium	Low to medium	Low to medium
Sheep								Low to medium	High		High	Low to medium
Furbearers	High	High	High								High	High
Small land mammals	Low to medium	High	High	High	High			Low to medium	High	High	High	High
Waterfowl					High	Low to medium	Low to medium	Low to medium	Low to medium			
Vegetation (wood)	High	High	High	Low to medium	Low to medium	Low to medium	Low to medium	Low to medium	High	High	High	High
Total number of resource categories by month	**5**	**5**	**6**	**3**	**4**	**3**	**3**	**6**	**6**	**5**	**7**	**6**

Sources: 1970–82 (Caulfield 1983); 2000 (Andersen and Jennings 2001)

Low to medium levels of activity; High levels of activity

M.3.3 Resource Importance

Data to calculate resources of importance for Arctic Village are not available. This is because there have been no comprehensive household harvest surveys conducted for that community; however, based on existing literature and statements from community members during scoping and elsewhere, the assumption is that caribou is a resource of primary subsistence, economic, cultural, and spiritual importance for the community of Arctic Village.

M.4 VENETIE

M.4.1 Harvest Data

Table M-15
Venetie Subsistence Harvest Estimates[1] by Resource Category, All Resources Study Years

Study Year	Resource	Percent of Households					Estimated Harvest				Percent of Total Harvest
		Use	Try to Harvest	Harvest	Give	Receive	Number*	Total Pounds**	Average HH Pounds	Per Capita Pounds	
2009	All resources	99	86	81	—	—	13,344	74,602	794	274	100.0
	Salmon	76	37	26	—	—	2,742	20,775	221	76	27.8
	Non-salmon fish	81	67	63	—	—	6,348	6,745	72	25	9.0
	Large land mammals	94	63	33	—	—	159	36,977	393	136	49.6
	Small land mammals	56	44	43	—	—	1,632	3,126	33	12	4.2
	Marine mammals	18	0	0	—	—	0	0	0	0	0.0
	Migratory birds	79	57	55	—	—	2,134	5,501	59	20	7.4
	Upland game birds	20	31	16	—	—	119	119	1	0	0.2
	Vegetation	67	46	43	—	—	210	1,360	15	5	1.8

Source: 2009 (Kofinas et al. 2016)
[1] The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

Table M-16
Venetie Subsistence Harvest Estimates by Resource Category, Non-Comprehensive Study Years

Study Year	Resource	Percent of Households					Estimated Harvest			
		Use	Try to Harvest	Harvest	Give	Receive	Number	Total Pounds	Average HH Pounds	Per Capita Pounds
2000	Migratory birds	—	—	68	—	—	2,077	3,306	94	25

Source: 2000 (Andersen and Jennings 2001)

Table M-17
Venetie Subsistence Harvest Estimates[4] by Selected Species, All Study Years

Study Year	Resource[1]	Percent of Households: Use	Percent of Households: Try to Harvest	Percent of Households: Harvest	Percent of Households: Give	Percent of Households: Receive	Estimated Harvest: Number[2]	Estimated Harvest: Total Pounds[3]	Estimated Harvest: Average HH Pounds	Estimated Harvest: Per Capita Pounds	Percent of Total Harvest
2000	Unknown scoter	—	—	—	—	—	1,354	1,354	39	10	—
	White-fronted geese	—	—	—	—	—	150	638	18	5	—
	Canada geese	—	—	—	—	—	153	609	17	5	—
	Long-tailed duck (oldsquaw)	—	—	—	—	—	217	326	9	2	—
	Mallard	—	—	—	—	—	65	122	3	1	—
2008–09	Moose	95	51	32	68	92	22	12,060	—	80	—
	Caribou	98	18	18	65	92	16	2,135	—	14	—
	Black bear	14	11	6	3	6	5	532	—	4	—
	Brown bear	5	8	2	0	2	1	150	—	1	—
	Lynx	3	3	3	2	0	1	—	—	—	—
2009	Moose	93	61	30	60	87	40	21,476	229	79	28.8
	Caribou	86	23	14	49	85	105	14,230	151	52	19.1
	Chum salmon	42	27	20	12	30	2,066	12,395	132	46	16.6
	Chinook salmon	69	27	16	26	62	675	8,374	89	31	11.2
	Arctic grayling	80	66	62	44	49	5,492	4,943	53	18	6.6
	Geese	68	45	37	36	56	969	3,142	33	12	4.2
	Whitefishes	41	13	8	12	40	853	1,791	19	7	2.4
	Beaver	26	15	14	14	15	65	1,298	14	5	1.7
	Snowshoe hare	43	36	35	21	16	574	1,148	12	4	1.5
	Black bear	19	17	8	6	12	10	886	9	3	1.2
2009–10	Moose	53	41	13	36	50	24	16,548	—	86	—
	Caribou	39	13	5	25	39	6	556	—	3	—
	Black bear	8	5	5	2	5	4	417	—	2	—
	Brown bear	3	2	2	2	2	1	196	—	1	—
	Lynx	3	3	3	2	2	86	—	—	—	—
2010–11	Moose	—	35	9	11	14	5	2,916	—	16	—
	Caribou	—	30	15	16	10	44	6,615	—	37	—
	Lynx	—	0	0	0	9	0	—	—	—	—
	Marten	—	0	0	0	4	0	—	—	—	—

Sources: 2000 (ADFG 2018); 2008–09, 2009–10 (Van Lanen, Stevens, Brown, Maracle, and Koster 2012); 2009 (Kofinas et al. 2016); 2010–11 (Stevens and Maracle n.d.)

Notes:

[1]This table shows individual species unless they are not available for a given study year.

[2]Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[3]Estimated pounds include only edible pounds and therefore do not include estimates for resources, such as furbearers, that are not typically eaten by community residents.

[4]The table provides harvest estimates from each study year based on a sample of households. Harvest studies generally do not capture a census of all households; therefore, data may underestimate community harvests if the sample excludes one or more particularly active harvester households.

For all resources study years (2009), species are listed in descending order by percent of total harvest and are limited to species accounting for at least 1.0 percent of the total harvest; for single resource study years, species are listed in descending order by total estimated pounds and are limited to the five top species. Years lacking percent of total harvest data were not comprehensive study years for all resources.

M.4.2 Seasonal Round

Table M-18
Venetie Annual Cycle of Subsistence Activities

Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish			Low to medium	High	High	High	High	High	High	Low to medium		
Caribou	High	High	High	Low to medium				Low to medium	Low to medium		Low to medium	Low to medium
Moose	Low to medium	High	High					High	High	Low to medium	High	Low to medium
Bear				High	High	Low to medium	Low to medium	Low to medium	High			
Furbearers	High	High	High								High	High
Small land mammals				Low to medium	High	Low to medium						
Waterfowl				High	High	High	Low to medium	High	High			
Berries							High	High	High			
Wood	High	High	High	High	Low to medium	Low to medium	Low to medium	Low to medium	High	High	High	High
Total number of resource categories by month	**4**	**4**	**5**	**6**	**5**	**5**	**5**	**7**	**7**	**2**	**4**	**4**

Sources: 2000 (Andersen and Jennings 2001); 1970–82 (Caulfield 1983); Kofinas et al. 2016; 2008–09, 2009–10 (Van Lanen et al. 2012); 2010–11 (Stevens and Maracle n.d.)

Low to medium levels of activity; High levels of activity

M.4.3 Resource Importance

Table M-19
Material and Cultural Importance of Subsistence Resources, Venetie

Resource Level	Resource	Cultural Importance		Material Importance
		Percent of Households		Percent of Total Harvest
		Trying to Harvest	Receive	
Major resources	Arctic grayling	66	49	6.6
	Caribou	21	56	19.1
	Chinook salmon	27	62	11.2
	Chum salmon	27	30	16.6
	Geese	45	56	4.2
	Moose	47	61	28.8
Moderate resources	Bearded seal	0	15	—
	Beaver	15	15	1.7
	Black bear	11	8	1.2
	Blueberry	41	49	0.9
	Bowhead	0	15	—
	Low bush cranberry	35	30	0.8
	Muskrat	11	10	0.5
	Other birds	31	8	0.2
	Parka squirrel (ground)	10	12	0.2
	Ptarmigan	27	8	0.1
	Snowshoe hare	18	8	1.5
	Whitefishes	13	40	2.4
Minor resources	Beluga	0	6	—
	Brown bear	6	1	0.5
	Grouse	7	2	—

Sources: 2000 (ADFG 2018); 2008–09, 2009–10 (Van Lanen et al. 2012); 2009 (Kofinas et al. 2016); 2010–11 (Stevens and Maracle n.d.)

[1]Resources that contributed an average of less than 1 percent of harvest, less than 5 percent attempting harvests, and less than 5 percent receiving harvests are categorized as minor and are not be shown.

[2]Major resources contribute >9 percent total harvest, have ≥50 percent of households attempting harvest, or have ≥50 percent of households receiving resource.

[3]Moderate resources contribute 2 to 9 percent of total harvest, have 11 to 49 percent of households attempting harvest, or have 11 to 49 percent of households receiving resource.

[4]Minor resources contribute <2 percent of total harvest, have ≤10 percent of households attempting harvest, or have ≤10 percent of households receiving resource.

M.5 CARIBOU STUDY COMMUNITIES

Table M-20
Caribou Harvest Data for All Available Study Years, Caribou Study Communities

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Alatna	1981-82[1]	—	—	6	—	6	6	724	19	5	0.5
	1982-83[1]	—	—	0	—	—	0	0	0	0	—
	1983-84[1]	—	—	4	—	—	4	471	8	3	0.4
	1997–98	73	46	36	36	46	21	2,730	248	109	—
	1998–99	100	90	60	50	60	11	1,430	143	53	—
	1999–00	100	57	0	0	100	0	—	0	0	—
	2001–02	27	0	0	0	27	0	—	0	0	—
	2002–03	100	67	67	50	83	34	4,420	368	123	—
	2011	100	83	67	67	100	28	3,705	412	118	39.3
	Average	***83***	***57***	***38***	***34***	***69***	***16***	***2,048***	***195***	***67***	***39.3***
Allakaket	1981-82[1]	—	—	6	—	6	6	724	19	5	0.5
	1982-83[1]	—	—	0	—	—	0	0	0	0	—
	1983-84[1]	—	—	4	—	—	4	471	8	3	0.4
	1997–98	42	15	6	10	39	11	1,375	25	8	—
	1998–99	100	55	26	20	86	43	5,623	92	29	—
	1999–00	93	34	12	15	86	13	1,719	29	10	—
	2001–02	21	7	7	3	15	9	1,170	19	7	—
	2002–03	96	68	44	32	68	106	13,728	312	53	—
	2011	76	48	33	48	62	95	12,350	217	84	—
	Average	***72***	***38***	***21***	***21***	***59***	***46***	***5,994***	***116***	***32***	***—***
Anaktuvuk Pass	1990–91	—	—	55	—	—	592	69,964	985	223	—
	1991–92	—	—	51	—	—	545	66,712	940	245	—
	1992	—	74	—	—	—	600	70,222	889	260	82.6
	1993–94	—	—	43	—	—	574	67,713	846	219	—
	1994–95	—	—	—	—	—	322	43,792	—	—	83.2
	1996–97	—	—	—	—	—	210	28,587	—	—	90.0
	1998–99	—	—	—	—	—	500	68,000	—	—	89.5
	1999–00	—	—	—	—	—	329	44,744	—	—	75.2
	2006–07	92	61	53	47	63	696	81,490	1,000	299	—
	2011	95	63	53	52	73	616	77,706	914	251	79.2
	2002–03	—	—	—	—	—	436	59,310	—	—	91.5

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Anaktuvuk Pass *(continued)*	2001–02	—	—	—	—	—	271	36,910	—	—	75.6
	2000–01	—	—	—	—	—	732	99,579	—	—	89.1
	2014	89	45	40	47	68	770	104,664	1057	330	84.2
	2015	—	—	—	—	—	1,165	136,305	—	—	—
	2016	—	—	—	—	—	859	100,503	936	—	—
	2017	—	—	—	—	—	548	64,116	1,135	—	—
	2019	—	—	—	—	—	918	107,406	—	—	—
	Average	***92***	***61***	***49***	***49***	***68***	***594***	***73,762***	***967***	***261***	***84.0***
Arctic Village	***No Comparable Caribou Harvest Data***										
Atqasuk	1994	—	—	—	—	—	266	36,176	613	152	65.3
	1996	—	—	—	—	—	398	54,182	860	241	65.0
	1997	—	—	—	—	—	282	38,352	685	167	61.7
	2003	93	66	61	66	66	189	—	—	—	—
	2004	100	79	79	69	74	314	—	—	—	—
	2005	96	70	59	74	63	203	—	—	—	—
	2006	95	67	60	76	57	170	—	—	—	—
	2014	—	—	—	—	—	173	20,241	316	—	—
	2015	—	—	—	—	—	186	21,762	—	—	—
	2016	—	—	—	—	—	269	31,473	480	—	—
	2017	—	—	—	—	—	145	16,965	257	—	—
	2018	—	—	—	—	—	380	44,460	679	—	—
	2019	—	—	—	—	—	179	20,943	—	—	—
	Average	***96***	***70***	***65***	***71***	***65***	***247***	—	**—**	**—**	**—**
Beaver	1985	—	3	0	0	0	0	—	0	0	0.0
	2010–11	—	—	—	—	—	5	650	—	—	—
	2011	0	0	0	0	0	0	—	0	0	0
	Average	***0***	***0***	***0***	***0***	***0***	***0***	—	***0***	***0***	***0***
Bettles	1981–82	—	—	15	—	5	14	1,788	72	28	10.6
	1983	—	—	10	—	—	5	644	25	8	4.4
	1984	—	—	6	—	—	3	451	12	5	4.4
	1997–98	14	29	0	14	14	0	—	0	0	—
	1998–99	60	40	40	60	20	25	3,276	364	107	—
	1999–00	67	44	44	33	33	21	2,773	173	52	—
	2002–03	58	8	0	12	58	0	—	0	0	—
	2011	63	25	25	25	50	6	780	98	65	37.1
	Average	***52***	***29***	***18***	***29***	***30***	***9***	***1,214***	***93***	***33***	***14.1***

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Birch Creek	2008–09	25	0	0	25	25	0	—	0	0	—
	2009–10	40	7	0	33	40	0	—	0	0	—
	2010–11	—	0	0	0	8	0	—	0	0	—
	2018	17	0	0	0	17	0	—	0	0	0.0
	Average	***27***	***2***	***0***	***15***	***23***	***0***	***—***	***0***	***0***	***0.0***
Chalkyitsik	2008–09	0	0	0	0	0	0	—	0	0	0
	2009–10	0	0	0	0	0	0	—	0	0	0
	2010–11	0	0	0	0	0	0	—	0	0	0
	Average	***0***	***0***	***0***	***0***	***0***	***0***	—	***0***	***0***	***0***
Circle	2008–09	85	23	3	5	83	1	130	—	1.3	—
	2009–10	7	7	7	0	7	4	400	—	5.9	—
	2010–11	—	0	0	0	0	0	—	—	0	—
	2017	70	15	10	25	60	5	624	20	8	2.0
	Average	***54***	***11***	***5***	***7.5***	***38***	***2***	***289***	***20***	***4***	***2.0***
Coldfoot	***2011***	***75***	***50***	***25***	***50***	***50***	***2***	***325***	***65***	***33***	***85.3***
Eagle	2017 (Eagle)	55	45	31	26	22	40	5,178	74	32	4.7
	2017 (Eagle Village)	69	62	0	69	31	0	0	0	0	0.0
	2004	61	61	14	15	52	19	1,957	28.8	15.2	15.7
	Average	***62***	***56***	***15***	***37***	***35***	***20***	***2,378***	***34***	***16***	***6.8%***
Evansville	1981–82	—	—	15	—	5	14	1,788	72	28	10.6
	1983	—	—	10	—	—	5	644	25	8	4.4
	1984	—	—	6	—	—	3	451	12	5	4.4
	1997	50	14	7	21	50	3	334	19	8	—
	1998	67	25	17	8	58	4	455	33	16	—
	1999	67	25	17	17	50	2	282	22	10	—
	2002–03	58	8	0	12	58	0	—	0	0	—
	2011	77			25	77	—	—	—	—	0.0
	Average	***64***	***18***	***10***	***17***	***50***	***4***	***565***	***26***	***11***	***4.9***
Fort Yukon	1986–87	73	13	9	10	64	156	15,587	74	25	2.5
	2008–09	12	2	1	13	3	3	355	—	1	—
	2009–10	20	10	9	8	18	35	3,518	—	8	—
	2017	44	5	5	17	42	31	4,170	21	9	1.8
	Average	***37***	***8***	***6***	***12***	***32***	***56***	***5,907***	***47***	***11***	***2.2***

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Kaktovik	1981–82	—	—	—	—	—	43	—	—	—	—
	1982–83	—	—	—	—	—	160	—	—	—	—
	1983–84	—	—	—	—	—	107	—	—	—	—
	1985–86	—	—	—	—	—	235	—	—	—	—
	1985	95	76	69	67	86	235	27,941	527	149	45.3
	1986	98	66	60	53	94	178	21,188	378	109	25.2
	1986–87	—	—	—	—	—	201	—	—	—	—
	1987–88	—	—	55	—	—	185	22,229	383	104	—
	1990	—	—	48	—	—	113	13,453	224	67	—
	1991	—	—	50	—	—	181	22,113	369	94	—
	1992a	96	70	55	53	75	158	19,136	304	99	11.2
	1992b	—	66	—	—	—	136	15,926	—	—	8.8
	1994–95	—	—	—	—	—	78	10,608	—	—	8.4
	2002–03	—	—	—	—	—	112	15,232	—	—	14.5
	2007	—	—	—	—	—	181	21,168	258	—	27.1
	2008	—	—	—	—	—	185	21,586	263	—	21.3
	2009	—	—	—	—	—	170	19,872	231	—	15.7
	2010	—	—	—	—	—	115	13,458	168	—	17.0
	2010–11	94	53	46	51	93	429	58,305	686	203	28.7
	2011	—	—	—	—	—	170	19,909	249	—	20.1
	2012	—	—	—	—	—	155	18,145	227	—	—
	2014	—	52	—	—	—	248	29,016	363	—	—
	2015	—	—	—	—	—	303	35,451	445	—	—
	2016	—	—	—	—	—	133	15,561	199	—	—
	2017	—	—	—	—	—	119	13,923	176	—	—
	2018	—	—	—	—	—	108	12,636	164	—	—
	2019	—	—	—	—	—	125	14,625	—	—	—
	Average	***96***	***66***	***55***	***56***	***87***	***170***	***22,613***	***410***	***118***	***20.3***

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Nuiqsut	1985	98	90	90	80	60	513	60,021	790	150	37.5
	1992	—	81	—	—	—	278	32,551	—	—	21.7
	1993	98	74	74	79	79	672	82,169	903	228	30.7
	1994–95	—	—	—	—	—	258	30,186	—	—	36.3
	1995–96	—	—	—	—	—	362	42,354	—	—	23.1
	1999–00	—	—	—	—	—	413	—	—	112	—
	2000–01	—	—	—	—	—	496	57,985	—	—	31.6
	2002–03	95	79	63	62	75	586	68,534	692	166	—
	2003–04	99	68	62	65	79	501	58,617	598	147	—
	2004–05	92	70	56	49	58	437	51,129	544	134	—
	2005–06	94	86	76	—	—	562	65,754	707	—	—
	2006–07	97	77	74	66	69	475	—	—	143	—
	2010	100	60	59	97	96	363	—	—	102	—
	2011	99	62	61	81	96	546	—	—	147	—
	2012	97	74	70	81	81	564	—	—	157	—
	2013	95	47	45	49	80	397	—	—	118	—
	2014	90	66	64	67	59	774	105,193	974	253	28.3
	2015	96	84	78	74	72	628	73,527	728	180	—
	2016	96	76	67	79	81	481	56,277	592	132	—
	2017	96	72	60	74	85	635	74,338	715	164	—
	2018	99	84	74	88	88	608	71,113	658	157	—
	2019	100	98	91	87	78	636	74,439	658	153	—
	2020	98	88	79	82	76	629	73,639	657	160	—
	Average	***96***	***73***	***67***	***71***	***75***	***490***	***60,668***	***742***	***157***	***29.9***
Point Lay	1987	94	72	72	63	73	157	18,418	428	153	17.2
	1994	—	—	—	—	—	223	30,260	522	171	31.3
	2002	—	—	—	—	—	154	20,944	322	85	22.1
	2012	93	64	60	71	76	356	48,380	705	186	31.3
	2014	—	—	—	—	—	951	111,267	1,486	—	—
	2015	—	63	—	—	—	224	28,548	1,182	—	—
	2016	—	—	—	—	—	215	25,155	339	—	—
	2017	—	—	—	—	—	290	33,930	456	—	—
	2018	—	—	—	—	—	191	22,347	293	—	—
	2019	—	—	—	—	—	223	26,091	—	—	—
	Average	***94***	***66***	***66***	***67***	***75***	***326***	***39,267***	***698***	***169***	***24.2***

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Stevens Village	2009–10	5	0	0	5	5	0	—	—	0	—
	2008–09	—	0	0	0	10	0	—	—	0	—
	2014	0	0	0	0	0	0	0	0	0	0.0
	Average	***3***	***0***	***0***	***2***	***5***	***0***	***0***	***0***	***0***	***0.0***
Utqiaġvik	1987	—	—	26	—	—	1,595	186,669	199	62	30.1
	1988	—	—	27	—	—	1,533	179,314	191	59	29.2
	1989	—	—	39	—	—	1,656	193,744	207	64	22.2
	1992	—	46	—	—	—	1,993	233,206	—	—	17.1
	1995–96	—	—	—	—	—	2,155	293,094	—	—	24.5
	1996–97	—	—	—	—	—	1,158	157,420	—	—	13.3
	2000	—	—	—	—	—	3,359	456,851	—	—	29.3
	2001	—	—	—	—	—	1,820	247,520	—	—	22.9
	2003	—	—	—	—	—	2,092	284,444	—	—	22.8
	2014	70	38	33	38	52	4,323	587,897	371	111	30.6
	2015	—	—	—	—	—	3,000	351,000	293	—	—
	2016	—	—	—	—	—	3,246	379,782	316	—	—
	2017	—	—	—	—	—	2,636	308,412	257	—	—
	2018	—	—	—	—	—	3,829	447,993	374	—	—
	2019	—	—	—	—	—	3,273	382,941	—	—	—
	Average	***86***	***51***	***42***	***67***	***68***	***3,055***	***371,650***	***276***	***90***	***24.2***
Venetie	2008–09	98	18	18	65	92	16	2,135	—	14	—
	2009	86	23	14	49	85	105	14,230	151	52	19.1
	2009–10	39	13	5	25	39	6	556	—	3	—
	2010–11	—	30	15	16	10	44	6,615	—	37	—
	Average	***74***	***21***	***13***	***39***	***56***	***43***	***5,884***	***151***	***26***	***19.1***
Wainwright	1988	—	—	57	—	—	505	59,085	476.49	117	23.0
	1989	—	—	66	—	—	711	83,187	699.05	177.75	23.7
	1992	—	68	—	—	—	947	110,851	—	—	34.3
	2002	—	—	—	—	—	866	117,749	806	221	19.1
	2009	97	64	61	62	84	1,231	167,356	1,073	284	41.7
	2014	—	—	—	—	—	951	111,267	725	—	—
	2015	—	70	—	—	—	756	88,452	573	—	—
	2016	—	—	—	—	—	914	106938	690	—	—
	2017	—	—	—	—	—	806	94,302	608	—	—
	2018	—	—	—	—	—	1012	118,404	772	—	—
	2019	—	—	—	—	—	804	94,068	—	—	—
	Average	***97***	***64***	***61***	***62***	***84***	***816***	***103,209***	***749***	***193***	***29.5***

Community	Study Year	Percent of Households (HH)					Estimated Harvest				Percent of Total Harvest
		Using	Trying to Harvest	Harvesting	Giving	Receiving	Total Number	Total Pounds	Average HH Lbs	Per Capita Lbs	
Wiseman	1991	—	—	—	—	—	10	1,260	—	—	28.2
	2011	80	80	60	60	20	4	520	104	40	13.6
	Average	***80***	***80***	***60***	***60***	***20***	***7***	***890***	***104***	***40***	***20.9***

Source: (ADF&G 2023, SRB&A 2022, NSB 2020, Person et al. 2019, Bacon, Hepa, Brower, Pederson, Olemaun, George, and Corrigan 2011, Van Lanen, Stevens, Brown, Maracle, and Koster 2012, Fuller and George 1999, McGee, McIntosh, and Strong 1984, Marcotte and Haynes 1985, Strong and McIntosh 1985, Brown, Walker, and Vanek 2004, Harcharek, Kayotuk, George, and Pederson 2018, Pedersen 1990, Kofinas, BurnSilver, Magdanz, Stotts, and Okada 2016, Stevens and Maracle n.d.)
1 Data are for Alatna and Allakaket combined
2 Data are for Bettles and Evansville combined

Table M-21
Total Annual Harvest Summary of Porcupine Caribou, Available Study Years

Canadian User Group	Estimated Harvest							
	Inuvialuit (NWT)[1]	NWT Gwich'in[2]	Vuntut Gwichin[3]	Tr'ondek Hwech'in[4]	Nacho Nayak Dun[5]	Yukon licensed[6]	NWT licensed[7]	Total (all user groups)
1985/86	—	—	347	—	—	414	—	—
1986/87	—	—	638	—	—	33	—	—
1987/88	—	—	829	—	—	152	—	—
1988/89	—	—	1,164	—	—	148	—	—
1989/90	—	—	532	—	—	92	—	—
1990-91	—	—	421	—	—	194	—	—
1991-92	—	—	593	—	—	185	—	—
1992-93	—	—	522	—	—	35	—	—
1993-94	—	—	236	—	—	215	—	—
1994-95	—	—	453	—	—	270	—	—
1995-96	—	1,906	—	—	—	—	—	—
1996-97	—	1,638	—	—	—	—	—	—
1997-98	—	2,206	—	—	—	—	—	—
1998-99	—	1,093	—	—	—	—	—	—
1999-00	—	452	—	—	—	—	—	—
2000-01	—	2,054	—	—	—	—	—	—
2010–11	121	1,197	265	1	0	38	98	1,720
2011–12	294	939	511	3	0	13	90	1,850
2012–13	176	615	403	1	0	8	80	1,283
2013–14	368	1,936	473	2	3	81	57	2,920
2014–15	123	451	114	0	0	3	58	749
2015–16	345	2,558	148	12	5	232	67	3,367
2016-17[8]	—	—	—	—	—	—	—	1,083
2017-18	314	302	193	0	0	2	34	845
2018-19	—	—	—	—	—	—	—	—
2019-20	—	2,579	222	3	6	239	—	—
2020-21	—	1,743	413	—	—	143	—	—
2021-22	35	43	188	0	0	10	21	297
Average Across Available Study Years	222	1,357	433	2	2	125	63	1,568

Sources: Porcupine Caribou Management Board 2023, GRRB 2009
Note: The data provided above is a summary of data collected by each user group and submitted to the Porcupine Caribou Management Board annually. The methods of data collection and reporting vary by user group and reflect a combination of reported and estimated harvests.
[1]Including Inuvialuit in and around Aklavik, Inuvik, and Tuktoyaktuk. Estimated harvest.
[2]Including Gwich'in in and around Aklavik, Inuvik, Fort McPherson, and Tsiigehtchic. Minimum count harvest. NWT Gwich'in Data for the 1995-96, 1996-97, and 1997-98 time periods are for the calendar year 1995, 1996, and 1997
[3]Including First Nation Members in and around Old Crow. Minimum count harvest.
[4]Including First Nation Members in and around Dawson City. Minimum count harvest.
[5]Including First Nation Members in and around Mayo. Minimum count harvest.
[6]Including licensed hunters in the Yukon Territory. Mandatory kill reporting, total count.
[7]Including licensed hunters in the Northwest Territory. Maximum number of caribou harvested based on license sales.
[8] Data for the 2016-17 study year are based on incomplete data and are considered to be low compared to what was actually harvested by all Parties in Canada.

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Appendix N
Environmental Justice

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Appendix N. Environmental Justice

Table N-1

Minority and Low-Income Populations and Tribal Entities in the Study Area Communities

Region	Total Population	White (Percent)[1]	American Indian or Alaska Native (Percent)[2]	Asian (Percent)[2]	Black or African American (Percent)[2]	Pacific Islander (Percent)[2]	Other (Percent)	Two or More Races (Percent)	Hispanic or Latino (Percent)[3]	Minority[4] (Percent)	Minority Population Exceeds 50%	Minority Population Meaningfully Greater[5]	Median Household Income (Dollars)	Individuals Below Poverty Level (Percent)	Poverty Rate Meaningfully Greater[5]	Associated with Alaska Native Tribe
Alaska	733,391	59.4	15.2	6.0	3.0	1.7	2.5	12.2	6.8	40.6	–	–	80,287	10.4	–	–
North Slope Borough	11,031	27.9	52.1	5.8	1.5	2.9	1.1	8.7	5.0	72.1	Yes	Yes	83,992	8.6	No	–
Anaktuvuk Pass	425	16.7	74.1	0.0	0.0	0.0	0.0	9.2	1.6	83.3	Yes	Yes	62,788	35.5	Yes	Yes
Atqasuk	276	7.6	87.0	0.0	0.4	0.0	0.0	5.1	0.4	92.4	Yes	Yes	91,875	23.8	Yes	Yes
Kaktovik	283	4.2	95.1	0.0	0.0	0.0	0.0	0.7	0.0	95.8	Yes	Yes	78,250	17.4	Yes	Yes
Nuiqsut	512	6.8	92.6	0.0	0.2	0.0	0.0	0.4	0.0	93.2	Yes	Yes	68,393	6.7	No	Yes
Point Lay	330	5.8	92.1	0.0	0.0	0.0	0.0	2.1	0.3	94.2	Yes	Yes	78,750	20.1	Yes	Yes
Utqiagvik	4,927	14.1	53.8	12.1	1.5	5.8	0.6	12.0	3.5	85.9	Yes	Yes	93,661	8.2	No	Yes
Wainwright	628	3.3	95.5	0.0	0.6	0.0	0.0	0.5	0.5	96.7	Yes	Yes	84,000	8.4	No	Yes
Southeast Fairbanks Census Area	6,808	74.7	12.0	1.3	1.1	0.2	2.0	8.7	5.5	25.3	No	No	68,634	11.4	Yes	–
Eagle	83	97.6	0.0	0.0	0.0	0.0	0.0	2.4	1.2	2.4	No	No	48,750	6.5	No	Yes
Yukon-Koyukuk Census Area	5,343	21.1	71.7	0.1	0.1	0.1	0.5	6.3	1.3	78.9	Yes	Yes	43,405	23.2	Yes	–
Alatna	15	6.7	93.3	0.0	0.0	0.0	0.0	0.0	0.0	93.3	Yes	Yes	46,250	12.2	Yes	Yes
Allakaket	177	11.3	84.2	0.6	0.0	0.0	0.0	4.0	0.0	88.7	Yes	Yes	22,000	59.2	Yes	Yes
Arctic Village	151	4.0	92.7	0.0	0.0	0.0	0.0	3.3	0.0	96.0	Yes	Yes	37,708	45.8	Yes	Yes
Beaver	48	2.1	95.8	0.0	0.0	0.0	0.0	2.1	2.1	97.9	Yes	Yes	33,036	24.4	Yes	Yes
Bettles	23	73.9	17.4	0.0	0.0	0.0	0.0	8.7	4.3	26.1	No	No	N/A	0	No	No
Birch Creek	35	8.6	88.6	0.0	0.0	0.0	0.0	2.9	0.0	91.4	Yes	Yes	N/A	100	Yes	Yes
Chalkyitsik	56	1.8	92.9	0.0	0.0	0.0	0.0	5.4	1.8	98.2	Yes	Yes	28,333	52.7	Yes	Yes
Circle	91	7.7	92.3	0.0	0.0	0.0	0.0	0.0	0.0	92.3	Yes	Yes	26,875	13.8	Yes	Yes
Coldfoot	34	64.7	8.8	0.0	0.0	0.0	5.9	20.6	11.8	35.3	No	No	N/A	0	No	No
Evansville	12	50.0	41.7	0.0	0.0	0.0	8.3	0.0	8.3	50.0	Yes	Yes	82,083	0	No	Yes
Fort Yukon	428	8.6	83.9	0.0	0.0	0.0	0.0	7.5	0.7	91.4	Yes	Yes	36,250	12.1	Yes	Yes
Stevens Village	37	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	Yes	Yes	N/A	22.2	Yes	Yes
Venetie	205	5.9	93.2	0.0	0.0	0.0	0.0	1.0	0.5	94.1	Yes	Yes	45,625	31.2	Yes	Yes
Wiseman	5	80.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	No	No	N/A	0	No	No

Source: U.S. Census Bureau 2022a; 2022b; 2022c

– = Not applicable

N/A = Data not available

[1]Alone, non-Hispanic or Latino

[2]Alone or in combination with one or more other races

[3]Hispanic or Latino; can be of any race
[4]100 percent, minus White, non-Hispanic, or Latino
[5]Consistent with BLM (2022) guidelines, the meaningfully greater threshold is defined as follows: if the minority and/or low-income population percentage in a given community is equal to or greater than 110 percent of the minority and/or low-income population percentage in a geographic reference area. For the purposes of this analysis, Alaska is the reference area.

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Appendix O

Economy

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Appendix O. Economy

Table O-1
Populations of the Potentially Affected Communities and Areas, 2013 to 2022

Area	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	% Change
Communities											
Anaktuvuk Pass	381	352	395	384	408	433	401	425	411	412	8%
Atqasuk	268	255	277	247	267	284	286	276	290	283	5%
Utqiaġvik	4,587	4,580	4,672	4,425	4,652	4,672	4,754	4,927	4,889	4,707	3%
Kaktovik	282	277	274	267	274	283	279	283	267	265	-6%
Nuiqsut	468	468	476	483	523	544	535	512	526	492	5%
Point Hope	729	712	755	731	782	812	803	830	881	841	13%
Point Lay	236	215	248	246	288	292	310	330	330	309	24%
Wainwright	572	595	605	593	644	643	658	628	640	623	8%
Venetie	214	208	217	225	219	215	207	205	185	194	-10%
Arctic Village	161	173	157	153	158	156	151	151	140	137	-18%
North Slope Borough	10,135	10,071	10,322	10,316	10,466	10,595	10,668	11,031	11,033	10,746	6%

Source: Alaska Department of Labor and Workforce Development (ADOLWD) 2022

Table O-2
Employment and Total Wages in Potentially Affected Communities and Areas

Area	Residents Employed		Employment Sector			Total Wages
	#	%	Private	Local	State	$ Millions
Kaktovik	125	71	41	84	0	4.96
Anaktuvuk Pass	150	68	35	115	0	4.08
Atqasuk	112	76	19	93	0	3.54
Nuiqsut	193	75	73	120	0	5.92
Point Hope	301	67	117	183	1	8.02
Point Lay	106	77	15	91	0	3.48
Wainwright	219	63	72	147	0	6.66
Utqiaġvik	2,044	71	875	1,155	14	111.01
Arctic Village	87	78	14	70	3	1.30
Venetie	103	57	23	80	0	1.64
North Slope Borough	3,261	71	1,258	1,988	15	148.49
Alaska	304,556	60	236,086	44,613	23,857	13,094.18

Source: ADOLWD 2018

Table O-3
Kaktovik Resident Employment by Industry and Worker Characteristics, 2016

Industry	Number of Workers	Percent of Total Employed	Female	Male	Age 45 and Over	Age 50 and Over
Natural Resources and Mining	1	0.8	0	1	0	0
Construction	15	12.0	0	15	5	4
Trade, Transportation and Utilities	3	2.4	0	3	1	1
Financial Activities	13	10.4	5	8	7	5
Professional and Business Services	3	2.4	1	2	3	1
Leisure and Hospitality	4	3.2	4	0	2	2
Local Government	84	67.2	47	37	34	26
Other	2	1.6	0	2	0	0

Source: ADOLWD 2018

Table O-4
City of Kaktovik Fiscal Year 2021 Sources and Uses of Funds

Source of Revenues	Amount
Locally Generated Revenues	**$1,393,325**
Tax Revenues	$54,278
Service Charges	$24,182
Enterprise Revenues	$901,733
Rentals	$60,270
Leases	$129,508
Sales	$33,321
Other Local Revenues	$190,034
State of Alaska Revenues	**$75,079**
Other Outside Revenues	**$895,992**
Total Operating Revenues	**$2,364,396**

Uses of Funds (Expenditures)	Amount
Administration and Finance	$204,480
Council	$12,018
Pull Tabs	$685,115
Bingo	$289,692
Recreation	$48,835
ASRC Summer Youth Program	$4,815
Others	$754,661
Total Operating Expenditures	**$1,999,617**

Source: Alaska Department of Commerce, Community, and Economic Development (ADCCED 2023)

Table O-5
North Slope Borough Employment and Total Wages by Sector, by Place of Work 2021

Sector	Number of Jobs	Total Wages ($)
Federal Government	16	1,063,255
State Government	64	5,181,116
Local Government	1,957	124,442,454
Mining	4,404	684,985,994
Retail Trade	287	11,019,977
Transportation and Warehousing	210	22,260,466
Educational and Health Services	489	49,073,467
Leisure and Hospitality	457	20,643,189
All Other Private	1,981	279,036,236
Total	**9,865**	**1,197,706,154**

Source: ADOLWD 2022. Quarterly Census of Employment and Wages (QCEW): Annual Employment and Wages, 2021.

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Appendix P

Essential Fish Habitat

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations	Full Phrase
Anadromous Waters Catalog	Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes
Arctic Fishery Management Plan	Fishery Management Plan for Fish Resources of the Arctic Management Area
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
ROP	Required Operating Procedure
Salmon Fishery Management Plan	Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska
SEIS	Supplemental Environmental Impact Statement
USFWS	US Fish and Wildlife Service

Appendix P. Essential Fish Habitat

P.1 Regulatory Background

The 1996 Sustainable Fisheries Act (Public Law 104-297) enacted additional management measures to protect commercially harvested fish species from overfishing. Along with reauthorizing the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, Public Law 94-265), one of the added management measures of the Sustainable Fisheries Act is to describe, identify, and minimize adverse effects to essential fish habitat (EFH). Definitions and rules involving EFH are presented in 50 Code of Federal Regulations (CFR) Part 600. For this supplemental environmental impact statement (SEIS), the applicable definitions and rules regarding EFH from the Magnuson-Stevens Act are as follows:

Essential fish habitat definition: "…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: 'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle" (50 CFR 600.10).

Adverse effect definition: "…any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.810).

Federal action requirement: "For any Federal action that may adversely affect EFH, Federal agencies must provide National Marine Fisheries Service with a written assessment of the effects of that action on EFH... Federal agencies may incorporate an EFH Assessment into documents prepared for other purposes such as… the National Environmental Policy Act" (50 CFR 600.920).

After an interim rule was issued in 1997, the National Marine Fisheries Service (NMFS) issued a final rule (67 FR 2343) in 2002 to implement the essential fish habitat provisions of the Magnuson-Stevens Act. This included the clarification that Regional Fishery Management Councils would describe and identify EFH in fishery management plans. In Alaska, fishery management plans are developed by the North Pacific Fishery Management Council (NPFMC) and are approved by the Secretary of Commerce. NMFS is responsible for implementing the EFH requirements of the Magnuson-Stevens Act.

P.2 Essential Fish Habitat in the Coastal Plain Program Area

The most current EFH descriptions and designations for salmon in Alaska, including the Arctic, are detailed in the *Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska* (Salmon Fishery Management Plan; NPFMC 2021). The Salmon Fishery Management Plan includes designations for (1) EFH in marine waters of the U.S. Exclusive Economic Zone (EEZ) in Alaska, which includes the

Chukchi and Beaufort seas and extends 200 nautical miles offshore; and (2) EFH for salmon in freshwater habitats that are identified in the *Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (Anadromous Waters Catalog; Giefer and Graziano 2023). EFH for the remaining species that use marine waters in the Arctic is described and designated in the *Fishery Management Plan for Fish Resources of the Arctic Management Area* (Arctic Fishery Management Plan; NPFMC 2009). The EFH descriptions for marine species in the Arctic have been updated by Amendment 2 to the Arctic Fishery Management Plan, as described in the *Essential Fish Habitat 5-year Review Summary Report, 2010 through 2015* (Simpson et al. 2017). Maps and data describing the EFH distribution for some species in the Arctic have also been updated on the Alaska EFH Mapper maintained by the NMFS (2023).

The five species for which EFH is currently designated in freshwater, estuarine, and/or marine waters in or near the Coastal Plain are pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), arctic cod (*Boregogadus saida*), saffron cod (*Eleginus gracilis*), and snow crab (*Chionoecetes opilio*).

P.2.1 Pacific Salmon

A new methodology was initiated in 2012 by the NMFS Alaska Fisheries Science Center to refine the EFH distribution of Pacific salmon in marine waters off Alaska. Previously, the marine EFH distribution of all five Pacific salmon species was designated broadly by the NPFMC (2006) as encompassing all waters in the U.S. EEZ, which extends 200 nautical miles offshore. Using catch, maturity, salinity, temperature, and station depth data from the Bering Sea and the Gulf of Alaska, Echave et al. (2012) modeled the distributions of all five Pacific salmon species in marine waters off Alaska and mapped the 95 percent spatial distributions for each species. This information was used along with additional habitat preference analyses of available biophysical data and catch information to substantially refine the EFH distributions for all life history stages of all Pacific salmon species in marine waters off Alaska.

On average, the spatial extent of EFH in marine waters of the EEZ off Alaska was reduced by 71 percent across all species and life-history stages. Distribution modeling data are not available for the Beaufort Sea (where no commercial fishing occurs), and for areas "Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described." (p. A-40 in NPFMC 2018). For areas adjacent to the Coastal Plain, the result is that EFH is no longer designated for any life history stages of any Pacific salmon species in the marine and estuarine waters of the Beaufort Sea (Simpson et al. 2017; NPFMC 2018; NMFS 2023).

However, it is well known that several Pacific salmon species occur in freshwater streams in Arctic Alaska. As early as 1881, pink salmon were recorded in the Colville River (Bean 1883), and it is likely that at least pink and chum salmon have established small, but sustainable spawning populations in a number of streams on the North Slope of Alaska (Craig and Haldorson 1986). There is strong evidence that a population of chum salmon spawns in the Mackenzie River watershed (Irvine et al. 2009), which drains into the Beaufort Sea east of the Arctic Refuge in the Northwest Territories, Canada. For Alaska, the salmon occurrence data in the Anadromous Waters Catalog (Johnson and Blossom 2017) were used by the NPFMC to determine the extent of freshwater EFH for Pacific salmon species in Arctic Alaska, including the freshwater streams on the Coastal Plain (NPFMC 2018).

The two salmon species that have been recorded in Coastal Plain streams have anadromous life histories that are described in general terms in **Table P-1**. More detailed life-history information can be found in Mecklenburg et al. (2002) and Quinn (2005).

Table P-1
Life History Characteristics for Pink and Chum Salmon

Species	Spawning Habitat	Migration to Sea from Spawning Habitat	Time at Sea Before Maturity
Pink salmon	Freshwater or intertidal zone	Immediately	18 months
Chum salmon	Freshwater	Immediately	2 to 5 years

In general, Pacific salmon have a difficult time establishing sustainable spawning populations in the Arctic because of marginal freshwater conditions, including low water temperatures (Craig 1989; Fechhelm and Griffiths 2001; Irvine et al. 2009). It is noteworthy that the two Pacific salmon species that appear to have established spawning populations on the North Slope of Alaska are those that spend very little time as juveniles in freshwater before migrating to saltwater; this trait along with the greater tolerance of colder water by the two species may have allowed pink and chum salmon to successfully colonize Arctic streams (Craig and Haldorson 1986). It is unknown how many sustainable spawning populations (versus runs of strays) of pink and chum salmon occur on the North Slope of Alaska, but the two species are commonly recorded, though typically in low numbers, in the Beaufort Sea (Craig and Haldorson 1986; Fechhelm and Griffiths 2001).

The freshwater streams in which pink and chum salmon have been recorded on the Coastal Plain, and for which EFH has been designated, are listed in **Table P-2**. In all cases, only adult salmon have been recorded as present in these waterbodies. The segments of the streams in which EFH for pink and chum salmon has been designated are illustrated on **Map 3-19** in **Appendix A**. The three streams in which these salmon species occur (Canning River, West Canning River, and Staines River) are all on the far western edge of the Coastal Plain).

Table P-2
River Systems in the Coastal Plain Program Area with Designated EFH Based on the Anadromous Waters Catalog

River System	Anadromous Waters Catalog Code	Salmon Species Recorded
Canning River	330-00-10210	pink (present), chum (present)
West Canning River	330-00-10220	pink (present)
Staines River	330-00-10230	pink (present)

Source: Giefer and Graziano 2023

P.2.2 Arctic Cod

Arctic cod are one of the most abundant fish species in coastal waters of the Beaufort Sea where they occur in a diversity of habitats, including nearshore and offshore waters, brackish lagoons and inlets, and river mouths (Moulton and Tarbox 1987; Johnson et al. 2010). They are considered semi-pelagic because of their common occurrence in both demersal (seabed) and pelagic (open water) habitats. Fish mature from 2 to 3 years of age, spawning occurs only once in a lifetime, and the maximum age spans a narrow range of 6 to 7 years (Cohen et al. 1990). Abundance tends to be greatest in nearshore habitats during the summer and in offshore habitats during winter (Craig et al. 1982). Arctic cod are believed to be the most important consumer of secondary production in the Alaskan Beaufort Sea (Frost and Lowry 1983) and are an important prey item for other fishes, birds, and marine mammals (Bradstreet and Cross 1982; Frost 1984).

The current extent of EFH for arctic cod in the offshore, nearshore, and estuarine waters adjacent to the Coastal Plain has been described for eggs, larvae, early juveniles, late juveniles, and adults (Simpson et al. 2017; NMFS 2023). The spatial extent of EFH for arctic cod in waters in and adjacent to the Coastal Plain is illustrated on **Map 3-19** in **Appendix A**.

P.2.3 Saffron Cod

Saffron cod are considered to be at the northern extent of their range in the Beaufort Sea, but the species is caught commonly in the western Beaufort Sea (Logerwell et al. 2015) and was also caught commonly in previous nearshore fish surveys at Point Thomson, approximately 8 miles to the west of the Coastal Plain boundary (Burril and Nemeth 2014). In contrast to arctic cod, adult saffron cod are completely demersal. Individuals mature around 2 to 3 years of age, after which they spawn once a year; adults live to be 10 to 14 years of age (Cohen et al. 1990). Saffron cod occur primarily in moderately saline nearshore habitats for much of the year, although they are known to migrate during summer to feed in brackish coastal habitats or move up rivers within the zone of tidal influence (Fechhelm et al. 1984; Mecklenburg et al. 2002). As with arctic cod, saffron cod are also a chief prey item for other fishes, birds, and marine mammals (Frost 1984).

The extent of EFH for saffron cod in the marine waters adjacent to the Coastal Plain has not been specifically described and mapped, but the EFH text description for the species in the Arctic Fishery Management Plan (NPFMC 2009) indicates that saffron cod occur throughout Arctic waters. The specific language indicates that adults and late juveniles are "…located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 meter) shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel." (NPFMC 2009, p. 81).

Climate change and the warming of Arctic marine waters has led to the process of borealization for some nearby fish communities (von Biela et al. 2023). In this case, borealization is a process whereby Arctic species are being displaced by species with more boreal region distributions as their ranges expand. Increases in saffron cod have been observed in Kaktovik and Jago lagoons over three distinct sampling periods (1998–1991, 2003–2005, and 2017–2019), which corresponds to declining sea ice at these locations. Between the first and last sampling periods, saffron cod catch rates increased in Kaktovik and Jago lagoons 18-fold and 19-fold, respectively. For these same time periods, the saffron cod community proportions in these lagoons increased 6 and 18-fold (von Biela et al. 2023).

P.2.4 Snow Crab

Snow crab are found in seabed habitats in Arctic nearshore waters where the substrate is composed predominantly of mud (NPFMC 2009). The distribution of snow crab in Arctic waters off Alaska has been updated with new information indicating the species occurs in nearshore waters of the Chukchi and Beaufort seas east to the Canadian border (Simpson et al. 2017; NMFS 2023). The current extent of EFH for snow crab in nearshore waters adjacent to the Coastal Plain has been described for eggs, late juveniles, and adults.

P.3 Proposed Action

Federal legislation (Public Law 115-97) was passed in December 2017, lifting the prohibition on oil and gas development imposed by Section 1003 of the Alaska National Interest Lands Conservation Act and requiring the Bureau of Land Management (BLM) to implement an oil and gas leasing program on the Coastal Plain of the Arctic Refuge. To assess the effects of an oil and gas leasing program on the Coastal Plain, the BLM must evaluate the potential impacts of likely subsequent oil and gas development activities on biological resources through the NEPA process (this Leasing SEIS). Post-leasing activities could include seismic exploration, ice road construction and drilling exploration, gravel road and pad development, transportation of building modules in nearshore waters, and the construction of pipelines to transport oil and gas in and from the Coastal Plain.

As part of the process of assessing impacts on biological resources, the BLM must also consider the potential impacts of post-leasing activities on designated EFH in the Coastal Plain program area. As part of any leases granted, the BLM will require adherence to oil and gas leasing stipulations and required operation procedures developed specifically for the Coastal Plain, and will also require special protections for specific habitats and resources (see **Section P.5** below). Post-leasing, the BLM will provide an opportunity, subject to appropriate conditions developed through a future NEPA process, to construct necessary infrastructure, primarily expected to be pipelines and roads, to bring oil and gas resources from leases in the Coastal Plain to the Trans-Alaska Pipeline System.

P.4 Potential Adverse Effects on EFH

The potential adverse effects on EFH from post-leasing oil and gas exploration and development activities in the Coastal Plain program area would be the same as those described for other fish habitats in the Leasing SEIS **Section 3.3.2**, Fish and Aquatic Species. Impacts to offshore marine EFH would be negligible as only infrequent shipping traffic is likely to occur to support onshore development activities; however, a seawater treatment plant, if constructed in nearshore waters, has the potential to adversely affect marine EFH by covering seabed habitats and disrupting the movements of marine and anadromous fish.

Other potential effects on nearshore and estuarine EFH could involve disturbance to saline and brackish waters and seabed habitats as a result of the delivery of building modules by barge, the construction of a barge dock, and the possible construction of a seawater treatment plant and piping in marine habitats. Potential effects on freshwater EFH from seismic and drilling exploration activities could include noise and vibration effects on fish eggs and juvenile and adult fish. Effects from ice road construction, gravel mining, and gravel road and pad construction could include direct habitat loss and/or alteration; changes in water quality (e.g., increased turbidity, sedimentation); changes in water volume (e.g., water withdrawals for ice roads); physical alterations in flow patterns and riverine/lacustrine geomorphology; point and non-point source pollution (e.g., sheet flow of contaminated road dust, contaminant spills); and barriers to fish movements.

The primary differences among the Leasing SEIS action alternatives with respect to potential impacts on EFH are the variable setback distances from waterbodies required for infrastructure development under each alternative (with case-by-case exceptions for road and pipeline crossings and gravel mines). For example, the required setback distances for the construction of infrastructure from waterbodies increase from Alternative B (the least restrictive) to Alternative C (moderate restrictions) and Alternative D (the most restrictive).

Specific streams known to be important for anadromous fish, such as the Canning River, are also afforded increasing infrastructure setback distances along the continuum between Alternatives B, C, and D. Similarly, there are no setback distances from the coast for infrastructure development under Alternative B, but increasing setback distances from the coast are required under Alternatives C and D (with exceptions for barge landings, barge docks, and pipelines). Alternative D also includes setback distances from known springs (which are important for overwintering fish) and aufeis areas that would help protect fish habitats.

Largely because of these setback distances, the greatest risk for impacts to EFH in the Coastal Plain program area would occur under Alternative B, with less risk for Alternative C, and the least risk for Alternative D.

P.5 PROPOSED MITIGATION MEASURES

A set of specific lease stipulations and required operating procedures (ROPs) prepared for this Leasing SEIS would mitigate the potential impacts on EFH from post-leasing oil and gas development activities. Proper implementation of these protective measures should ensure that impacts to EFH in the Coastal Plain program area are avoided or minimized. The following list of lease stipulations and ROPs summarizes the mitigation measures that apply to fish habitats; details for each measure can be found in **Table 2-2**, in **Chapter 2**, Alternatives. These mitigation procedures largely address the relevant and comparable "Recommended Conservation Measures" identified in *Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska, EFH 5-year Review: 2010 through 2015* (Limpinsel et al. 2017).

- **Lease Stipulation 1—Rivers and Streams:** (No Surface Occupancy) Permanent oil and gas facilities including gravel pads, roads, airstrips, and pipelines would be prohibited in the streambed, and variable setback distances from stream banks are required for the construction of those facilities (with case-by-case exceptions for essential road and pipeline crossings and gravel mines). Setback distances increase for specific streams and rivers and are smallest under Alternative B, intermediate for Alternative C, and largest under Alternative D.
- **Lease Stipulation 2—Canning River Delta and Lakes:** (No Surface Occupancy) Permanent oil and gas facilities including gravel pads, roads, airstrips, and pipelines would be prohibited within 0.5 miles of any waterbody in the delta areas of the Canning and Tamyariak rivers (with case-by-case exceptions for essential road and pipeline crossings).
- **Lease Stipulation 3—Spring/Aufeis:** Before drilling, the operator would be required to conduct studies to ensure drilling will not disrupt flow to or from perennial springs and that waste injection wells would not contaminate any perennial springs. For Alternative D, selected springs and aufeis areas would not be offered for lease sale or would be protected with infrastructure setback distances.
- **Lease Stipulation 4—Nearshore marine, lagoon, and barrier island habitats of the Southern Beaufort Sea within the boundary of the Arctic Refuge:** (No Surface Occupancy) Exploratory well drill pads, production well drill pads, or a central processing facility for oil or gas would not be permitted in coastal waters, lagoons, or barrier islands within the boundaries of the Coastal Plain. On a case-by-case basis, barge landings, docks, spill response staging and storage areas, and pipelines may be permitted. All open water activities in these coastal areas would be coordinated and timed to avoid impacts to wildlife and fish populations.
- **Lease Stipulation 9—Coastal Area:** Before beginning exploration or development within 2 miles inland of the coast, the lessee/operator/contractor would be required to develop and implement an impact and conflict avoidance and monitoring plan to assess, minimize, and mitigate the effects of the infrastructure and its use on coastal habitats and the use of those habitats by wildlife and people. For Alternative C, No Surface Occupancy restrictions would apply: exploratory well drill pads, production well drill pads, or a central processing facility would not be permitted within 2 miles inland of the coast. On a case-by-case basis, barge landings, docks, spill response staging and storage areas, and pipelines may be permitted.
- **ROP 1—**Areas of operation would be left clean of all debris (which could eventually reside in low-lying streambeds and lake basins). All solid waste and garbage would be disposed of in accordance with applicable federal, State, and local laws and regulations.

- **ROP 2—**The lessee/operator/contractor would prepare and implement a comprehensive waste management plan for all phases of exploration, development, and production, including seismic activities.
- **ROP 3—**Refueling equipment within 100 feet of the active floodplain of any waterbody would be prohibited (Alternative B). The refueling buffer distance is increased to 500 feet under Alternatives C and D.
- **ROP 7—**A lessee/operator/contractor proposing a permanent oil and gas development would be required to design and implement a monitoring study of contaminants in locally used subsistence foods (Alternatives C and D).
- **ROP 8—**Withdrawal of unfrozen water from springs, rivers, and streams during winter (from the onset of freeze-up to break-up) would be prohibited. The removal of ice aggregate from grounded areas 4 feet deep or less may be authorized from rivers on a site-specific basis (Alternatives B and C).
- **ROP 9—**Withdrawal of unfrozen water from lakes and the removal of ice aggregate from grounded areas 4 feet deep or less during winter (onset of freeze-up to break-up) and withdrawal of water from lakes during the summer may be authorized on a site-specific basis, depending on water volume and depth, the fish community, and connectivity to other lakes or streams and adjacent bird nesting sites. For Alternatives C and D, additional modeling and monitoring of lake recharge may be required to ensure natural hydrologic regime, water quality, and aquatic habitat for birds.
- **ROP 11—**Protects stream banks and freshwater sources, minimizes soil compaction and the breakage, abrasion, compaction, or displacement of vegetation. During winter tundra travel, ice road construction, and seismic work, detailed procedures would be followed to minimize damage to stream banks and freshwater sources, and minimize soil compaction of and damage to vegetation. Slightly more stringent measures would be implemented under Alternative D.
- **ROP 12—**Maintains spring breakup runoff patterns and fish passage, minimizes flooding from infrastructure, prevents streambed sedimentation and scour, and protects stream banks and water quality. Waterways would be crossed using a low-angle approach. Crossings reinforced with additional snow or ice (bridges) would be removed, breached, or slotted before spring breakup. Ramps and bridges would be substantially free of soil and debris.
- **ROP 13—**Avoids additional freeze-down of aquatic habitat harboring overwintering fish and their aquatic invertebrate prey. Travel along streambeds would be prohibited unless it can be demonstrated that there would be no additional impacts from such travel on overwintering fish, aquatic invertebrates, and water quality. Rivers, streams, and lakes would be crossed at areas of grounded ice or with the approval of the BLM (when it has been demonstrated that no additional impacts would occur on fish or aquatic invertebrates).
- **ROP 14—**When conducting vibroseis-based surveys above potential fish overwintering areas (water 6 feet deep or greater, ice plus liquid depth), lessees/operators/contractors would follow the recommendations of Morris and Winters (2005) to minimize impacts on fish. Only a single set of vibroseis shots would be conducted, if possible; if multiple shot locations are required, these would be conducted with minimal delay; multiple days of vibroseis activity above the same overwintering area would be avoided, if possible. Seismic surveys would not be conducted over unfrozen water with fish overwintering potential (water 6 feet deep or greater).
- **ROP 16—**Exploratory drilling would be prohibited in fish-bearing rivers and streams and other fish-bearing waterbodies to maintain water quality and minimize alteration of riparian habitat. On

a case-by-case basis, the BLM Authorized Officer may consider exploratory drilling in the floodplains of rivers and streams. Under Alternative D, this would only apply to rivers or streams that do not support resident, anadromous, or endemic fish populations.

- **ROP 17—**To minimize surface impacts from exploratory drilling, construction of gravel roads to support exploration would be prohibited. Use of a previously constructed road or pad may be permitted if it is environmentally preferred.
- **ROP 19—**Water quality and the diversity of fish, aquatic invertebrates, and wildlife populations and habitats would be protected by restricting oilfield infrastructure within 500 feet of fish-bearing waterbodies (unless further setbacks are stipulated under Lease Stipulations 1, 2, or 3); pipeline and road crossings would be permitted on a case-by-case basis. Temporary winter exploration and construction camps would be prohibited on frozen lakes and river ice but would be allowed on river sand and gravel bars.
- **ROP 20—**Causeways and docks would be prohibited in river mouths and deltas. Artificial gravel islands and bottom-founded structures would be prohibited in river mouths and active stream channels on river deltas. All these infrastructure features would be designed to ensure free passage of marine and anadromous fish and to prevent significant changes to nearshore oceanographic circulation patterns and water quality characteristics.
- **ROP 21—**A detailed set of measures would be implemented to ensure that oilfield facilities are designed and located to minimize the development footprint and impacts on other purposes of the Arctic Refuge.
- **ROP 22—**A detailed set of measures would be used to reduce the potential for ice-jam flooding, damage from aufeis, impacts on wetlands and floodplains, erosion, alteration of natural drainage patterns, and restrictions of fish passage. These measures include the preference for single-span bridges over culverts and the use of best management practices developed by the U.S. Fish and Wildlife Service (USFWS) and U.S. Forest Service (McDonald & Associates 1994; USFS 2008) to facilitate fish passage at road crossings of streams.
- **ROP 24—**Gravel mine site design and reclamation would be done in accordance with a plan approved by the BLM to minimize the impact of mineral-materials mining on air, land, water, fish, and wildlife resources. Whenever possible, gravel mining would occur outside of active riverine floodplains.
- **ROP 35—**Before final abandonment, land used for oil and gas infrastructure—including well pads, production facilities, access roads, and airstrips—would be reclaimed to ensure eventual restoration of ecosystem function. The leaseholder would be required to develop and implement a BLM-approved abandonment and reclamation plan.
- **ROP 41—**On a case-by-case basis, the BLM, in consultation with the USFWS, may permit low-ground-pressure vehicles to travel off gravel pads and roads during summer (winter tundra travel is covered under ROP 11). Permission for such use would be granted only after the vehicles to be used can be shown to have minimal impacts on soils and vegetation.
- **ROP 43—**Prevents the introduction or spread of nonnative, invasive species in the Coastal Plain. All equipment and vehicles (including helicopters, planes, boats, and barges) intended for use either off or on roads would be certified to be free of nonnative invasive species before transiting into the Coastal Plain.
- **ROP 45—**Minimize the loss of individuals and habitat for mammalian, avian, fish, and invertebrate species designated as sensitive by the BLM in Alaska. If a development is proposed in an area that

provides potential habitat for BLM sensitive species, the proponent would conduct surveys at appropriate times of the year and in appropriate habitats to detect the presence of BLM sensitive species. The survey results would be submitted to the BLM with the application for development.

P.6 ESSENTIAL FISH HABITAT FINDING

No offshore marine EFH impacts are probable based on the scope of the likely post-leasing actions. Nearshore and estuarine EFH would receive sufficient protections under Lease Stipulations 4 and 9, and ROP 20, which substantially restrict and/or mitigate oil and gas activities in those marine waters. The possible construction of a seawater treatment plant in nearshore waters, with the potential to inhibit the movement of marine and anadromous fish, would be mitigated specifically by ROPs 20 and 21.

The only other activities authorized in nearshore and estuarine waters are the construction and use of barge landings and docking structures, which should result in small, localized impacts to marine EFH. For freshwater EFH, the lease stipulations and ROPs listed above would provide substantial environmental protections to minimize or avoid effects on EFH.

Although unavoidable impacts may occur in some freshwater habitats in the Coastal Plain, those streams and rivers that provide freshwater EFH would be protected with setback distances for the construction of most permanent oilfield infrastructure (essential pipelines, road crossings, and possibly gravel mines could be permitted within the setback buffers). Also, since streams and rivers comprising freshwater EFH are listed in the Anadromous Waters Catalog, they are granted further regulatory protection under the Anadromous Fish Act (AS 16.05.871), which requires additional review and permitting of development activities by the Alaska Department of Fish and Game. Based on these considerations, oil and gas exploration and development in the Coastal Plain program area is assigned the EFH assessment determination: May affect, not likely to adversely affect.

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Appendix Q

Air Resources Technical Support Document

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July 2023

Air Resources Technical Support Document

BLM Coastal Plain Oil and Gas Leasing Program Draft Supplemental Environmental Impact Statement

Contents

APPENDIX

TABLES

FIGURES

1.0 Air Quality

1.1 Supporting Information for Affected Environment

1.1.1 Ambient Air Quality Standards

The U.S. Environmental Protection Agency (EPA) and the state of Alaska have set time-averaged ambient air quality standards for criteria air pollutants, including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and two categories of particulate matter (less than 10 microns in diameter [PM_{10}] and less than 2.5 microns in diameter [$PM_{2.5}$]). These standards are listed in Table 1-1.

Table 1-1. National and Alaska Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS – Primary	NAAQS – Secondary	AAAQS	Form
CO	1 hour	35 ppm	N/A	40 mg/m^3	Not to be exceeded more than once per year
CO	8 hours	9 ppm	N/A	10 mg/m^3	Not to be exceeded more than once per year
NO_2	1 hour	100 ppb	N/A	188µg/m^3	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
NO_2	Annual	53 ppb	53 ppb	100 µg/m^3	Annual mean, not to be exceeded
SO_2	1 hour	75 ppb	N/A	196 µg/m^3	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
SO_2	3 hours	N/A	0.5 ppm	1300 µg/m^3	Not to be exceeded more than once per year
SO_2	24 hours	N/A	N/A	365 µg/m^3	Not to be exceeded more than once per year
SO_2	Annual	N/A	N/A	80 µg/m^3	Annual mean, not to be exceeded
PM_{10}	24 hours	150 µg/m^3	150 µg/m^3	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
$PM_{2.5}$	24 hours	35 µg/m^3	35 µg/m^3	35 µg/m^3	98th percentile, averaged over 3 years
$PM_{2.5}$	Annual	12 µg/m^3	15 µg/m^3	12 µg/m^3	Annual mean, averaged over 3 years

Pollutant	Averaging Period	NAAQS – Primary	NAAQS – Secondary	AAAQS	Form
O_3	8 hours	0.070 ppm	0.070 ppm	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years

Source: EPA 2023a (40 CFR 50); ADEC 2022 (18 AAC 50.010)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; mg/m^3 = milligrams per cubic meter; µg/m^3 = micrograms per cubic meter; All AAAQS are primary except for 3-hour SO_2.

1.1.2 Ambient Air Quality Monitoring Data

Five air quality monitoring stations are located within approximately 100 miles of the Coastal Plain and have verified data in the last 5 years or at least 3 years of data within the past 10 years. These stations are Kaktovik, Point Thomson, Nuiqsut, A-Pad, and CCP, and are shown in Figure 1-1. Kaktovik and Nuiqsut are the only two monitors that have current data through 2022. Table 1-2 through Table 1-6 summarize measurements of criteria pollutants at these stations. Three years of data are shown where available since the form of some NAAQS requires a 3-year average.

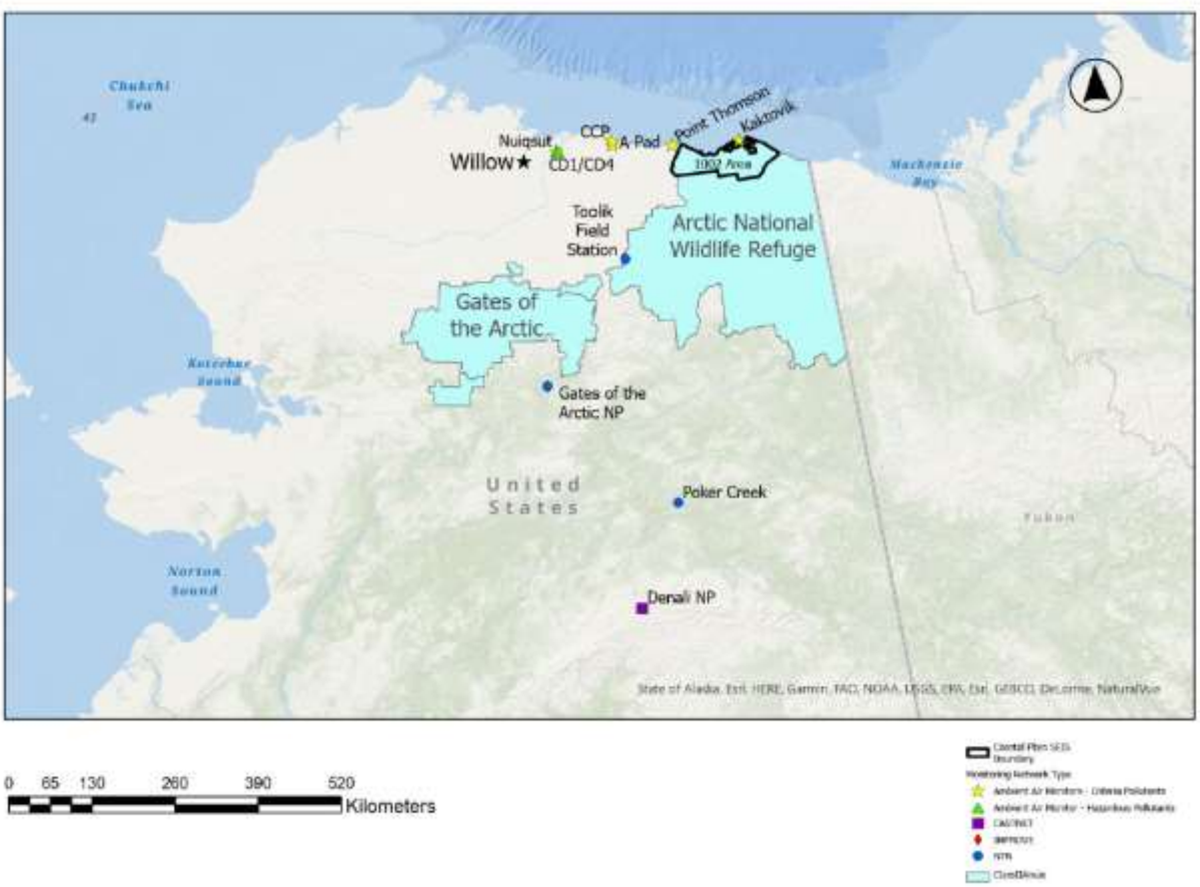


Figure 1-1. Map of monitoring stations for air quality and air quality related values.

Table 1-2. Criteria Air Pollutant Monitoring Values at the Kaktovik Monitor

Pollutant (Units)	Avg. Period	Rank	Q4 2021 – Q3 2022	NAAQS	Below NAAQS?
CO (ppm)	1 hour	2nd highest daily maximum	0.25	35	Yes
CO (ppm)	8 hour	2nd highest daily maximum	0.24	8	Yes
NO_2 (ppb)	1 hour	98th percentile of daily maximum	9.78	100	Yes [1]
NO_2 (ppb)	Annual	Annual average	0.41	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily maximum	1.46	75	Yes [1]
SO_2 (ppb)	3 hour	2nd highest daily maximum	2.49	500	Yes
SO_2 (ppb)	24 hour	2nd highest	1.56	140	Yes
SO_2 (ppb)	Annual	Average	0.30	30	Yes
PM_{10} (µg/m^3)	24 hour	2nd highest	53.64	150	Yes [1]
$PM_{2.5}$ (µg/m^3)	24 hour	98th percentile	7.80	35	Yes [1]
$PM_{2.5}$ (µg/m^3)	Annual	Average	2.77	12	Yes [1]
O_3 (ppb)	8 hour	4th highest daily maximum	42	70	Yes [1]

Source: Air Sciences, Inc.

Notes: NAAQS = National Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; µg/m^3 = micrograms per cubic meter; NAAQS and measurement values for O_3 were converted from ppm to ppb. Air Sciences, Inc. provided hourly concentration measurements which were put into the form of the NAAQS. Annual averages are reported in AirSci (2022).

[1]Compliance with NAAQS requires a 3-year average. Comparison here is for informational purposes only.

Table 1-3. Criteria Air Pollutant Monitoring Values at the Point Thomson Monitor

Pollutant (Units)	Avg. Period	Rank	2016 - 2017	NAAQS	Below NAAQS?
CO (ppm)	1 hour	2nd highest daily maximum	1	35	Yes
CO (ppm)	8 hour	2nd highest daily maximum	<1	8	Yes
NO_2 (ppb)	1 hour	98th percentile of daily maximum	14	100	Yes [1]
NO_2 (ppb)	Annual	Annual average	1.0	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily maximum	1	75	Yes [1]
SO_2 (ppb)	3 hour	2nd highest daily maximum	<1	500	Yes
SO_2 (ppb)	24 hour	2nd highest	<1	140	Yes
SO_2 (ppb)	Annual	Average	<1	30	Yes
PM_{10} (µg/m^3)	24 hour	2nd highest	20.0	150	Yes [1]
$PM_{2.5}$ (µg/m^3)	24 hour	98th percentile	9.0	35	Yes [1]

Pollutant (Units)	Avg. Period	Rank	2016 - 2017	NAAQS	Below NAAQS?
$PM_{2.5}$ (μg/m^3)	Annual	Average	2.8	12	Yes [1]
O_3 (ppb)	8 hour	4th highest daily maximum	46	70	Yes [1]

Source: ADEC 2018.

Notes: NAAQS = National Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; μg/m^3 = micrograms per cubic meter; NAAQS and measurement values for O_3 were converted from ppm to ppb.

[1]Compliance with NAAQS requires a 3-year average. Comparison here is for informational purposes.

Table 1-4. Criteria Air Pollutant Monitoring Values at the Nuiqsut Monitor

Pollutant (Units)	Avg. Period	Rank	2020	2021	2022	Avg. [1]	NAAQS	Below NAAQS?
CO (ppm)	1 hour	2nd highest daily maximum	9	1	1	3.7	35	Yes
CO (ppm)	8 hour	2nd highest daily maximum	3	1	<1	1.3	8	Yes
NO_2 (ppb)	1 hour	98th percentile of daily maximum	32.4	28.2	25.6	28.7	100	Yes
NO_2 (ppb)	Annual	Annual average	2	2	2	2	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily maximum	4.2	0.9	2.5	2.5	75	Yes
SO_2 (ppb)	3 hour	2nd highest daily maximum	3.8	<0.1	<0.1	1.3	500	Yes
SO_2 (ppb)	24 hour	2nd highest	3.6	<0.01	<0.01	1.2	140	Yes
SO_2 (ppb)	Annual	Average	<0.001	<0.001	<0.001	<0.001	30	Yes
PM_{10} (μg/m^3)	24 hour	2nd highest	60	70	60	63.3	150	Yes
$PM_{2.5}$ (μg/m^3)	24 hour	98th percentile	6	8	7	7	35	Yes
$PM_{2.5}$ (μg/m^3)	Annual	Average	1.2	2.3	2.6	2.0	12	Yes
O_3 (ppb)	8 hour	4th highest daily maximum	41	42	42	41.7	70	Yes

Source: SLR 2023; SLR 2022a; SLR 2021; ADEC 2018

Notes: NAAQS = National Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; μg/m^3 = micrograms per cubic meter; NAAQS and measurement values for O_3 were converted from ppm to ppb.

[1]Average calculated over the most recent 3 years of data.

Table 1-5. Criteria Air Pollutant Monitoring Values at the A-Pad Monitor

Pollutant (Units)	Avg. Period	Rank	2014	2015	2016	Avg. [1]	NAAQS	Below NAAQS?
NO_2 (ppb)	1 hour	98th percentile of daily maximum	33.3	36.4	24.8	31.5	100	Yes
NO_2 (ppb)	Annual	Annual average	3.0	3.0	2.0	2.7	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily maximum	4.3	4.3	3.3	4.0	75	Yes
SO_2 (ppb)	3 hour	2nd highest daily maximum	5	4	<1	3.0	500	Yes
SO_2 (ppb)	24 hour	2nd highest	1.7	2.1	<0.1	1.3	140	Yes
SO_2 (ppb)	Annual	Average	0.50	0.10	<.01	0.20	30	Yes
O_3 (ppb)	8 hour	4th highest daily maximum	51	44	43	46	70	Yes

Source: ADEC 2018.

Notes: NAAQS = National Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; $\mu g/m^3$ = micrograms per cubic meter; NAAQS and measurement values for O_3 were converted from ppm to ppb.

[1]Average calculated over the most recent 3 years of data.

Table 1-6. Criteria Air Pollutant Monitoring Values at the CCP Monitor

Pollutant (Units)	Avg. Period	Rank	2014	2015	2016	Avg. [1]	NAAQS	Below NAAQS?
CO (ppm)	1 hour	2nd highest daily maximum	1.0	1.0	1.0	1.0	35	Yes
CO (ppm)	8 hour	2nd highest daily maximum	1	1	1	1	8	Yes
NO_2 (ppb)	1 hour	98th percentile of daily maximum	84.0	78.0	89.0	83.7	100	Yes
NO_2 (ppb)	Annual	Annual average	9.0	10.0	11.0	10	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily maximum	10	8.7	9.3	9.3	75	Yes
SO_2 (ppb)	3 hour	2nd highest daily maximum	10	9	<1	6.3	500	Yes
SO_2 (ppb)	24 hour	2nd highest	8.6	7.7	10	8.8	140	Yes
SO_2 (ppb)	Annual	Average	1.2	3.4	10	4.9	30	Yes
PM_{10} ($\mu g/m^3$)	24 hour	2nd highest	30	60	40	43.3	150	Yes
$PM_{2.5}$ ($\mu g/m^3$)	24 hour	98th percentile	11	9.0	16	12	35	Yes
$PM_{2.5}$ ($\mu g/m^3$)	Annual	Average	3.7	3.2	3.0	3.3	12	Yes

Pollutant (Units)	Avg. Period	Rank	2014	2015	2016	Avg. [1]	NAAQS	Below NAAQS?
O_3 (ppb)	8 hour	4th highest daily maximum	54	42	42	46	70	Yes

Source: ADEC 2018.

Notes: NAAQS = National Ambient Air Quality Standards; ppm = parts per million; ppb = parts per billion; μg/m^3 = micrograms per cubic meter; NAAQS and measurement values for O_3 were converted from ppm to ppb.

[1]Average calculated over the most recent 3 years of data.

A number of VOCs (including HAPs) have been measured on a monthly basis at the CPAI Nuiqsut monitoring station since April 2014. Sampling at a nearby site, CD4, also began in 2014 and was moved to the CD1 monitoring station in April 2017. The CD4 and CD1 data sets have been combined to characterize VOC concentrations at the closest active oilfield site to Nuiqsut. Since March 2022, continuous VOC monitoring was added to the monthly sampling at both locations. Table 1-7 and Table 1-8 provide a summary of historical concentrations for benzene, ethylbenzene, n-hexane, toluene, and xylene. Formaldehyde measurements are not available at either site. A short-term VOC monitoring program was also conducted from February 2018 through April 2018 at the Putu monitoring station, approximately 3 km northeast of Nuiqsut. Data from this station is not shown due to the short collection period. More information can be found in SLR (2022b).

Table 1-7. HAP Concentrations at the Nuiqsut Monitor

Pollutant	Number of Samples Above Detection Limit Since 2014	Avg. of Measurements Above Detection Limit (μg/m^3) [1]	Maximum of Measurements Above Detection Limit (μg/m^3) [1]	Acute REL or AEGL (μg/m^3)
Benzene	4	0.94	1.20	27
Ethylbenzene	3	1.19	1.98	140,000 [2]
n-Hexane	1	2.93	2.93	10,000,000 [2]
Toluene	13	4.59	16.64	5,000
Xylene	8 (m/p-xylene), 5 (o-xylene)	4.06	10.82	22,000

Source: SLR 2022b; EPA 2021a

Notes: μg/m^3 = micrograms per cubic meter; REL = Reference Exposure Level; AEGL = Acute Exposure Guideline Level; Benzene, ethylbenzene, toluene, and xylene measurements reported from toxic organic (TO) method TO-12; n-hexane by TO-15; Xylene is the sum of o-xylene and m/p-xylene

[1]Values converted from ppb to μg/m^3 at standard temperature and pressure

[2]AEGL reported here since RELs are not available for these pollutants

Table 1-8. HAP Concentrations at the CD1/CD4 Monitor

Pollutant	Number of Samples Above Detection Limit Since 2014	Avg. of Measurements Above Detection Limit (μg/m³) [1]	Maximum of Measurements Above Detection Limit (μg/m³) [1]	Acute REL or AEGL (μg/m³)
Benzene	5	1.30	1.91	27
Ethylbenzene	2	1.23	1.12	140,000 [2]
n-Hexane	-	-	-	10,000,000 [2]
Toluene	7	3.90	10.91	5,000
Xylene	11 (m/p-xylene), 3 (o-xylene)	3.09	1.34	22,000

Source: SLR 2022b; EPA 2021a

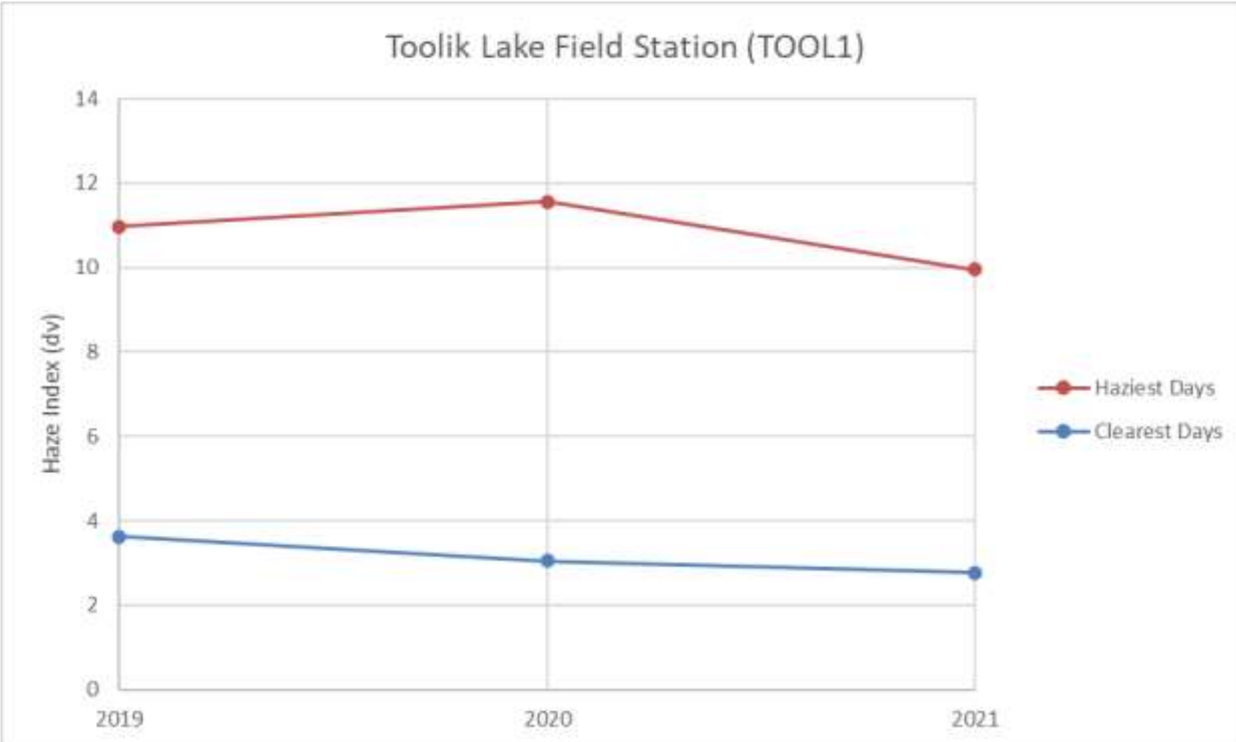
Notes: μg/m³ = micrograms per cubic meter; REL = Reference Exposure Level; AEGL = Acute Exposure Guideline Level; Benzene, ethylbenzene, toluene, and xylene measurements reported from toxic organic (TO) method TO-12; n-hexane by TO-15; Xylene is the sum of o-xylene and m/p-xylene

[1]Values converted from ppb to μg/m³ at standard temperature and pressure

[2]AEGL reported here since RELs are not available for these pollutants

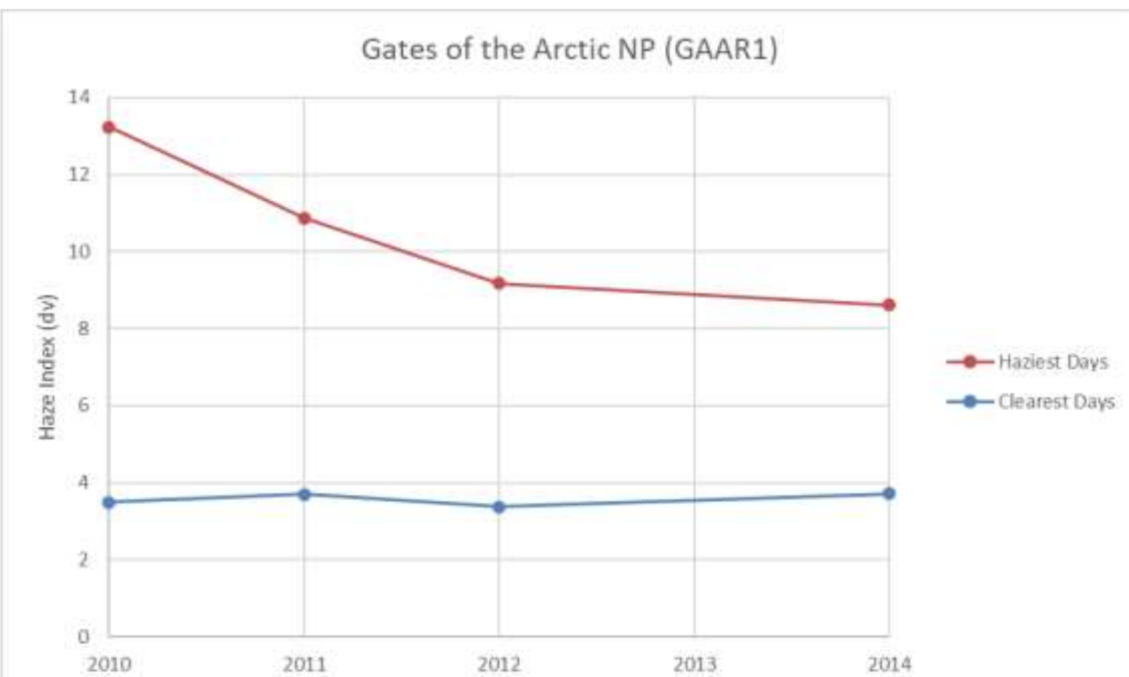
1.1.3 Visibility Monitoring Data

Visibility trends on the 20% haziest days and 20% clearest days are shown in Figure 1-2 through Figure 1-4 for the Toolik Field Station, Bettles Field Station (Gates of the Arctic National Park) and Denali National Park. Trends on the 20% most impaired days are also shown for Denali National Park.



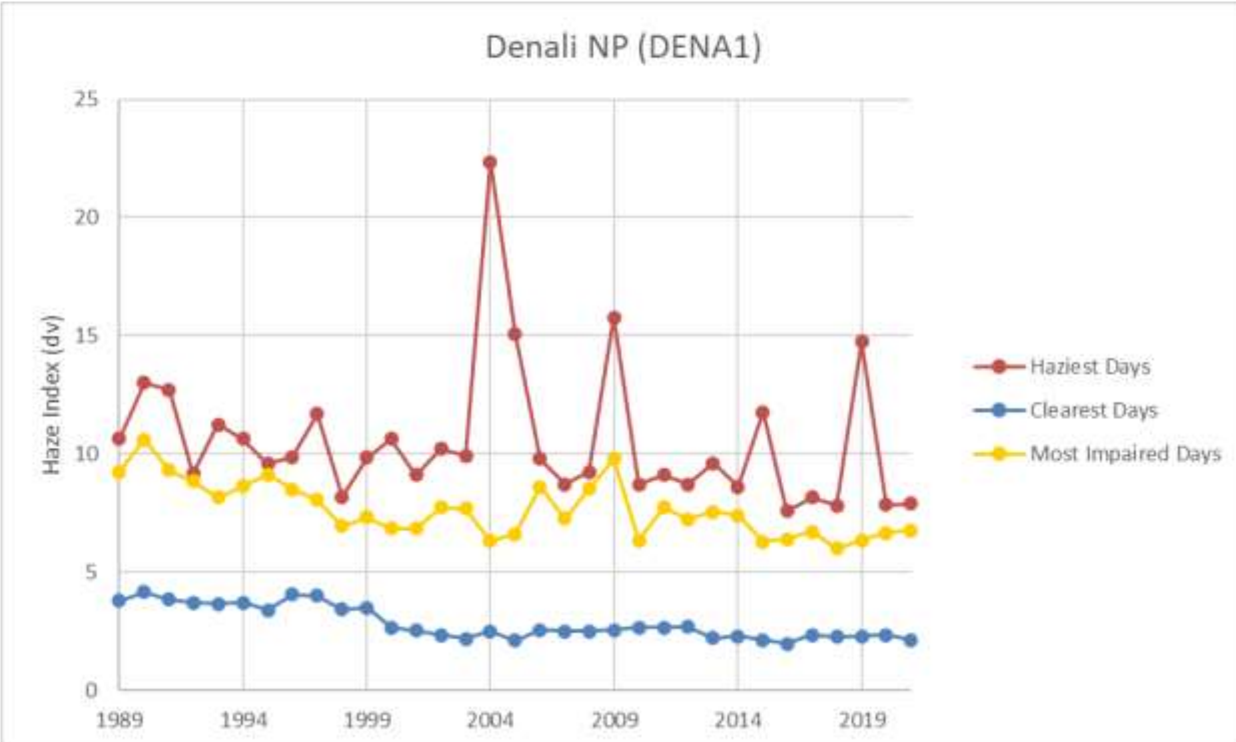
Source: FED 2023

Figure 1-2. Visibility on the Haziest and Clearest Days for Toolik Field Station.



Source: FED 2023

Figure 1-3. Visibility on the Haziest and Clearest Days for Bettles Field Station (Gates of the Arctic National Park).

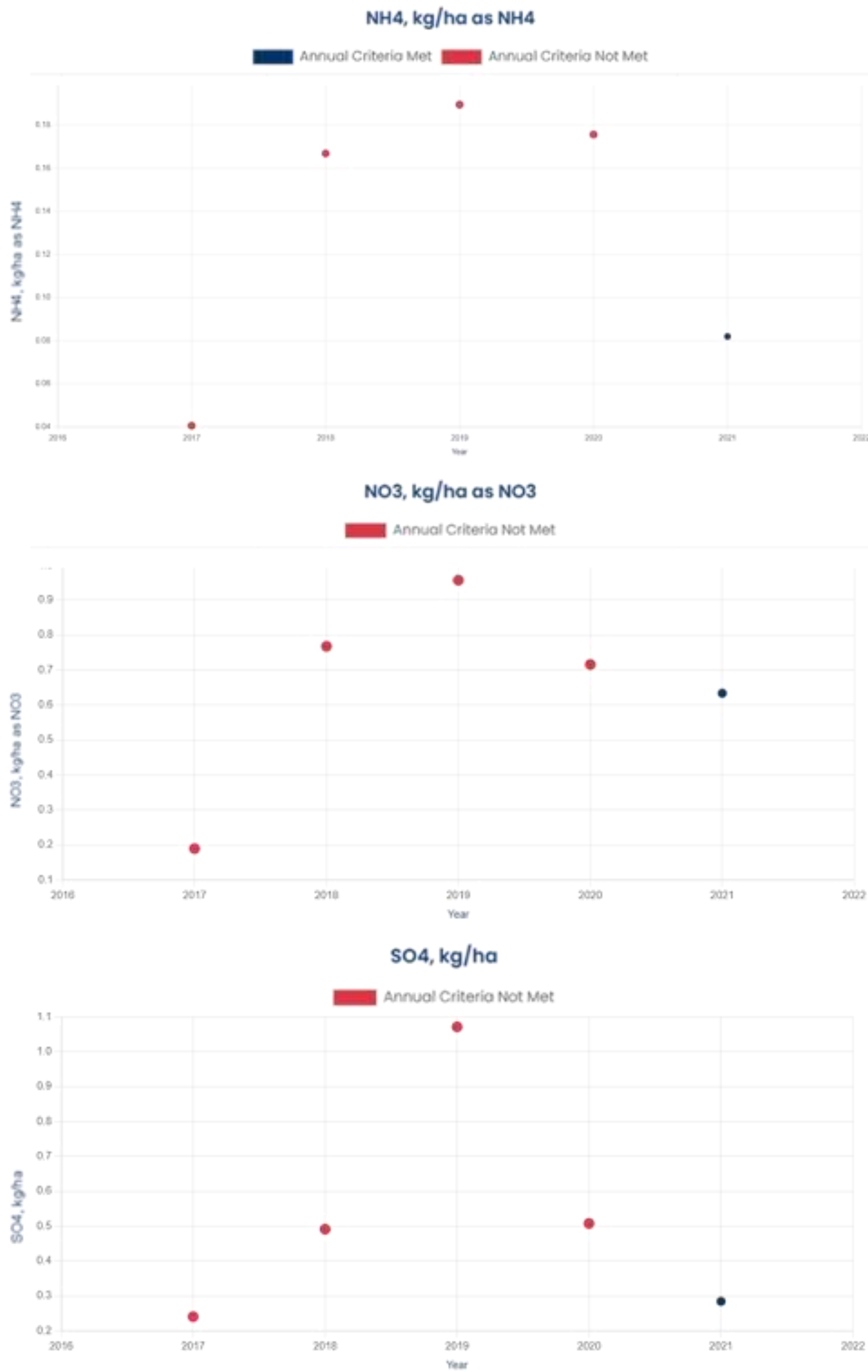


Source: FED 2023

Figure 1-4. Visibility on the Haziest, Most Impaired, and Clearest Days for Denali National Park.

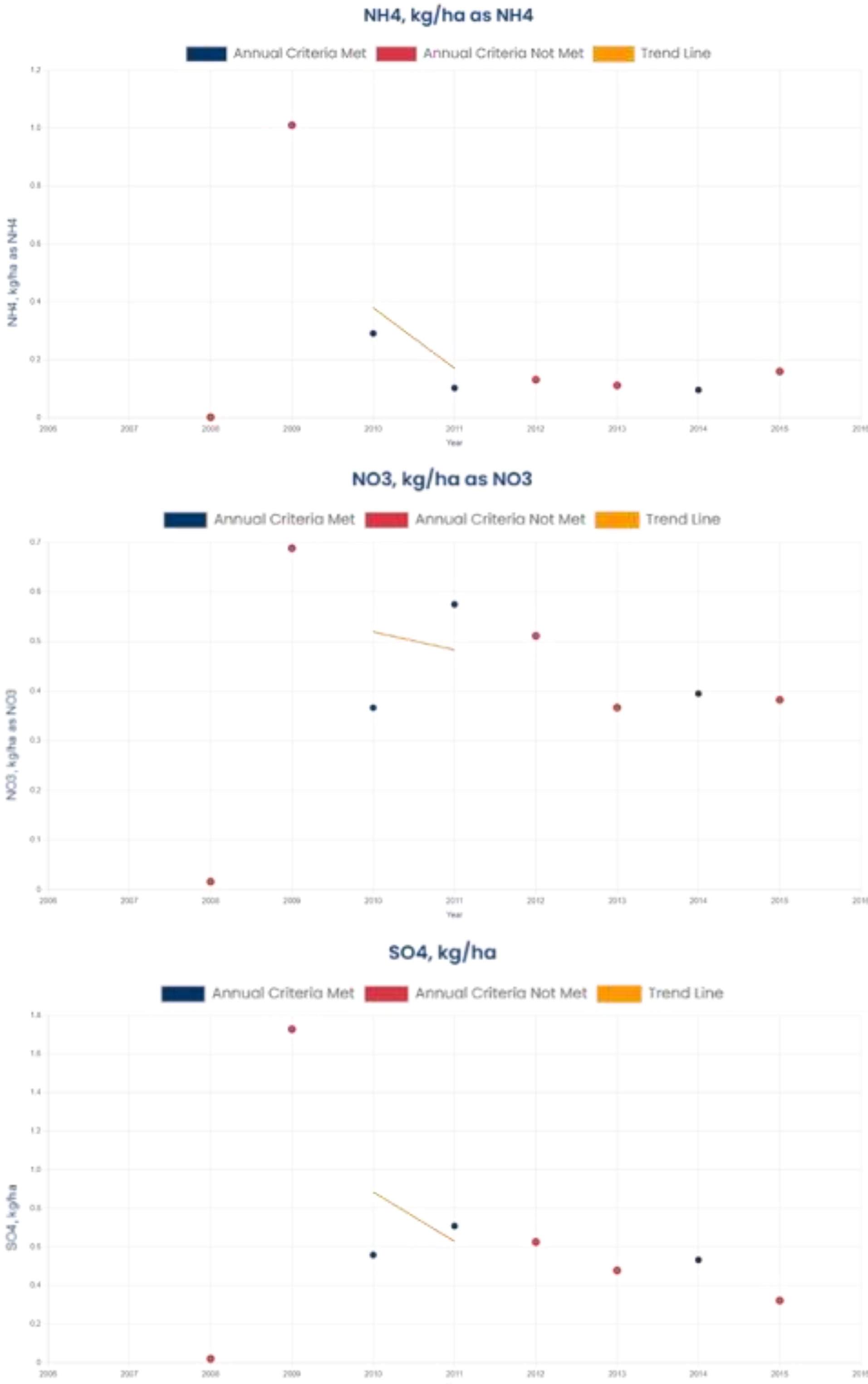
1.1.4 Deposition Monitoring Data

The closest active monitoring stations to the program area are Toolik Field Station (NTN Site AK96), Gates of the Arctic National Park (NTN Site AK06), Poker Creek (NTN Site AK01), and Denali National Park (NTN Site AK03). Trends for ammonium (NH_4^-), nitrate (NO_3^-), and sulfate (SO_4^{-2}) at Toolik Field Station (NTN Site AK96), Gates of the Arctic National Park (NTN Site AK06), Poker Creek (NTN Site AK01), and Denali National Park (NTN Site AK03) are shown in Figure 1-5 through Figure 1-8. The blue dots on the graphs indicate yearly concentrations that met the annual completeness criteria, while the red dots indicate yearly concentrations that did not meet the annual completeness criteria. The trendlines shown in yellow represent a 3-year moving average where the minimum data completeness criteria are met for that 3-year period.



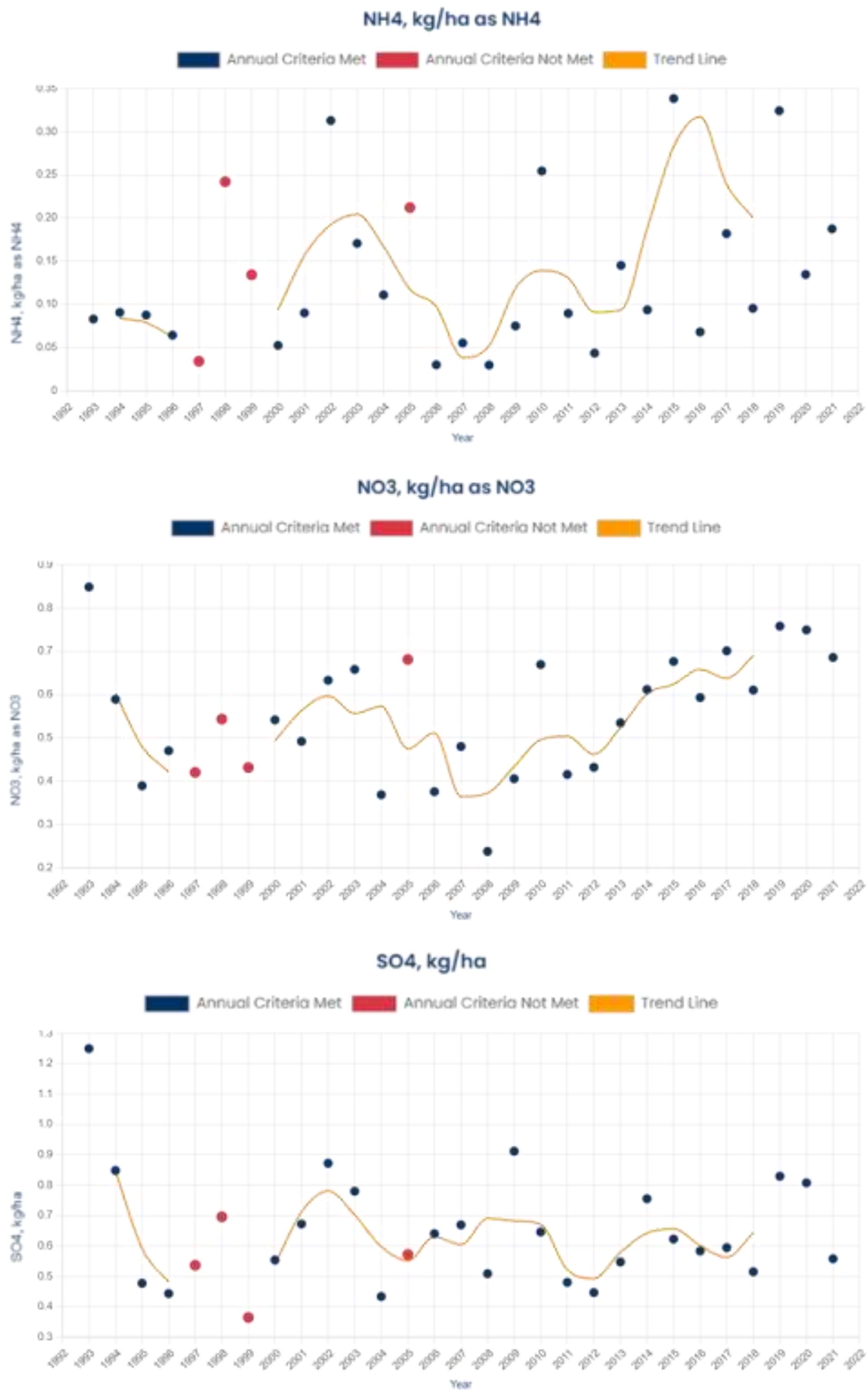
Source: NADP 2023

Figure 1-5. Trends in Wet Deposition of Ammonium (NH_4^-), Nitrate (NO_3^-), and Sulfate (SO_4^{-2}) at Toolik Field Station.



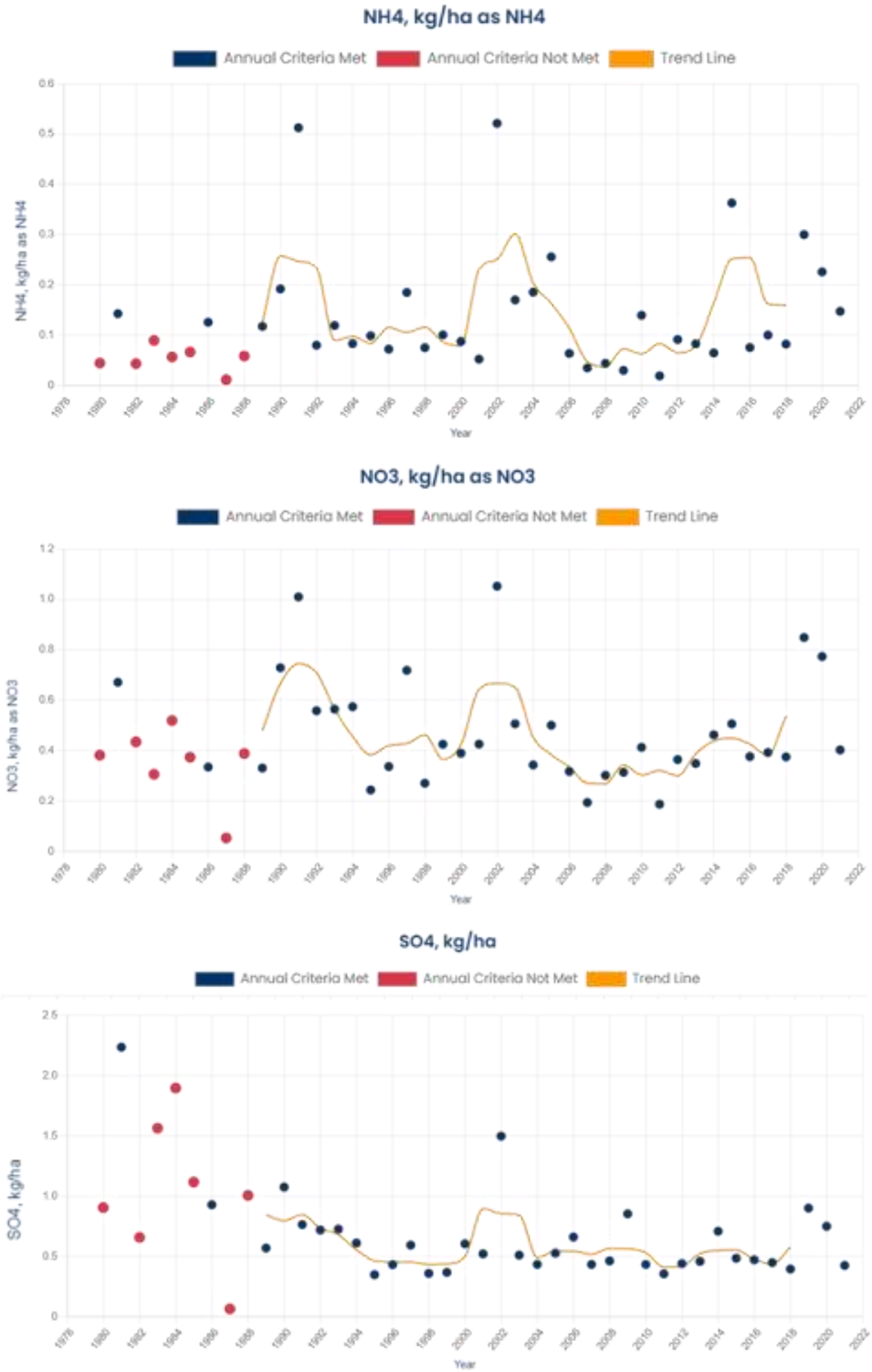
Source: NADP 2023

Figure 1-6. Trends in Wet Deposition of Ammonium (NH_4^-), Nitrate (NO_3^-), and Sulfate (SO_4^{-2}) at Gates of the Arctic National Park.



Source: NADP 2023

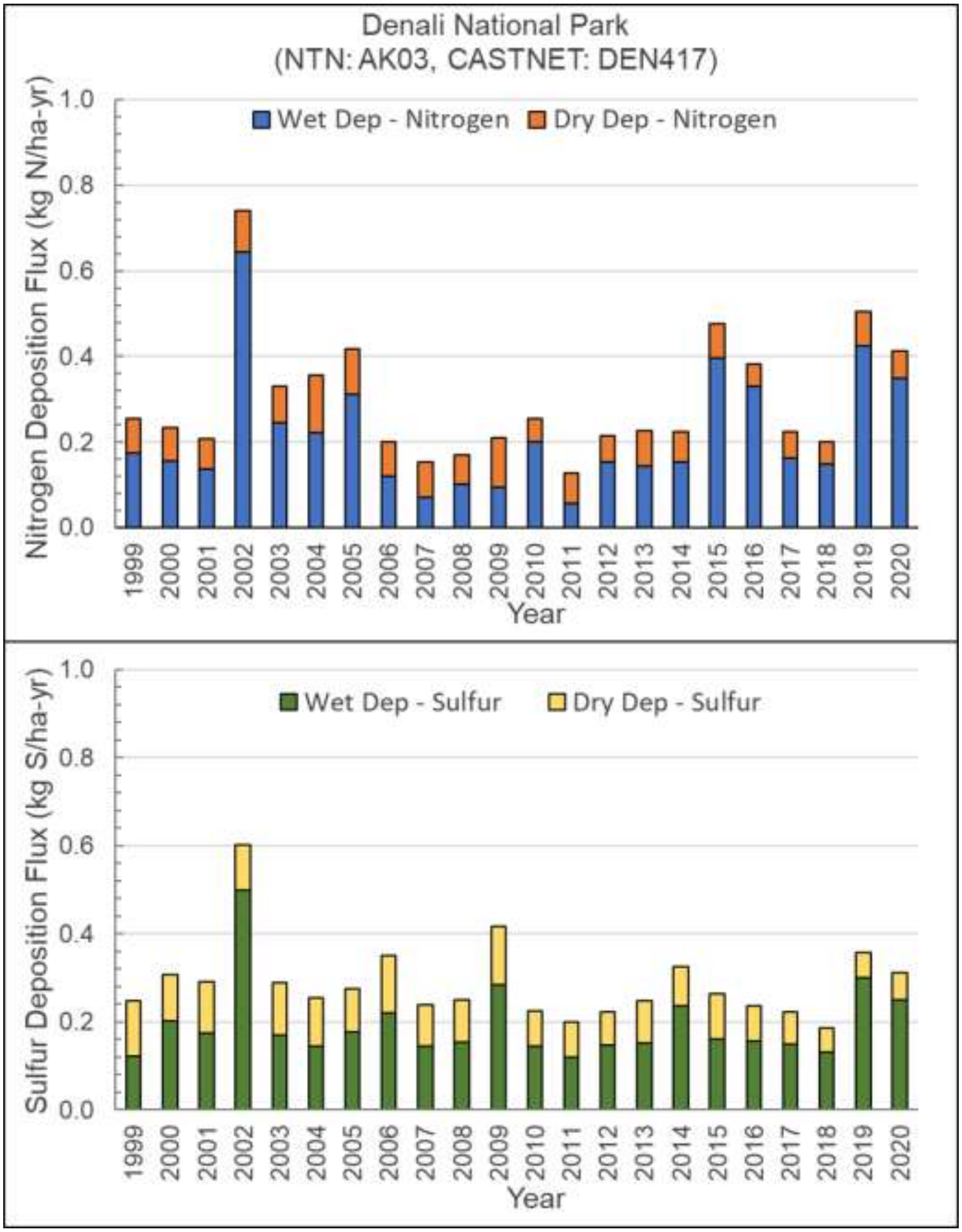
Figure 1-7. Trends in Wet Deposition of Ammonium (NH_4^-), Nitrate (NO_3^-), and Sulfate (SO_4^{-2}) at Poker Creek.



Source: NADP 2023

Figure 1-8. Trends in Wet Deposition of Ammonium (NH_4^-), Nitrate (NO_3^-), and Sulfate (SO_4^{-2}) at Denali National Park.

Total (wet and dry) nitrogen and sulfur deposition fluxes are shown in Figure 1-9. Total nitrogen deposition fluxes in all years are well below the critical load for the tundra ecoregion of Alaska of 1.0 to 3.0 kg N/ha/yr (Sullivan 2016). A critical load is the level of deposition below which no harmful effects are expected to an ecosystem.



Source: EPA 2023b

Figure 1-9. Total Nitrogen and Sulfur Deposition Flux at Denali National Park.

1.2 Supporting Information for Environmental Consequences

1.2.1 Oil and Gas Emissions in the Program Area

An emission inventory of criteria and hazardous air pollutants and greenhouse gases (GHGs) is developed for each action alternative (i.e., Alternatives B, C, and D). The inventory includes emissions from construction, drilling and completion of new wells, operation and maintenance activities, and processing, storage, and transfer of produced oil and gas from hypothetical developments in the program area. The Reasonably Foreseeable Development (RFD) scenario for oil and gas resources in the Coastal Plain (Appendix B of the Draft SEIS) provides annual estimates of the oil production from hypothetical developments under each alternative. The RFD notes that there are currently no gas pipelines connecting the North Slope to potential markets and any future gas pipelines would likely first connect to better characterized and established gas fields. It assumes that natural gas would re-injected into the formation to maintain reservoir pressure and enhance oil recovery. Thus, estimated emissions from natural gas are limited to use within the program area as discussed below.

1.2.1.1 Emission Inventory Development Methodology

Emission inventories are prepared for the oil and gas RFD scenarios for Alternatives B, C, and D described in Appendix B of the Draft SEIS. The RFD includes projected oil production from one to four hypothetical developments depending on the action alternative; the RFD assumes that each individual hypothetical development has the same annual production schedule. Emissions are calculated using year-specific estimates for each action alternative of (i) oil production from the RFD scenario and (ii) emission rates per unit of oil production.

Emission rates per unit of oil production are developed using data from the Willow project oil and gas emission inventory for Alternative E in the Willow Master Development Plan Final SEIS (BLM 2023). The Willow project represents a future large development on Alaska's North Slope (Figure 1-1), which includes one CPF, three to five well pads, and associated infrastructure. To support development of Alternative B, C, and D emissions, annual emissions per barrel of oil production are estimated from Willow Alternative E, which is a 3-pad development with a deferred fourth pad. The Willow Alternative E-based emission rates include emissions associated with reinjection of natural gas into producing oil formations and use for fueling plant and facility equipment.

Three representative developments are developed using the emissions from Willow Alternative E to develop the emissions inventory for the various hypothetical CPF and well pad combinations under each action alternative described in the RFD:

- Alternative B: The RFD scenario for Alternative B includes four hypothetical developments with four total CPFs and 14 total satellite pads (Appendix B of the SEIS). The emissions inventory for Alternative B is developed assuming two hypothetical developments with one CPF with three pads each and two hypothetical developments with one CPF with four pads each. The emission rates per unit of oil production for the 3-pad developments are developed using the 3-pad production and emissions from Willow Alternative E. The emission rates for the 4-pad development are estimated using the Willow Alternative E production rate with the 4-pad emissions (i.e., including emissions from the deferred fourth pad).

- Alternative C: The RFD scenario for Alternative C includes three hypothetical developments with two CPFs and 9 pads in total (Appendix B of the SEIS). The emissions inventory for Alternative C is conservatively developed using three hypothetical developments with a CPF and three satellite pads each using the 3-pad production and emissions from Willow Alternative E.

- Alternative D: The RFD scenario for Alternative D includes one hypothetical development with a single CPF and 6 pads. The emission rates per unit of oil production for the 6-pad development are developed using the Willow Alternative E 3-pad production with the 3-pad emissions plus the emissions from three additional pads.

The 3-pad production values are used to develop the representative emission factors because the production schedule of each hypothetical development for each action alternative is the same regardless of the number of well-pads. Thus, these representative development emission factors are conservatively high.

For each hypothetical development, annual emissions are estimated for pre-development years (i.e., years with construction and development before first oil production) as the product of Willow Alterative E annual emissions and the ratio of the peak annual oil production of the Coastal Plain action alternative and the peak annual production from Willow Alternative E. Annual emissions for each hypothetical development are estimated for production years (i.e., years with oil production) as the product of Willow Alternative E annual emissions per barrel and the annual barrels of oil projected for each hypothetical development.

For each action alternative, the peak year of emissions are reported. The peak emission year is selected by finding the maximum emission year for each pollutant. The peak emission years are as follows: Alternative B, Year 37 (2059); Alternative C, Year 37 (2059); and Alternative D, Year 31 (2053). For each action alternative, the maximum emission year is the same for all pollutants, except PM_{10}, benzene, and formaldehyde in Alternative B which peak in Year 33 (2055); formaldehyde in Alternative C which peaks in Year 20 (2042); and formaldehyde in Alternative D which peaks in year 14 (2036).

The temporal scope, pollutants, and source categories for the emissions inventory are listed below.

Temporal Scope

- Years: Peak Emission Year for each action alternative
- Period: Annual

Pollutants

- Criteria air pollutants and precursors: NO_x, SO_2, PM_{10}, $PM_{2.5}$, VOC, CO
- Greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), 100-year and 20-year carbon dioxide equivalents (CO_2e)
- Hazardous air pollutants: formaldehyde, n-hexane, benzene, toluene, ethylbenzene, xylenes

Source Categories

- Construction
    - Drill Pads
    - Gravel Roads, Valve Pads, and Water Access Pads

    - Ice Pads
    - Ice Roads
    - Pipelines
    - Central Processing Facility (CPF)
    - Airstrip construction (at CPF)
    - Air and ground transport for personnel and supplies
    - Power generation for construction
- Drilling
    - Well Drilling
    - Air and ground transport for personnel and supplies
- Operation
    - Drill Pads
    - Central Processing Facility
    - Support equipment (turbines/generators, heaters, incinerators, flares, etc.)
    - Power generation and injection turbines
    - Air and ground transport for personnel and supplies

1.2.1.2 Results

Oil and gas emission inventory results for the peak emission year for each action alternative are summarized in Table 1-9. GHG emissions are calculated annually and are reported in Section 2.2.1.

Table 1-9. Peak Annual Emissions of Criteria and Hazardous Air Pollutants and Greenhouse Gases under Alternatives B, C, and D

Pollutant	Alternative B	Alternative C	Alternative D
Criteria Air Pollutants and Precursors (short tons/year)			
NO_x	3,074	2,488	1,011
CO	2,915	2,360	956
VOC	2,646	2,018	1,154
SO_2	246	200	79
PM_{10}	795	645	258
$PM_{2.5}$	374	303	121
Hazardous Air Pollutants (short tons/year)			
Total HAPs[1]	335	254	151
Benzene	4	3	2
Toluene	11	9	4
Ethylbenzene	44	33	22
Xylenes	87	64	43
n-Hexane	135	101	62
Formaldehyde	54	44	17

[1] Estimated as the sum of emissions of benzene, toluene, ethylbenzene, xylenes, formaldehyde, and n-hexane.

1.2.2 Regional Photochemical Modeling

Regional photochemical modeling is conducted with the Comprehensive Air quality Model with Extensions (CAMx)[1] to assess impacts of hypothetical development scenarios in the program area on air quality and AQRVs. CAMx is a state-of-the-science photochemical grid model with a "one-atmosphere" treatment of tropospheric air pollution (ozone, particulates and precursors) over spatial scales ranging from neighborhoods to continents. CAMx has been used to analyze air quality impacts in other modeling studies in the U.S., including State Implementation Plans and other actions related to EISs by BLM and other agencies under NEPA and programmatic NEPA assessments, and by the EPA to support federal rulemaking.

CAMx modeling was previously performed for the Willow Master Development Plan EIS (BLM 2023), a proposed oil and gas development located west of the Coastal Plain. The Willow base case simulation at 4 km resolution was evaluated for maximum daily 8-hour ozone, and 24-hr averaged $PM_{2.5}$ and $PM_{2.5}$ species (sulfate, nitrate, ammonium, elemental carbon, organic carbon, crustal soil, and sodium). Overall, the model was shown to perform reasonably well. Details of the model performance evaluation are provided in Attachment B of the ARTSD for the Willow EIS (BLM 2023). The Willow future year (2025) photochemical modeling database includes Willow and other existing and reasonably foreseeable cumulative sources on the North Slope as described in Section 1.2.2.3 below

In the Coastal Plain EIS, the Willow CAMx modeling platform is supplemented with emissions from hypothetical development scenarios in the program area to assess a range of potential air quality and AQRV impacts resulting from oil and gas development. Impacts are assessed throughout the 4 km resolution modeling domain and specifically at the areas shown in Figure 1-10. The 4 km domain is centered on the North Slope of Alaska. The meteorology, boundary conditions, and other modeling configuration parameters are discussed in BLM (2023). The emissions applied in the modeling are discussed below.

[1] https://www.camx.com/

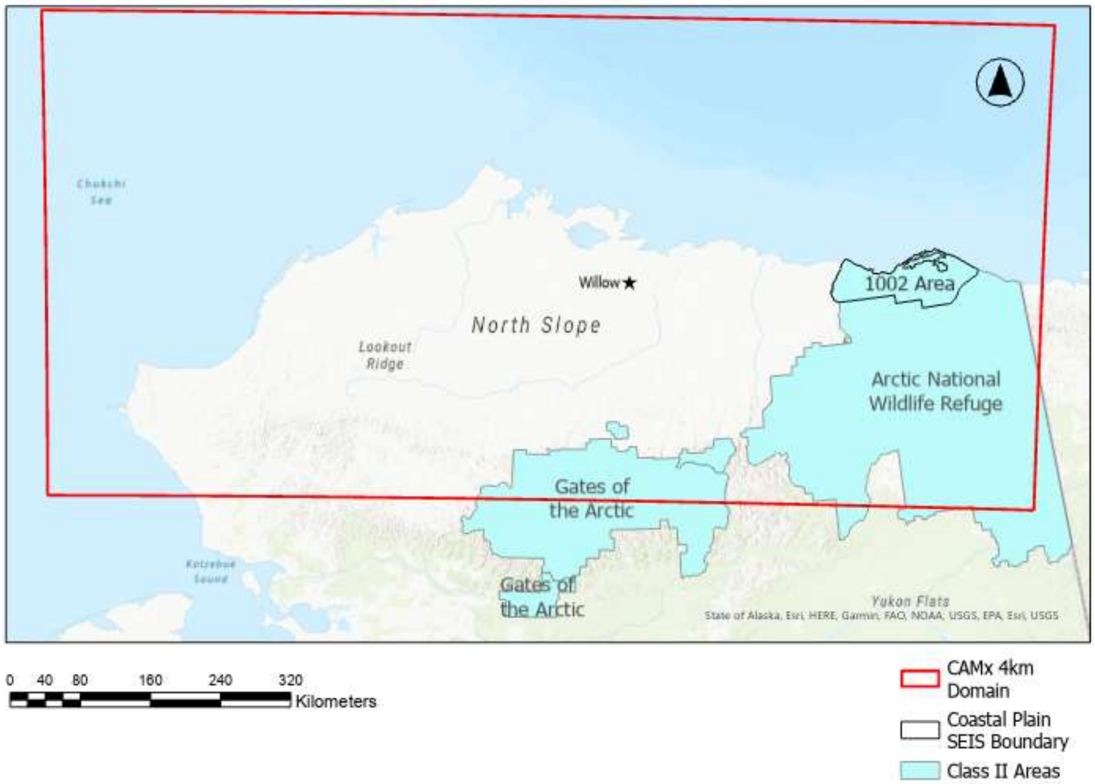


Figure 1-10. Regional CAMx modeling domain and assessment areas.

Air quality impacts are assessed by comparing modeled criteria air pollutant (CAP) levels (including O_3, $PM_{2.5}$, PM_{10}, NO_2, SO_2, and CO) to the applicable NAAQS and AAAQS listed in Table 1-1. AQRV impacts include changes in visibility and atmospheric deposition. Modeled visibility is compared to natural background conditions and modeled cumulative nitrogen deposition is compared to critical load thresholds of 1.0 to 3.0 kg/ha-yr for the Alaska tundra region (Pardo et al. 2011, Sullivan 2016). Sulfur deposition is also modeled.

1.2.2.1 Modeling Scenarios

Three CAMx model runs are performed:

- Run 1 is the No Action Alternative scenario (also named base case scenario) which includes the regional cumulative emissions in the North Slope and the Willow project development (BLM 2023) but without the oil and gas RFD in the program area. This run serves as the base case cumulative scenario.
- Run 2 is a high oil and gas development scenario that is consistent with the oil and gas RFD for Alternative B. It includes the base case cumulative emissions and additional emissions from four hypothetical future developments in the program including four CPFs, 14 well pads, and associated infrastructure. Each development has one CPF. Out of the 14 well pads, two of the developments are assumed to have 3 well pads and two others are assumed to have 4 well pads.
- Run 3 is a low oil and gas development scenario, which includes the base case cumulative emissions and additional emissions from one potential future development in the program area that includes one CPF, four well pads, and

associated infrastructure. Together the low and high development scenarios in the modeling provide a lower and upper bound around the action alternatives.

1.2.2.2 Development of Oil and Gas Emissions for Modeling High and Hypothetical low Development Scenarios

This section provides an overview of oil and gas emissions included in the CAMx modeling of hypothetical development in the Coastal Plain.

For the high and low development scenarios, peak annual emissions are modeled for four hypothetical developments and one hypothetical development, respectively, using the emissions for Alternative B from Section 1.2.1.2, and therefore the analysis is generally conservative. The modeled oil and gas emissions for the high development scenario are the same as those shown in Table 1-9 for Alternative B. Table 1-10 presents the modeled oil and gas emissions for the low development scenario which are lower than the emissions under all action alternatives (Section 1.2.1.2).

Each alternative has lease stipulations and Required Operating Procedures (ROPs) which restrict where future developments can occur in the program area. Developments would only occur on lands open for leasing. The CPFs for each hypothetical future development modeled are located only in areas subject to standard terms and conditions. The well pads are placed in areas subject to standard terms and conditions or subject to controlled surface use or subject to timing limitations. No developments are modeled in areas of no surface occupancy (NSO) or on Kaktovik Inupiat Corporation native lands.

Table 1-10. Modeled Oil and Gas Emissions for the Hypothetical low Development Scenario

Pollutant	Annual Emissions (short tons/year)
NO_x	771
CO	731
VOC	712
SO_2	61
PM_{10}	199
$PM_{2.5}$	93

1.2.2.3 Other Cumulative Regional Emissions for CAMx Modeling

An emissions inventory for all sources within the modeling domain is required for the CAMx regional modeling. This section provides a brief overview of the regional emissions (other than the program area oil and gas inventory) for the far-field CAMx modeling. These cumulative emissions are from regional CAMx modeling performed for the Willow EIS and are described in detail in BLM (2023).

The SMOKE (Sparse Matrix Operator Kerner Emissions) modeling system was used to prepare and process emissions inputs into the format required by CAMx. A complete emissions inventory for photochemical modeling including point sources, area sources, non-road and on-road mobile sources, sea salt, dust, biogenic emissions, lightning-related emissions, and fire emissions was applied in the modeling.

Regional emissions for the CAMx far-field modeling for sources other than the future hypothetical developments in the program area are based on the Bureau of Ocean Energy

Management (BOEM) Arctic Air Quality Modeling Study (Fields Simms 2018; Stoeckenius 2017) with revisions for the Willow EIS (BLM 2023) to account for known future projects. A summary of existing regional emissions for the North Slope and adjacent waters (the Beaufort Sea and Chukchi Sea planning areas) is available from the BOEM modeling study (Fields Simms 2018) and the BLM Willow EIS (BLM 2023). Existing emissions from onshore sources (e.g., oil and gas production and exploration, airports, pipelines, and non-oil and gas-related stationary and mobile sources) comprise most of the total regional emissions; emissions from offshore sources (e.g., drilling rigs, survey/drilling vessels and aircraft, and commercial vessels) are small in comparison. Overall, onshore oil and gas sources comprise the largest fraction of existing emissions for all CAPs in the 4 km domain except for PM from unpaved roads.

1.2.2.4 Air Quality Impacts Analysis Approach

Modeled concentrations are processed in the form of the NAAQS and AAAQS for CAPs and are compared to these standards. CAMx hourly concentrations for each model grid cell are averaged to the appropriate period (see Table 1-1). This process is performed for the entire 4 km modeling domain. The modeled impacts from the hypothetical high and low development scenarios are derived by difference of modeled concentrations between the scenarios that include additional development (Run 2 and Run 3 described in Section 1.2.2.1) and the base case cumulative scenario (Run 1). This difference is calculated using modeled concentrations in the form of the NAAQS.

1.2.2.5 Air Quality Related Values Impacts Analysis Approach

Air quality related value (AQRV) impacts for atmospheric deposition and visibility impairment are assessed. Atmospheric nitrogen and sulfur deposition are evaluated at two federally managed Class II areas: the Arctic National Wildlife Refuge and Gates of the Arctic National Park. Visibility impairment is assessed at the nearest Class I area, Denali National Park. The visibility impairment calculation requires data on background extinction and other visibility parameters in the IMPROVE equation; these data are available only for Class I areas. Since Denali is outside the modeling domain, modeled visibility impacts at Gates of the Arctic (the closest area to Denali within the domain) are used as a surrogate for evaluation using background extinction and other visibility parameters for Denali.

Total nitrogen and sulfur deposition, including both wet and dry deposition fluxes, are derived in CAMx by aggregating the hourly model output to annual totals for each grid cell. Both the maximum and the average total deposition from all cells within the assessment areas are reported for the sum of all nitrogen containing compounds and likewise for sulfur. Cumulative modeled total nitrogen deposition fluxes are compared to critical loads for atmospheric nitrogen deposition. The critical load for nitrogen deposition in the Alaska tundra ecoregion is 1.0 to 3.0 kg N/ha-yr (Pardo et al. 2011, Sullivan 2016).

Visibility impacts due to oil and gas development in the program area for the high and low development scenarios are determined by calculating the incremental changes in the visibility extinction from background concentrations due to the oil and gas emissions under each scenario. The quantity that measures the extinction changes in the Haze Index is referred to as “delta deciview” (Δdv). The modeled visibility impacts from high and low oil and gas development scenarios are compared to 0.5 Δdv and 1.0 Δdv thresholds consistent with Federal Land Manager Air Quality Related Values Work group (FLAG) guidance (2010).

1.2.2.6 Photochemical Modeling Results

Table 1-11 and Table 1-13 provide a summary of modeled maximum cumulative ambient air quality concentrations in the hypothetical high and low development scenarios, respectively, for all criteria pollutants in the modeling domain and assessment areas. The modeled cumulative air quality concentrations for all criteria pollutants are below the NAAQS and AAAQS in both hypothetical development scenarios (the ambient air quality standards are shown in Table 1-11).

Figure 1-11 shows the spatial distribution of modeled impacts to ambient air NO_2 concentrations due to oil and gas development in the program area in the hypothetical high and low development scenarios. Modeled peak impacts to NO_2 concentrations are over 10 ppb (12.8 ppb) in the high development scenario and 6.8 ppb in the low development scenario. Similar figures with the spatial distribution of modeled impacts for other criteria pollutants and different forms of the NAAQS are presented in Appendix A.

The results presented in the figures in Appendix A indicate that the maximum impacts for all pollutants due to hypothetical oil and gas development are located within the program area, except for ozone whose peak impacts are located just outside the program area; ozone is a secondary pollutant formed from precursor emissions of NO_x and VOC in the program area. Peak ozone impacts due to high and low hypothetical development scenarios are 2.2 ppb and 0.8 ppb, respectively. Maximum CO impacts in the high scenario are 0.005 ppm and 0.003 ppm for the low scenario. Peak $PM_{2.5}$ impacts for the high scenario are 2.1 μg/m^3 and 1.5 μg/m^3 for the low scenario. Maximum PM_{10} impacts for the high scenarios are 23.4 μg/m^3 and 16.4 μg/m^3, for the low scenario. Finally, peak SO_2 impacts for the high and low development scenarios are 0.56 ppb and 0.46 ppb, respectively.

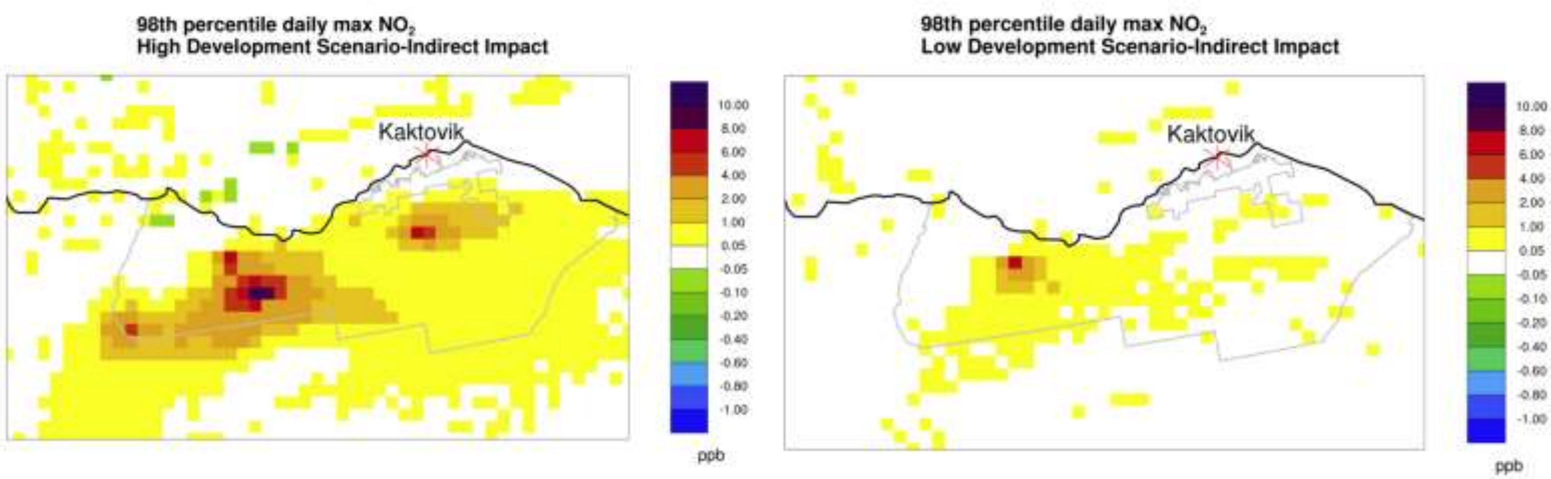


Figure 1-11. Modeled Spatial Distribution of NO_2 impacts due to the Hypothetical High (left) and Low (right) Oil and Gas Development scenarios.

Table 1-12 shows modeled impacts under the hypothetical high development scenario for all criteria pollutants in terms of the standards; the values shown are the oil and gas development impacts at the location and time of the peak cumulative impacts in each area. In the program area, modeled oil and gas development impacts under the high development scenario represent 84% of the cumulative annual average NO_2 concentrations, 0.6% of the cumulative 1-hour NO_2 peak concentrations, 17% of the cumulative annual $PM_{2.5}$ concentrations, 13% of the cumulative 24-hour $PM_{2.5}$ concentrations and 63% of the cumulative 24-hour PM_{10} concentrations. In general, at other assessment areas and in the modeling domain because the peak cumulative impacts due to all regional emission sources on the North Slope occur in locations that are far from the program area, the peak impacts from the hypothetical high development are small at those locations (also see figures titled "High Development Scenario-Cumulative" and "High Development Scenario-Indirect Impact" in Appendix A) and the cumulative concentrations are largely the result of other regional sources. At Kaktovik, modeled oil and gas development impacts under the high development scenario represent 25% of the cumulative annual average NO_2 concentrations, 2% of the cumulative annual $PM_{2.5}$ concentrations, 0.2% of the cumulative 24-hour $PM_{2.5}$ concentrations and 3% of the cumulative 1-hour SO_2 concentrations. Modeled impacts at Kaktovik for other pollutants and forms of the NAAQS are close to zero.

Table 1-14 shows the modeled impacts under the hypothetical low development scenario for all criteria pollutants in terms of the standards. In the program area, modeled oil and gas development impacts under the low development scenario represent 79% of the cumulative annual average NO_2 concentrations, 0.1% of the cumulative 1-hour NO_2 peak concentration, 12% of the cumulative annual $PM_{2.5}$ concentration, 12% of the cumulative 24-hour $PM_{2.5}$ concentration and 54% of the cumulative 24-hour PM_{10} concentrations. In general, at other assessment areas and in the modeling domain because the peak cumulative impacts due to all regional emission sources on the North Slope occur in locations that are far from the program area, the peak impacts from the hypothetical low development are small at those locations (also see figures titled "Low Development Scenario-Cumulative" and "Low Development Scenario-Indirect Impact" in Appendix A) and the cumulative concentrations are largely the result of other regional sources. At Kaktovik, modeled oil and gas development impacts under the low development scenario represent 9% of the cumulative annual average NO_2 concentrations, 1% of the cumulative annual $PM_{2.5}$ concentration and 0.02% of the cumulative 24-hour $PM_{2.5}$. Modeled impacts at Kaktovik for other pollutants and forms of the NAAQS are close to zero. Overall, as expected, impacts are lower in the low development scenario compared to the high development scenario.

Figures of cumulative concentrations for all pollutants and each modeling scenario's indirect impacts are provided under separate cover as part of Appendix A.

Table 1-11 Modeled Cumulative Concentrations under the Hypothetical High Development Scenario

	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
	ppm	ppm	ppb	ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm
Primary NAAQS and AAAQS[a]	**9**	**35**	**100**	**53**	**70**	**12**	**35**	**150**	**75**	**0.5**
Secondary NAAQS	**NA**	**NA**	**NA**	**53**	**70**	**15**	**35**	**150**	**NA**	**0.5**
Modeled Concentrations										
Program Area	0.18	0.18	18.24	3.53	43.47	2.91	6.74	29.30	0.85	0.0008
Arctic National Wildlife Refuge (excluding Program Area)	0.44	0.62	3.86	0.61	56.29	2.51	5.92	30.48	0.74	0.0021
Gates of the Arctic	0.17	0.18	1.23	0.19	53.44	1.44	3.92	9.88	0.68	0.0009
Kaktovik	0.17	0.17	5.22	0.57	39.26	2.25	7.26	14.29	0.29	0.0003
Full Domain[1]	0.90	3.08	72.39	22.02	56.29	10.05	31.35	121.33	58.07	0.0574

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 modeling domain.

[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.

Table 1-12 Modeled Concentrations in the Hypothetical High Oil and Gas Development Scenario at the location and time of the peak cumulative impact in each area.

	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
	ppm	ppm	ppb	ppb	ppb	µg/m^3	µg/m^3	µg/m^3	ppb	ppm
Primary NAAQS and AAAQS[a]	**9**	**35**	**100**	**53**	**70**	**12**	**35**	**150**	**75**	**0.5**
Secondary NAAQS	**NA**	**NA**	**NA**	**53**	**70**	**15**	**35**	**150**	**NA**	**0.5**
Modeled Concentrations										
Program Area	0.000	0.000	0.090	2.947	0.004	0.487	0.873	18.435	0.386	0.00026
Arctic National Wildlife Refuge (excluding Program Area)	0.000	0.000	0.894	0.003	0.001	0.029	0.014	0.000	0.000	0.00000
Gates of the Arctic	0.000	0.000	0.000	0.002	0.005	0.002	0.000	0.001	0.000	0.00000
Kaktovik	0.000	0.000	0.000	0.137	0.000	0.050	0.006	0.003	0.007	0.00003
Full Domain[1]	0.000	0.000	0.000	0.003	0.001	0.001	0.000	0.000	0.000	0.00000

NA indicates "not applicable"

1 Full Domain values represent the program area oil and gas impacts at the location and time of the peak cumulative impact anywhere in the North Slope modeling domain and happen to be zero here.

[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.

Table 1-13 Modeled Cumulative Concentrations under the Hypothetical Low Development Scenario

	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
	ppm	ppm	ppb	ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm
Primary NAAQS and AAAQS[a]	**9**	**35**	**100**	**53**	**70**	**12**	**35**	**150**	**75**	**0.5**
Secondary NAAQS	**NA**	**NA**	**NA**	**53**	**70**	**15**	**35**	**150**	**NA**	**0.5**
Modeled Concentrations										
Program Area	0.18	0.18	18.18	2.72	43.46	2.75	6.70	23.41	0.68	0.0007
Arctic National Wildlife Refuge (excluding Program Area)	0.44	0.62	2.97	0.61	56.29	2.49	5.91	30.48	0.74	0.0021
Gates of the Arctic	0.17	0.18	1.23	0.19	53.43	1.43	3.92	9.88	0.68	0.0009
Kaktovik	0.17	0.17	5.22	0.48	39.26	2.22	7.26	14.29	0.28	0.0003
Full Domain[1]	0.90	3.08	72.39	22.02	56.29	10.05	31.35	121.33	58.07	0.0574

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.

Table 1-14 Modeled Concentrations in the Hypothetical Low Oil and Gas Development Scenario at the location and time of the peak cumulative impact in each area.

	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
	ppm	ppm	ppb	ppb	ppb	µg/m³	µg/m³	µg/m³	ppb	ppm
Primary NAAQS and AAAQS[a]	**9**	**35**	**100**	**53**	**70**	**12**	**35**	**150**	**75**	**0.5**
Secondary NAAQS	**NA**	**NA**	**NA**	**53**	**70**	**15**	**35**	**150**	**NA**	**0.5**
Modeled Concentrations										
Program Area	0.000	0.000	0.025	2.141	0.001	0.323	0.837	12.545	0.219	0.00019
Arctic National Wildlife Refuge (excluding Program Area)	0.000	0.000	0.000	0.001	0.000	0.006	0.002	0.000	0.000	0.00000
Gates of the Arctic	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00000
Kaktovik	0.000	0.000	0.000	0.045	0.000	0.015	0.001	0.001	0.000	0.00000
Full Domain[1]	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.00000

NA indicates "not applicable"

1 Full Domain values represent the program area oil and gas impacts at the location and time of the peak cumulative impact anywhere in the North Slope modeling domain and happen to be zero here.

[a] AAAQS are presented in units consistent with the Primary NAAQS to assist with comparison to modeled impacts.

Modeled total annual nitrogen (N) and sulfur (S) fluxes are evaluated in the following areas: Arctic National Wildlife Refuge (excluding the program area), the program area, and Gates of the Arctic. Table 1-15 presents the spatial maximum and average of cumulative modeled nitrogen and sulfur deposition across each of these three areas in the hypothetical high development scenario. Similarly, Table 1-16 presents the cumulative deposition in the hypothetical low development scenario. Spatial maps of modeled cumulative nitrogen and sulfur deposition are provided in Appendix A.

The cumulative nitrogen deposition impacts shown in Table 1-15 for the hypothetical high development scenario are below or within the critical load range at the three areas assessed. Across these areas, maximum annual cumulative nitrogen deposition in the hypothetical high development scenario ranges from approximately 0.6 to 2.1 kg N/ha-yr while average nitrogen deposition ranges from approximately 0.3 to 0.6 kg N/ha-yr. The average nitrogen deposition values are below the critical loads in all three areas. Maximum annual cumulative sulfur deposition varies from approximately 0.6 to 0.7 kg S/ha-yr while average sulfur deposition varies from 0.3 to 0.4 kg S/ha-yr.

Table 1-15. Cumulative Deposition in the Hypothetical High Development Scenario: 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 (excluding Program Area)	0.67	0.33	Below	0.71	0.32
Program Area	2.05	0.63	Within	0.58	0.28
Gates of the Arctic	0.59	0.38	Below	0.68	0.37

Cumulative nitrogen deposition fluxes shown in Table 1-16 for the hypothetical low development scenario are below or within the critical load range at all areas assessed. Maximum annual cumulative nitrogen deposition varies from 0.6 to 1.4 kg N/ha-yr across these three assessment areas while average nitrogen deposition varies from 0.3 to 0.5 kg N/ha-yr. Maximum annual cumulative sulfur deposition varies from 0.4 to 0.7 kg S/ha-yr while average sulfur deposition varies from 0.3 to 0.4 kg S/ha-yr.

Table 1-16. Cumulative Deposition in the Hypothetical Low Development Scenario: 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 (excluding Program Area)	0.66	0.33	Below	0.71	0.32
Program Area	1.44	0.51	Within	0.43	0.26
Gates of the Arctic	0.59	0.38	Below	0.68	0.37

Table 1-17 shows the modeled impacts of the hypothetical high development scenario on visibility. The values shown were determined by difference between the high development scenario and the No Action Alternative scenario. Table 1-18 similarly shows modeled visibility impacts in the hypothetical low development scenario. The 1 and 0.5 Δdv thresholds are never exceeded in the low development scenario. The 1 Δdv threshold is not exceeded in the high development scenario but the 0.5 Δdv threshold is exceeded for three days (out of 365). The maximum expected visibility impacts are 0.936 Δdv and 0.243 Δdv in the high and low development scenarios, respectively. The visibility impacts during the 20 percent worst days (W20) are generally an order of magnitude lower than the maximum values. The visibility impacts at Denali NP would be lower than those shown here as it is farther away from any oil and gas development that would occur in the program area compared to the Gates of the Arctic.

Table 1-17. Modeled Visibility Impacts in the High Development Scenario

Assessment Area	Δdv (Max)	Δdv (98th percentile)	Δdv (W20[a])	Δdv (B20[b])	Number of Days	
					Δdv > 1	Δdv > 0.5
Gates of the Arctic[c]	0.936	0.280	0.072	0.000	0	3

[a] Average of the Delta-deciview values for days in a full year above the 80th percentile (20% worst visibility days).
[b] Average of the Delta-deciview values for days in a full year below the 20th percentile (20% best visibility days).
[c] Gates of the Arctic is the closest area to Denali NP that is within the 4 km modeling domain and its impacts serve as surrogate impacts for Denali NP

Table 1-18. Modeled Visibility Impacts in the Low Development Scenario

Assessment Area	Δdv (Max)	Δdv (98th percentile)	Δdv (W20[a])	Δdv (B20[b])	Number of Days	
					Δdv > 1	Δdv > 0.5
Gates of the Arctic[a]	0.243	0.074	0.018	0.000	0	0

[a] Average of the Delta-deciview values for days in a full year above the 80th percentile (20% worst visibility days).
[b] Average of the Delta-deciview values for days in a full year below the 20th percentile (20% best visibility days).
[c] Gates of the Arctic is the closest area to Denali NP that is within the 4 km modeling domain and its impacts serve as surrogate impacts for Denali NP

1.2.3 Near-field Model Tiering

The near-field air quality impacts of a potential development in the Coastal Plain were estimated by incorporating by reference a near-field modeling analysis conducted for the Willow EIS (BLM 2023). Results from the near-field analysis conducted for Alternative E the Willow project are provided below and used as a surrogate for the near-field analysis for the Coastal Plain SEIS. Near-field impacts from a future development in the Coastal Plain of the same scale as Willow with similar nearby RFFAs are expected to be generally similar to those modeled for the Willow project as discussed below.

The EPA regulatory air dispersion model AERMOD was used to assess concentrations of CAPs (excluding O_3 and Pb) and select HAPs within 31 miles (50 km) of the project for five development scenarios – construction, two pre-drilling scenarios, developmental drilling, and routine operations:

- The construction scenario included the construction of drill sites, a processing facility, an operations center, an airstrip, gravel access roads, pipelines, communications facilities, living quarters, temporary facilities (seasonal ice roads to gravel mines, ice pads, etc.), and additional infrastructure.
- Pre-drilling activities occur before the processing facility is fully functional so electricity would not be available for electric drill rigs to operate. Diesel-fired drill rigs, hydraulic fracturing units, and associated ancillary support equipment would be used until highline power is available. Two pre-drilling scenarios were modeled, one for pre-drilling activities occurring with two diesel-fired drill rigs, and a second with one diesel-fired drill rig.
- The developmental drilling scenario included drilling and hydraulic fracturing operations occurring at the same time as localized construction and operational activities throughout the Willow project area.
- The routine operations scenario involves the production and processing of oil, gas, and produced water after temporary and transient activities associated with construction and drilling are complete.

Flare emissions were included in the developmental drilling and routine operations scenarios using two different operating conditions, typical operations and emergency or upset conditions. Maximum flaring emissions occur during emergency/upset conditions. The modeled short-term impacts included flares operating at upset conditions with maximum hourly rates for all hours of the year. Long term impacts included upset conditions for up to 10 hours per year. In addition to Willow project sources, emissions from Reasonably Foreseeable Future Action (RFFA) sources within 31 miles of the Willow project area were also included for the developmental drilling and routine operations scenarios to assess expected cumulative long-term CAPs and HAPs impacts. A detailed description of the emissions inventory development for the Willow near-field modeling analysis is provided in BLM (2023).

Meteorology data used in the near-field modeling was prepared using the AERMET meteorological processor with five years of National Weather Service (NWS) surface and upper air observations. Observed data was obtained from nearby monitoring stations and was assumed to represent meteorological conditions in the Willow project area. Differences in meteorology and terrain at the Willow project site compared to the Coastal Plain potential future development site may cause differences in air quality impacts between the two.

Model results were assessed within the modeling domain and at a nearby community (Nuiqsut) located approximately 25 miles from the Willow project site. Modeled CAPs concentrations, in the form of the applicable standards, were added to background concentrations and the totals were compared to the NAAQS and AAAQS. Ambient air quality monitoring data from a nearby monitoring station (Nuiqsut Monitoring Station, approximately 25 miles from Willow project site) was used as representative ambient air background concentrations. Three years of data, from 2018-2020, were used to calculate background concentrations in the form of the NAAQS. The background concentrations used for the Willow project are not necessarily representative of background concentrations at the Coastal Plain potential future development site which may cause differences in air quality impacts between the two projects. AERMOD does not include the necessary chemical reactions to model O_3 or secondary $PM_{2.5}$ and these were instead assessed with regional CAMx modeling. Secondary $PM_{2.5}$ concentrations resulting from Willow project sources were estimated from the Willow CAMx analysis and the concentrations were added to the AERMOD $PM_{2.5}$ and PM_{10} modeled concentrations. More details on this process are provided in BLM (2023).

Select HAPs, including benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde, were modeled for the routine operations scenario only since emissions are substantially higher compared to other scenarios. These select HAPs are commonly emitted from oil and gas development. As mentioned above, the routine operations scenario included Willow project sources and RFFAs so the modeling results represent cumulative HAPs impacts. Modeled 1-hour and 8-hour cumulative HAP concentrations were compared to Acute Reference Exposure Limits (RELs) and Acute Exposure Guideline Levels (AEGLs). Annual cumulative HAPs concentrations were compared to non-cancer reference concentration thresholds (RfCs) and a cancer risk assessment was performed at a nearby community, comparing annual concentrations of carcinogenic HAPs (benzene, ethylbenzene, and formaldehyde) to a 1-in-1 million cancer threshold. Monitored HAPs in the North Slope of Alaska are frequently below the measurement detection limit, indicating that ambient air concentrations are typically low (see Section 1.1.2, Table 1-7 and Table 1-8). Background ambient air concentrations were therefore not added to the modeled results.

All CAPs and HAPs results are below the applicable standards and thresholds. Table 1-19 through Table 1-32 provide results within the modeling domain and at a nearby community (Nuiqsut) for each of the modeling scenarios.

Separate model runs were performed for the two flare operating conditions (typical and emergency/upset) and results are presented in Table 1-22 through Table 1-25 for cumulative CAPs impacts and Table 1-29 and Table 1-30 for HAPs cumulative impacts. The impacts of emergency flares were also modeled without other Willow project or RFFA sources for the routine operations scenario (Table 1-26 and Table 1-32Table 1-32). Emergency flares contributed a small portion of the total cumulative CAPs impacts from all sources, ranging from less than 1% to 7% depending on the pollutant. Emergency flaring HAPs impacts were substantially lower than the cumulative HAPs impacts except for formaldehyde, both in the model domain and at the nearby community, and n-hexane at the nearby community. The impact of RFFA sources during the routine operations scenario was also determined and compared to the total cumulative CAPs impacts from all sources. RFFAs contribute significantly, ranging from 3% to 74% of the total cumulative impacts within the modeling domain and from 1% to 34% at the nearby community.

Table 1-19. Near-field Impacts During Construction

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	10,828.2	27%	10,346.5	26%
CO	8 hours	3,863.6	39%	3,446.2	34%
NO_2	1 hour	131.5	70%	54.7	29%
NO_2	Annual	21.2	21%	4.0	4%
SO_2	1 hour	12.8	7%	9.7	5%
SO_2	3 hours	15.1	1%	10.4	1%
SO_2	24 hours	10.5	3%	9.4	3%
SO_2	Annual	1.9	2%	1.8	2%
PM_{10}	24 hours	49.9	33%	50.8	34%
$PM_{2.5}$	24 hours	18.5	53%	7.7	22%
$PM_{2.5}$	Annual	4.1	34%	1.7	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-20. Near-field Impacts During Pre-Drilling Activity with Two Diesel-Fired Drill Rigs

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,735.8	29%	10,326.5	26%
CO	8 hours	4,449.0	46%	3,438.4	34%
NO_2	1 hour	91.0	48%	28.9	15%
NO_2	Annual	14.0	14%	3.8	4%
SO_2	1 hour	12.8	7%	9.0	5%
SO_2	3 hours	13.5	1%	10.1	1%
SO_2	24 hours	11.4	3%	9.3	3%
SO_2	Annual	2.0	3%	1.8	2%
PM_{10}	24 hours	49.3	33%	10.5	7%
$PM_{2.5}$	24 hours	16.4	47%	7.5	21%
$PM_{2.5}$	Annual	3.6	30%	1.6	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2

which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-21. Near-field Impacts During Pre-Drilling Activity with One Diesel-Fired Drill Rig

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,117.1	28%	10,317.7	26%
CO	8 hours	4,067.8	41%	3,436.6	34%
NO_2	1 hour	82.3	44%	30.2	16%
NO_2	Annual	10.3	10%	3.8	4%
SO_2	1 hour	12.1	6%	9.0	5%
SO_2	3 hours	12.7	1%	10.1	1%
SO_2	24 hours	10.7	3%	9.3	3%
SO_2	Annual	1.9	2%	1.8	2%
PM_{10}	24 hours	41.8	28%	30.5	20%
$PM_{2.5}$	24 hours	13.0	37%	7.5	21%
$PM_{2.5}$	Annual	2.7	22%	1.6	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-22. Near-field Cumulative Impacts During Developmental Drilling With Typical Flare Activity

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,591.2	29%	10,326.8	26%
CO	8 hours	4,321.5	43%	3,442.9	34%
NO_2	1 hour	157.9	84%	41.2	22%
NO_2	Annual	28.6	29%	4.0	4%
SO_2	1 hour	34.5	18%	13.2	7%
SO_2	3 hours	36.5	3%	13.7	1%
SO_2	24 hours	22.4	6%	9.9	3%
SO_2	Annual	2.7	3%	1.8	2%
PM_{10}	24 hours	84.2	56%	10.9	7%
$PM_{2.5}$	24 hours	29.3	84%	7.7	22%

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
$PM_{2.5}$	Annual	6.1	51%	1.7	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-23. Near-field Cumulative Impacts During Developmental Drilling with Emergency Flare Activity

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,591.2	29%	10,330.6	26%
CO	8 hours	4,321.5	43%	3,444.7	34%
NO_2	1 hour	157.9	84%	41.2	22%
NO_2	Annual	28.6	29%	4.0	4%
SO_2	1 hour	34.5	18%	13.2	7%
SO_2	3 hours	36.5	3%	13.7	1%
SO_2	24 hours	22.4	6%	9.9	3%
SO_2	Annual	2.7	3%	1.8	2%
PM_{10}	24 hours	84.2	56%	10.9	7%
$PM_{2.5}$	24 hours	29.3	84%	7.7	22%
$PM_{2.5}$	Annual	6.1	51%	1.7	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-24. Near-field Cumulative Impacts During Routine Operations With Typical Flare Activity

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,591.0	29%	10,326.5	26%
CO	8 hours	4,350.7	44%	3,442.6	34%
NO_2	1 hour	162.1	86%	40.5	22%
NO_2	Annual	28.6	29%	4.0	4%
SO_2	1 hour	34.5	18%	13.2	7%
SO_2	3 hours	36.5	3%	13.7	1%
SO_2	24 hours	22.4	6%	9.9	3%
SO_2	Annual	2.7	3%	1.8	2%
PM_{10}	24 hours	83.1	55%	10.9	7%
$PM_{2.5}$	24 hours	29.5	84%	7.7	22%
$PM_{2.5}$	Annual	6.2	51%	1.7	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-25. Near-field Cumulative Impacts During Routine Operations With Emergency Flare Activity

Pollutant	Averaging Period	Total Concentration in Model Domain (μg/m³)	Percent of NAAQS/ AAAQS	Total Concentration at Nearby Community (μg/m³)	Percent of NAAQS/ AAAQS
CO	1 hour	11,591.0	29%	10,326.5	26%
CO	8 hours	4,350.7	44%	3,442.6	34%
NO_2	1 hour	162.1	86%	40.5	22%
NO_2	Annual	28.6	29%	4.0	4%
SO_2	1 hour	34.5	18%	13.2	7%
SO_2	3 hours	36.5	3%	13.7	1%
SO_2	24 hours	22.4	6%	9.9	3%
SO_2	Annual	2.7	3%	1.8	2%
PM_{10}	24 hours	83.1	55%	10.9	7%
$PM_{2.5}$	24 hours	29.5	84%	7.7	22%
$PM_{2.5}$	Annual	6.2	51%	1.7	14%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m^3 = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; NAAQS and AAAQS are the same for all pollutants except for 24-hour and annual SO_2 which do not have defined NAAQS. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-26. Near-field Impacts from Emergency Flaring Only During Routine Operations

Pollutant	Averaging Period	Maximum Modeled Concentration in Model Domain (μg/m^3)	Percent of Total Concen-tration	Maximum Modeled Concentration at Nearby Community (μg/m^3)	Percent of Total Concen-tration
CO	1 hour	124.0	1%	26.8	0%
CO	8 hours	33.7	1%	8.1	0%
NO_2	1 hour	8.9	6%	2.9	7%
NO_2	Annual	1.1E-04	0.0004%	3.0E-05	0.0008%
SO_2	1 hour	1.2	4%	0.3	3%
SO_2	3 hours	1.2	3%	0.3	2%
SO_2	24 hours	0.3	1%	0.1	1%
SO_2	Annual	1.0E-05	0.0004%	3.0E-06	0.0002%
PM_{10}	24 hours	0.7	1%	0.2	2%
$PM_{2.5}$	24 hours	3.8E-01	1%	0.1	1%
$PM_{2.5}$	Annual	4.0E-05	0.001%	1.0E-05	0.001%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; μg/m^3 = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; Maximum modeled concentration is from emergency flaring only. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-27. Near-field Impacts from Reasonably Foreseeable Future Action (RFFA) Sources Only During Routine Operations

Pollutant	Averaging Period	Maximum Modeled Concentration in Model Domain ($\mu g/m^3$)	Percent of Total Concen-tration	Maximum Modeled Concentration at Nearby Community ($\mu g/m^3$)	Percent of Total Concen-tration
CO	1 hour	352.3	3%	23.6	0.2%
CO	8 hours	237.5	5%	8.1	0.2%
NO_2	1 hour	65.2	41%	13.9	34%
NO_2	Annual	4.3	15%	0.1	3%
SO_2	1 hour	25.5	74%	4.2	32%
SO_2	3 hours	26.4	73%	3.7	27%
SO_2	24 hours	13.0	58%	0.6	6%
SO_2	Annual	0.9	32%	1.1E-02	0.6%
PM_{10}	24 hours	5.0	6%	0.5	4%
$PM_{2.5}$	24 hours	3.4	11%	0.2	2%
$PM_{2.5}$	Annual	0.4	7%	9.0E-03	0.5%

Source: BLM (2023)

Notes: NAAQS = National Ambient Air Quality Standards; AAAQS = Alaska Ambient Air Quality Standards; $\mu g/m^3$ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; Maximum modeled concentration is from RFFA sources only. Total concentration includes the maximum modeled concentration in the form of the NAAQS/AAAQS plus the background concentration. PM_{10} and $PM_{2.5}$ total concentrations also include secondary $PM_{2.5}$ impacts from CAMx modeling.

Table 1-28. Hazardous Air Pollutant (HAP) Thresholds

Pollutant	Acute REL (µg/m3)	AEGLs (µg/m3)	RfC (µg/m3)	Cancer Unit Risk Factor Thresholds (1/(µg/m3))
Benzene	27	29,000	30.0	7.80E-06
Ethylbenzene	--	140,000	260.0	2.50E-06
Formaldehyde	55	1,100	9.8	1.30E-05
n-Hexane	--	10,000,000	700.0	--
Toluene	5,000	250,000	5,000.0	--
Xylene	22,000	560,000	100.0	--

Source: EPA 2021a; EPA 2021b

Notes: REL = Reference Exposure Limit; AEGL = Acute Exposure Guideline Level; RfC = non-cancer reference concentration; $\mu g/m^3$ = micrograms per cubic meter;

Table 1-29. Near-field Cumulative HAPs Impacts During Routine Operations With Typical Flare Activity

Pollutant	Max 1-hour Modeled Conc. In Model Domain (µg/m³)	Max 8-hour Modeled Conc. In Model Domain (µg/m³)	Max Annual Modeled Conc. In Model Domain (µg/m³)	Max 1-hour Modeled Conc. At Nearby Community (µg/m³)	Max 8-hour Modeled Conc. At Nearby Community (µg/m³)	Max Annual Modeled Conc. At Nearby Community (µg/m³)
Benzene	9.9	7.0	0.3	0.8	0.1	0.002
Ethylbenzene	258.4	181.1	6.8	0.7	0.3	0.014
Formaldehyde	5.9	4.2	0.2	1.0	0.3	0.004
n-Hexane	632.2	443.1	16.7	3.3	0.7	0.040
Toluene	29.1	20.4	0.8	0.3	0.04	0.002
Xylene	508.9	356.7	13.4	1.3	0.6	0.028

Source: BLM (2023)

Notes: HAPs = Hazardous Air Pollutants; µg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area

Table 1-30. Near-field Cumulative HAPs Impacts During Routine Operations With Emergency Flare Activity

Pollutant	Max 1-hour Modeled Conc. In Model Domain (µg/m³)	Max 8-hour Modeled Conc. In Model Domain (µg/m³)	Max Annual Modeled Conc. In Model Domain (µg/m³)	Max 1-hour Modeled Conc. At Nearby Community (µg/m³)	Max 8-hour Modeled Conc. At Nearby Community (µg/m³)	Max Annual Modeled Conc. At Nearby Community (µg/m³)
Benzene	9.9	7.0	0.3	0.8	0.1	0.002
Ethylbenzene	258.4	181.1	6.8	0.7	0.3	0.014
Formaldehyde	46.2	11.2	0.2	6.9	4.1	0.004
n-Hexane	632.2	443.1	16.7	4.2	2.5	0.040
Toluene	29.1	20.4	0.8	0.3	0.1	0.002
Xylene	508.9	356.7	13.4	1.3	0.6	0.028

Source: BLM (2023)

Notes: HAPs = Hazardous Air Pollutants; µg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area

Table 1-31. Estimated Cancer Risk at a Nearby Community Due to Routine Operations Activity

Pollutant	Exposure Adjustment Factor	Max Annual Modeled Conc., Typical Flare Activity (µg/m³)	Cancer Risk, Typical Flare Activity	Max Annual Modeled Conc., Emergency Flare Activity (µg/m³)	Cancer Risk, Emergency Flare Activity
Benzene	4.30E-01	1.58E-03	5.30E-09	1.58E-03	5.30E-09
Ethylbenzene	4.30E-01	1.40E-02	1.70E-09	1.40E-02	1.70E-09
Formaldehyde	4.30E-01	3.62E-03	8.83E-09	3.65E-03	8.83E-09
		Total:	1.58E-08	Total:	1.58E-08

Source: BLM (2023)

Notes: µg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area

Table 1-32. Near-field HAPs Impacts from Emergency Flaring Only During Routine Operations

Pollutant	Max 1-hour Modeled Conc. In Model Domain (µg/m³)	Max 8-hour Modeled Conc. In Model Domain (µg/m³)	Max Annual Modeled Conc. In Model Domain (µg/m³)	Max 1-hour Modeled Conc. At Nearby Community (µg/m³)	Max 8-hour Modeled Conc. At Nearby Community (µg/m³)	Max Annual Modeled Conc. At Nearby Community (µg/m³)
Benzene	1.7	0.4	4.7E-06	0.2	0.1	1.3E-06
Ethylbenzene	0.1	0.02	2.7E-07	0.01	0.01	8.0E-08
Formaldehyde	46.2	11.2	1.3E-04	6.9	4.1	4.0E-05
n-Hexane	27.9	6.8	8.0E-05	4.2	2.5	2.0E-05
Toluene	1.5	0.4	4.2E-06	0.2	0.1	1.2E-06
Xylene	0.4	0.1	1.2E-06	0.1	0.04	3.4E-07

Source: BLM (2023)

Notes: µg/m³ = micrograms per cubic meter; The nearby community is approximately 25 miles from the Willow project area; Maximum modeled concentration is from emergency flaring only.

1.3 Supporting Information for Cumulative Impacts

Emissions for reasonably foreseeable future onshore oil and gas projects are quantified, where information is available, and included in the cumulative effects analysis. Applicable RFFA emissions in tons per year for oil and gas exploration, development, and production are presented in Table 1-33. Alpine CD-5 expansion project emissions are estimated using tons of pollutant per million barrels of oil (tons/MMBO) emission factors multiplied by the estimated barrels of oil per day. Daily emissions are then multiplied by 365 to get an annual total. The emission factors are estimated based on the Willow Project Alternative E (BLM 2023). Greater Mooses Tooth 1 and Greater Mooses Tooth 2 emissions are based on potential-to-emit (PTE) for stationary sources, as provided in their respective permit applications (Hirsch 2023). Willow emissions are obtained and presented for the selected Alternative E peak year (year 7) annual emissions prepared by BLM (2023). Nanushuk (Pikka) emissions are based on the maximum PTE emissions during overlapping drilling and operations phases (USACE 2018). The Alaska LNG project emissions are based on potential impact of construction emissions as estimated in the FSEIS prepared by the U.S. Department of Energy (2023).

Table 1-33. Emissions from Selected Reasonably Foreseeable Future Oil and Gas Projects Included in the Cumulative Effects Analysis.

Pollutant	Alpine CD-5 (tpy)	Greater Mooses Tooth 1 (tpy)[1]	Greater Mooses Tooth 2 (tpy)[2]	Willow (tpy)[3]	Nanushuk (tpy)[4]	Alaska LNG Project (tpy)[5]
NOx	435.8	74.6	67.9	835.0	1,089	7,591
CO	417.2	67.0	63.3	839.9	1,108	4,184
VOC	29.9	98.7	72	599.1	126.6	1,687
PM_{10}	145.1	4.49	4.3	545.7	52.2	1,101
$PM_{2.5}$	52.4	4.49	4.3	126.9	52.5	665
SO_2	340.4	5.7	5.8	54.9	267.2	2,160
CO_2	555,959	--	--	1,027,703	--	--
CH_4	205.0	--	--	356.2	--	--
N_2O	1.3	--	--	2.4	--	--
CO_2e	573,227	--	--	1,057,755	638,852	--
Total HAPs	43.2	0.8	8.5	73.8	5.95	--
Benzene	0.6	--	0.2	1.3	--	--
Toluene	1.4	--	0.2	2.6	--	--
Ethyl-Benzene	5.6	--	0.0	8.6	--	--
Xylene	11.2	--	0.0	17.2	--	--
n-Hexane	17.1	--	3.6	28.6	--	--
Formaldehyde	7.2	--	4.5	15.5	--	--

Source: ConocoPhillips Alaska (2019),[1] Hirsch (2021)[2], BLM (2023)[3], Dowl (2018)[4], U.S. Department of Energy (2023)[5]

Note: Total HAPs is based on the sum of the six individual HAPs listed

CO2e values are based on the IPCC Sixth Assessment 20-year GWP

CO2e value for previously published Nanushuk EIS is based on IPCC Fifth Assessment 20-year GWP

The additional RFFAs listed in Appendix F of the SEIS (e.g., Greater Prudhoe Bay/Kuparuk and Arctic Strategic Transportation and Resources) would also result in emissions of GHGs that would contribute to climate change as well as criteria and hazardous air pollutants that would affect ambient air concentrations and air quality related values.

The near-field modeling tiering is described in Section 1.2.3 for a large hypothetical development in the North Slope including both project sources and other RFFA sources within approximately 50 kilometers of the development. Therefore, the results shown in Table 1-24 and Table 1-29 are representative of cumulative near-field criteria and hazardous air pollutant impacts.

The regional photochemical modeling discussed in Section 1.2.2 includes emissions from both hypothetical oil and gas developments in the program area as well as other cumulative sources within the modeling domain (Figure 1-10). This includes current and future anthropogenic onshore sources (e.g., oil and gas production and exploration, airports, pipelines, and non-oil and gas-related stationary and mobile sources) and offshore sources (e.g., drilling rigs, survey/drilling vessels and aircraft, and commercial vessels) as well as natural sources (e.g., sea salt, wildfire). The effects of long-range transport are also accounted for through the use of boundary conditions (background concentrations).

Modeled cumulative impacts on regional air quality and AQRVs are discussed in Section 1.2.2.6 and spatial maps are provided in Appendix A. In summary, the modeled cumulative air quality concentrations for all criteria pollutants are below the NAAQS and AAAQS in the program area, Kaktovik, nearby Class II areas, and across the entire modeling domain under both the hypothetical high and low development scenarios. The cumulative nitrogen deposition impacts under both hypothetical development scenarios are below the range of critical loads (1.0 to 3.0 kg N/ha-yr) in the Arctic National Wildfire Refuge (excluding the program area) and Gates of the Arctic and within the range of critical loads in the program area. The modeled maximum cumulative sulfur deposition impacts in the program area and nearby Class II areas range from 0.6 to 0.7 kg S/ha-yr while average sulfur deposition impacts range from 0.3 to 0.4 kg S/ha-yr. Potential visibility impacts in Denali National Park (the closest Class I area to the program area) from hypothetical oil and gas developments in the program area were assessed using modeled impacts at Gates of the Arctic as a surrogate, as it is the closest area to Denali within the modeling domain. The modeling indicates that cumulative visibility impairment in Denali National Park would potentially increase in the future due to the impacts from oil and gas development shown in Table 1-17 and Table 1-18. The visibility impacts at Denali NP would be lower than those shown as it is farther away than Gates of the Arctic from any oil and gas development that would occur in the program area.

2.0 Greenhouse Gases and Climate Change

2.1 Supporting Information for Affected Environment

2.1.1 Wind Rose from Kaktovik Ambient Air Monitoring Project (KAAMP) station

A new monitoring station in Kaktovik, the Bureau of Land Management (BLM) Kaktovik Ambient Air Monitoring Project (KAAMP) station, began collecting meteorology data in October 2021. The annual wind rose adapted from the Kaktovik, Alaska Ambient Air Monitoring Station: Annual Data Summary Report for October 15, 2021–September 30, 2022 is shown in Figure 3-1 (BLM 2022).

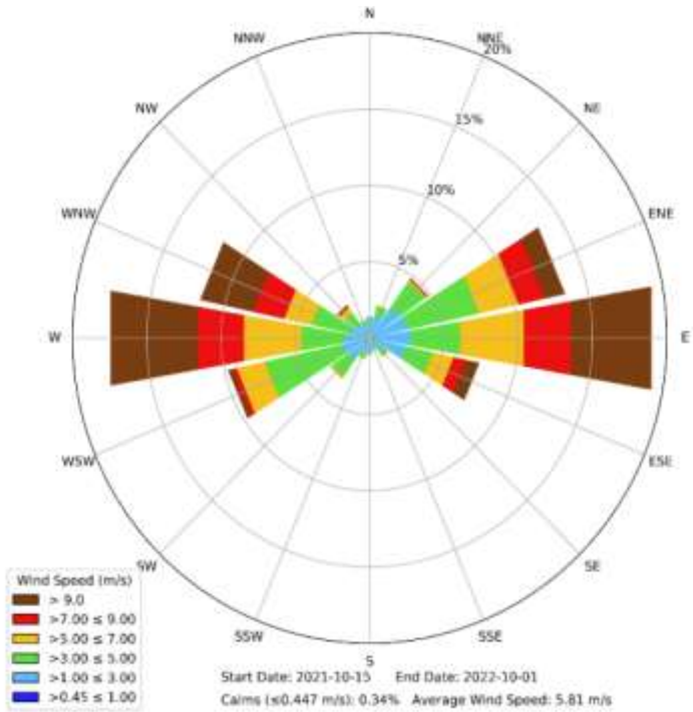


Figure 2-1. Wind rose showing historical wind observations on data collected at the Kaktovik Ambient Air Monitoring Project (KAAMP) station from October 2021 to September 2022.

2.1.2 Global Warming Potentials

GHGs differ in how effectively they absorb energy (radiative efficiency) and how long they stay in the atmosphere (atmospheric lifetime). Thus, the emission of the same mass of two different GHGs will result in different amounts of radiative forcing (i.e., the difference between the amount of incoming solar radiation and the amount of outgoing radiation) over a given period. Global warming potentials (GWPs) were developed to account for differences in the warming impacts of individual GHGs relative to CO_2. GWP is a measure of how much energy the emission of a given mass (e.g., 1 metric ton) of a GHG will absorb over a period of time relative to the emission of the same mass of CO_2. Thus, by definition, CO_2 has a GWP of 1 for all time periods. The GWPs of CH_4 and N_2O are estimated to be 29.8 and 273 over a 100-year time horizon, respectively, according to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC 2021). This means that a metric ton of CH_4 has approximately 29.8 times the GWP of a metric ton of CO_2 over a 100 year period. Over a 20 year period, the GWP of CH_4 is higher (i.e., 82.5) than the 100-year time horizon because the average atmospheric lifetime of CH_4 is approximately 12 years while CO_2 can remain in the atmosphere for hundreds of years (IPCC 2021). Thus, the warming effect of CH_4 is stronger in the short term relative to CO_2 and diminishes over time as it is removed from the atmosphere.

Carbon dioxide equivalents (CO_2e) are calculated by multiplying the emitted mass of each GHG by its GWP. The analysis presents emissions in CO_2e using both the 100-year and 20-year GWPs. The 20-year CO_2e is included to estimate the shorter term impacts of CH_4. Table 3-1 shows the 100-year and 20-year time horizon GWPs adapted from IPCC AR6 (IPCC 2021).

Table 2-1. 100-year and 20-year global warming potentials.

Time horizon	CO_2	CH_4*	N_2O
100 Year	1	29.8	273
20 Year	1	82.5	273

Source: IPCC 2021
Note:
* IPCC provides different GWP estimates for CH_4 depending on whether or not the source originates from fossil carbon. The fossil GWPs are used for CH_4 here and are higher than the non-fossil values as they account for the indirect radiative forcing caused by impacts to the carbon cycle.

2.2 Supporting Information for Environmental Consequences

Annual GHG emissions are estimated for the hypothetical development scenarios described in the RFD document (Appendix B of the SEIS) for each action alternative. Emissions are estimated for construction, drilling, routine operations, well workovers and interventions, diesel shipments to developments, and personnel transport as well as for the transportation, processing, and downstream combustion of produced oil. As noted in the RFD scenario, any produced natural gas is expected to be reinjected into producing oil formations. For this reason, natural gas emissions are accounted for in the development and production emissions but not in the transportation, processing, and downstream combustion emissions.

Descriptions of methods applied and the estimated annual emissions of CO_2, CH_4, and N_2O from development and production and transportation, processing, and downstream combustion are provided in Section 2.2.1 and Section 2.2.2, respectively. Emissions are also presented as 100-year and 20-year CO_2e using GWPs from IPCC AR6 (see Section 2.1.2).

2.2.1 GHG Emissions from Oil and Gas Development and Production in the Program Area

Annual emissions from construction, development, and production activities under each action alternative are estimated using annual oil production from the RFD scenario (Appendix B of the SEIS) and annual emission rates per unit of oil production developed using emissions data from the Willow Master Development Plan Final SEIS (BLM 2023). Consistent with the oil and gas emission inventory for Alternative E in the Willow Master Development Plan Final SEIS (BLM 2023), six years of pre-development construction emissions were assumed prior to which no construction associated activities are assumed to occur. A more detailed description of the approaches used to develop the oil and gas emissions for the RFD scenarios is provided in Section 1.2.1.

Annual GHG emissions for commuting of personnel from Anchorage to the North Slope by aircraft and shipments of diesel fuel via barge, rail and truck to the developments are also estimated using a similar methodology. Emission rates are developed using data from the oil and gas emission inventory for Alternative E of the Willow Master Development Plan Final SEIS (BLM 2023). A detailed description of the methods originally used to estimate these emissions in the Willow project is provided in Appendix E.2A of BLM (2023). For each hypothetical development, annual air travel and diesel shipment emissions for each development year are estimated as the product of the associated Willow Alterative E annual emissions per barrel and the annual oil production from the RFD scenario for each action alternative.

The annual GHG emissions from development and production activities under Alternative B, Alternative C, and Alternative D are provided in Table 2-2, Table 2-3, and

Table 2-4, respectively.

Table 2-2. Annual Greenhouse Gases Emissions (in metric tons) from Oil and Gas Development and Production under Alternative B

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	1,523	0.05	0.00[2]	1,525	1,527
5	70,458	2.64	0.42	70,651	70,790
6	68,836	2.68	0.44	69,035	69,176
7	86,163	3.29	0.46	86,388	86,561
8	140,622	11.17	0.87	141,192	141,781
9	223,883	41.98	0.83	225,359	227,572
10	143,459	43.69	0.34	144,855	147,157
11	324,477	90.79	1.02	327,460	332,245
12	610,245	194.93	1.67	616,510	626,782
13	683,378	215.73	1.82	690,304	701,673
14	789,893	242.16	2.36	797,753	810,515
15	900,203	284.68	2.30	909,313	924,316
16	842,727	294.64	1.86	852,014	867,542
17	1,053,581	352.43	2.59	1,064,792	1,083,365
18	1,365,862	466.09	3.30	1,380,653	1,405,216
19	1,451,400	491.34	3.48	1,466,993	1,492,887
20	1,556,752	517.36	4.01	1,573,264	1,600,528
21	1,683,690	565.85	3.98	1,701,639	1,731,459
22	1,637,445	580.34	3.57	1,655,715	1,686,298
23	1,867,298	666.08	4.08	1,888,262	1,923,365
24	2,282,562	793.69	5.26	2,307,650	2,349,478
25	2,440,265	851.77	5.63	2,467,186	2,512,075

[2] Emissions in year 4 are estimated on the basis of Willow Alternative E year 0 emissions adjusted for Coastal Plain Alternative specific activities. Willow Alternative E year 0 N_2O emissions are exclusively from non-road construction equipment and blasting activities, both of which are assumed to have negligible N_2O emissions. In subsequent project years, there are non-negligible N_2O emissions associated with sources such as on-road vehicles, heaters, and generators.

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
26	2,548,457	904.05	5.86	2,576,998	2,624,641
27	2,717,381	956.38	6.44	2,747,640	2,798,041
28	2,859,637	1,009.06	6.53	2,891,490	2,944,668
29	2,912,490	1,060.02	6.33	2,945,808	3,001,670
30	3,098,268	1,131.25	6.75	3,133,822	3,193,439
31	3,614,073	1,317.46	7.88	3,655,486	3,724,916
32	3,600,694	1,313.49	7.86	3,641,981	3,711,202
33	3,768,796	1,393.38	8.23	3,812,566	3,885,997
34	3,874,594	1,435.11	8.38	3,919,649	3,995,279
35	3,902,101	1,448.26	8.44	3,947,562	4,023,885
36	3,885,049	1,444.00	8.40	3,930,373	4,006,472
37	4,041,953	1,503.94	8.75	4,089,158	4,168,416
38	3,910,345	1,458.23	8.45	3,956,108	4,032,956
39	3,934,355	1,468.95	8.51	3,980,453	4,057,866
40	3,950,535	1,475.97	8.55	3,996,852	4,074,635
41	3,821,638	1,430.70	8.26	3,866,529	3,941,927
42	3,771,936	1,415.86	8.16	3,816,358	3,890,974
43	3,789,068	1,426.67	8.20	3,833,822	3,909,007
44	3,652,939	1,377.51	7.90	3,696,146	3,768,740
45	3,601,408	1,360.96	7.79	3,644,092	3,715,815
46	3,608,404	1,366.90	7.81	3,651,270	3,723,306
47	3,432,515	1,301.43	7.43	3,473,326	3,541,911
48	3,269,337	1,240.67	7.08	3,308,241	3,373,624
49	3,114,694	1,183.01	6.74	3,151,788	3,214,132
50	3,081,890	1,172.55	6.67	3,118,652	3,180,446
51	2,835,339	1,078.75	6.14	2,869,162	2,926,012
52	2,730,603	1,039.95	5.91	2,763,209	2,818,014
53	2,652,560	1,011.38	5.74	2,684,267	2,737,567
54	2,440,356	930.47	5.28	2,469,525	2,518,561
55	2,245,127	856.04	4.86	2,271,964	2,317,078
56	2,065,517	787.55	4.47	2,090,207	2,131,711
57	1,900,275	724.55	4.11	1,922,989	1,961,173
58	1,748,254	666.59	3.78	1,769,151	1,804,280
59	1,608,393	613.26	3.48	1,627,619	1,659,938
60	1,479,722	564.20	3.20	1,497,409	1,527,142
61	1,361,344	519.06	2.95	1,377,617	1,404,972
62	1,252,437	477.54	2.71	1,267,408	1,292,574
63	1,152,242	439.33	2.49	1,166,015	1,189,168
64	1,060,063	404.19	2.30	1,072,734	1,094,035
65	975,257	371.86	2.11	986,915	1,006,512
66	897,237	342.11	1.94	907,961	925,990

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
67	825,457	314.74	1.79	835,324	851,911
68	759,422	289.56	1.64	768,499	783,758
69	698,667	266.39	1.51	707,020	721,059
Total	**138,675,552**	**51,007**	**308**	**140,279,678**	**142,967,732**

Table 2-3. Annual Greenhouse Gases Emissions (in metric tons) from Oil and Gas Development and Production under Alternative C

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	1,523	0.05	0.00[2]	1,525	1,527
5	70,458	2.64	0.42	70,651	70,790
6	68,836	2.68	0.44	69,035	69,176
7	86,163	3.29	0.46	86,388	86,561
8	140,622	11.17	0.87	141,192	141,781
9	223,883	41.98	0.83	225,359	227,572
10	143,459	43.69	0.34	144,855	147,157
11	324,477	90.79	1.02	327,460	332,245
12	610,245	194.93	1.67	616,510	626,782
13	683,378	215.73	1.82	690,304	701,673
14	789,893	242.16	2.36	797,753	810,515
15	900,203	284.68	2.30	909,313	924,316
16	842,727	294.64	1.86	852,014	867,542
17	1,053,581	352.43	2.59	1,064,792	1,083,365
18	1,365,862	466.09	3.30	1,380,653	1,405,216
19	1,451,400	491.34	3.48	1,466,993	1,492,887
20	1,556,752	517.36	4.01	1,573,264	1,600,528
21	1,683,690	565.85	3.98	1,701,639	1,731,459
22	1,637,445	580.34	3.57	1,655,715	1,686,298
23	1,864,222	665.99	4.08	1,885,183	1,920,281
24	2,209,761	790.97	4.84	2,234,655	2,276,339
25	2,371,313	849.09	5.20	2,398,035	2,442,782
26	2,459,880	880.76	5.40	2,487,600	2,534,016
27	2,574,170	923.78	5.56	2,603,217	2,651,900
28	2,633,076	944.91	5.69	2,662,788	2,712,585
29	2,767,764	993.25	5.98	2,798,995	2,851,340
30	2,839,804	1,019.10	6.13	2,871,847	2,925,554
31	3,067,382	1,100.77	6.63	3,101,995	3,160,006
32	3,000,428	1,076.75	6.49	3,034,286	3,091,031
33	3,114,112	1,117.54	6.73	3,149,253	3,208,147

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
34	3,192,639	1,145.72	6.89	3,228,664	3,289,043
35	3,196,784	1,147.21	6.90	3,232,855	3,293,313
36	3,149,661	1,130.30	6.80	3,185,201	3,244,768
37	3,279,594	1,176.93	7.09	3,316,601	3,378,625
38	3,135,387	1,125.17	6.78	3,170,768	3,230,064
39	3,160,297	1,134.12	6.83	3,195,958	3,255,726
40	3,159,695	1,133.90	6.83	3,195,351	3,255,107
41	3,017,919	1,083.02	6.52	3,051,973	3,109,048
42	2,882,980	1,034.60	6.23	2,915,513	2,970,036
43	2,867,889	1,029.18	6.20	2,900,251	2,954,489
44	2,638,459	946.85	5.70	2,668,230	2,718,129
45	2,549,008	914.74	5.51	2,577,770	2,625,977
46	2,484,957	891.76	5.37	2,512,997	2,559,993
47	2,286,161	820.42	4.94	2,311,957	2,355,193
48	2,103,268	754.79	4.54	2,127,001	2,166,779
49	1,935,006	694.40	4.18	1,956,841	1,993,436
50	1,780,206	638.85	3.85	1,800,294	1,833,961
51	1,637,790	587.74	3.54	1,656,270	1,687,244
52	1,506,766	540.72	3.26	1,523,768	1,552,264
53	1,386,225	497.46	2.99	1,401,866	1,428,083
54	1,275,327	457.67	2.76	1,289,718	1,313,837
55	1,173,301	421.05	2.53	1,186,539	1,208,729
56	1,079,436	387.37	2.33	1,091,616	1,112,031
57	993,082	356.38	2.15	1,004,289	1,023,070
58	913,635	327.87	1.98	923,945	941,224
59	840,545	301.64	1.81	850,029	865,925
60	773,301	277.51	1.67	782,026	796,651
61	711,437	255.31	1.53	719,464	732,918
62	654,522	234.89	1.42	661,908	674,287
63	602,160	216.09	1.30	608,954	620,342
Total	**102,903,945**	**36,428**	**228**	**104,051,887**	**105,971,662**

Table 2-4. Annual Greenhouse Gases Emissions (in metric tons) from Oil and Gas Development and Production under Alternative D

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	1,523	0.05	0.00[2]	1,525	1,527
5	70,458	2.64	0.42	70,651	70,790
6	68,836	2.68	0.44	69,035	69,176

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
7	86,163	3.29	0.46	86,388	86,561
8	140,622	11.17	0.87	141,192	141,781
9	223,883	41.98	0.83	225,359	227,572
10	141,935	43.65	0.34	143,330	145,631
11	258,678	88.29	0.62	261,478	266,130
12	548,437	192.50	1.27	554,520	564,665
13	597,563	212.44	1.37	604,268	615,464
14	656,515	291.00	1.51	665,598	680,934
15	684,084	307.04	1.49	693,640	709,821
16	707,297	317.45	1.54	717,178	733,907
17	737,475	331.00	1.61	747,777	765,220
18	764,292	343.03	1.67	774,970	793,048
19	776,841	348.67	1.70	787,695	806,070
20	775,663	348.13	1.69	786,498	804,844
21	792,483	355.69	1.72	803,553	822,298
22	805,383	361.48	1.75	816,633	835,683
23	891,216	400.00	1.94	903,666	924,746
24	923,216	414.36	2.01	936,113	957,950
25	1,017,627	456.73	2.21	1,031,842	1,055,912
26	1,055,734	473.84	2.30	1,070,484	1,095,455
27	1,127,160	505.89	2.46	1,142,907	1,169,567
28	1,150,629	516.43	2.50	1,166,702	1,193,918
29	1,170,853	525.50	2.55	1,187,209	1,214,903
30	1,184,902	531.81	2.59	1,201,456	1,229,482
31	1,308,132	587.12	2.85	1,326,406	1,357,347
32	1,203,482	540.15	2.62	1,220,294	1,248,760
33	1,230,226	552.16	2.68	1,247,411	1,276,510
34	1,273,284	571.48	2.78	1,291,072	1,321,189
35	1,171,421	525.76	2.55	1,187,785	1,215,492
36	1,077,707	483.70	2.35	1,092,763	1,118,254
37	991,490	445.00	2.16	1,005,341	1,028,792
38	912,172	409.40	1.99	924,914	946,490
39	839,198	376.65	1.83	850,922	870,772
40	772,062	346.52	1.68	782,847	801,108
41	710,297	318.79	1.55	720,220	737,021
42	653,473	293.29	1.42	662,602	678,059
43	601,195	269.83	1.31	609,593	623,813
44	553,100	248.24	1.21	560,827	573,909
45	508,852	228.38	1.11	515,960	527,996
46	468,144	210.11	1.02	474,682	485,755
47	430,692	193.30	0.93	436,708	446,895

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
48	396,237	177.84	0.86	401,772	411,144
49	364,538	163.61	0.80	369,631	378,254
50	335,374	150.52	0.73	340,061	347,993
51	308,544	138.48	0.67	312,854	320,152
Total	**33,469,090**	**14,657**	**75**	**33,926,331**	**34,698,760**

2.2.2 GHG Emissions from Transportation, Processing, and Downstream Combustion of Oil from the Program Area

Annual GHG emissions from the transportation, processing, and downstream combustion of oil produced in the program area are estimated using the Bureau of Ocean Energy Management's (BOEM's) 2022 Greenhouse Gas Life Cycle Energy Emissions Model (GLEEM; Wolvovsky 2022) with updates. GLEEM estimates emissions from domestic processing, storage, transportation, and downstream combustion using U.S. national emissions data and emission factors from EPA (2023d, 2023e) and national fossil fuel throughput and consumption data from the Energy Information Administration (EIA 2023). A description of the model's capabilities and methodology can be found in Wolvovsky (2022). The 2022 version of GLEEM was downloaded from BOEM's website[3] and updated as follows:

- Input data are updated to use a 5-year average of recent years (2017-2021) instead of a single year.
- The national emission rates used in the standard release of GLEEM for crude oil refining are from the 'Petroleum Systems' source category of the EPA (2022a) national GHG inventory. This category excludes all combustion emissions of CO_2 from refineries except for flaring; these emissions are included in the industrial sector emissions of the Fossil Fuel Combustion source category instead. GLEEM was updated to use the total U.S. refinery GHG emissions reported under the GHGRP (Subpart Y of 40 CFR 98) and published by EPA (2022b). The emissions reported under GHGRP include both stationary fuel combustion emissions as well as process emissions from flares, vents, blowdowns, leaks, and other sources. Thus, this allows for a more comprehensive accounting of refinery emissions.
- GLEEM was updated to assume all oil from the program area is combusted. GLEEM accounts for the portion of fuels that are used in non-combustible products (e.g., fertilizer and plastics) and not combusted. Assuming that all oil is combusted results in a conservatively high estimate of combustion emissions.

As discussed in the RFD scenario report (Appendix B of the SEIS), it is expected that production pipelines would be constructed to connect developments in the program area to the Trans-Alaska Pipeline System (TAPS), which transports oil from the North Slope to the Valdez Marine Terminal in southern Alaska. Crude oil is then transported from the Valdez Marine Terminal to refineries in the US on polar tankers. Emissions from the transport of crude oil from the North Slope to U.S. refineries via the TAPS and polar tankers are estimated and added to the transportation emissions from GLEEM.

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[3] https://www.boem.gov/environment/greenhouse-gas-life-cycle-energy-emissions-model#:~:text=GLEEM%20is%20a%20Linux%2Dbased,contact%20boemgleem%40boem.gov.

Emissions from the transport of crude oil produced in the program area through TAPS are estimated using the oil production under Alternatives B, C, and D and the historical emissions intensities (i.e., metric tons of CO_2, N_2O, and CH_4 emitted per million barrels of oil transported) of TAPS and the Valdez Marine Terminal. The emission intensities are estimated as the ratio of the average annual GHGs emissions reported for TAPS pump stations and the Valdez Marine Terminal in the EPA (2023c) Facility Level Information on Greenhouse Gases tool and the average annual TAPS throughput (Alyeska Pipeline Service Company 2023) from 2017 to 2021. The five-year average emissions intensities are then multiplied by the projected annual oil production under each action alternative to estimate the annual GHGs emissions from oil transportation through TAPS to Valdez.

Emissions intensities for the polar tanker transport are obtained from the Willow Final SEIS (BLM 2023) and applied to the annual oil production under each action alternative to estimate GHGs from the transport from Valdez Marine Terminal to US refineries. The emissions intensities used for transport through TAPS and on polar tankers are provided in Table 2-5.

Table 2-5. Greenhouse Gases Emissions Intensities (in metric tons per million barrels of oil) used for Crude Oil Transport

Type	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
Trans-Alaska Pipeline System	1,183.41	0.03	0.004	1,185	1,187
Polar Tanker Transport	3,250.00	2.53	0.146	3,365	3,499

Annual GHGs emissions from oil transportation and processing under Alternatives B, C, and D are provided in Table 2-6,
Table 2-7, and
Table 2-8, respectively. Emissions from year 1 to year 7 are zero because production is not projected to start until year 8 (Appendix B of the SEIS). Annual GHG emissions from downstream combustion of oil produced within program area under Alternatives B, C, and D are shown in
Table 2-9, Table 2-10, and Table 2-11, respectively, and these emissions are also zero until production starts in year 8.

Table 2-6. Annual Greenhouse Gases Emissions (in metric tons) from Oil Transportation and Processing under Alternative B

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	67,505	86.33	4.36	71,269	75,819
11	135,011	172.66	8.73	142,539	151,638
12	270,021	345.33	16.46	284,805	303,004

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
13	248,420	317.86	15.02	261,993	278,744
14	228,546	291.99	14.62	241,238	256,626
15	210,263	268.67	13.25	221,887	236,046
16	260,947	333.19	16.27	275,319	292,878
17	312,977	400.17	19.33	330,178	351,267
18	433,751	553.92	26.77	457,565	486,756
19	399,050	509.92	25.07	421,089	447,962
20	367,126	468.89	22.42	387,220	411,930
21	337,756	431.74	20.83	356,307	379,060
22	378,241	482.73	23.65	399,081	424,521
23	420,887	537.47	26.51	444,140	472,465
24	533,028	681.23	32.77	562,276	598,177
25	490,386	626.49	30.91	517,495	550,511
26	451,155	575.93	28.12	475,994	506,346
27	415,062	530.46	26.39	438,074	466,029
28	381,857	487.98	23.72	402,874	428,591
29	418,815	534.75	26.47	441,975	470,157
30	458,215	585.37	28.26	483,374	514,223
31	567,369	725.10	35.47	598,660	636,873
32	521,980	666.41	32.55	550,725	585,845
33	480,221	613.98	29.71	506,627	538,984
34	441,804	564.70	27.93	466,257	496,016
35	406,460	519.48	25.22	428,824	456,201
36	373,943	477.24	23.56	394,596	419,747
37	344,027	439.91	21.95	363,129	386,312
38	316,505	404.39	19.40	333,852	355,163
39	291,184	371.64	17.89	307,142	326,727
40	267,890	342.59	16.41	282,580	300,635
41	246,459	315.18	14.98	259,941	276,551
42	226,742	289.37	14.58	239,346	254,596
43	208,602	266.10	13.22	220,140	234,163
44	191,914	245.33	11.88	202,468	215,397
45	176,561	226.02	10.57	186,182	198,094
46	162,436	207.14	10.28	171,417	182,333
47	149,442	190.65	9.02	157,586	167,633
48	137,486	175.52	8.78	145,113	154,363
49	126,487	161.72	7.56	133,369	141,891
50	116,369	148.22	7.35	122,793	130,604
51	107,059	137.00	7.16	113,097	120,317
52	98,494	126.04	5.99	103,885	110,528
53	90,615	115.32	5.83	95,643	101,721

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
54	83,366	106.81	5.69	88,101	93,730
55	76,696	97.51	4.55	80,844	85,982
56	70,561	90.39	4.43	74,463	79,226
57	64,916	82.44	4.31	68,550	72,894
58	59,723	76.64	4.21	63,155	67,194
59	54,944	69.99	3.11	57,879	61,568
60	50,549	64.47	3.02	53,295	56,693
61	46,505	59.07	2.94	49,068	52,181
62	42,785	54.79	2.86	45,200	48,087
63	39,362	50.60	2.80	41,633	44,300
64	36,213	46.52	2.73	38,345	40,796
65	33,316	42.51	1.67	35,039	37,280
66	30,650	39.59	1.62	32,272	34,359
67	28,199	35.75	1.57	29,693	31,577
68	25,943	32.97	1.52	27,342	29,079
69	23,867	30.25	1.48	25,173	26,768
Total	**14,036,661**	**17,932**	**876**	**14,810,119**	**15,755,160**

Table 2-7. Annual Greenhouse Gases Emissions (in metric tons) from Oil Transportation and Processing under Alternative C

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	67,505	86.33	4.36	71,269	75,819
11	135,011	172.66	8.73	142,539	151,638
12	270,021	345.33	16.46	284,805	303,004
13	248,420	317.86	15.02	261,993	278,744
14	228,546	291.99	14.62	241,238	256,626
15	210,263	268.67	13.25	221,887	236,046
16	260,947	333.19	16.27	275,319	292,878
17	312,977	400.17	19.33	330,178	351,267
18	433,751	553.92	26.77	457,565	486,756
19	399,050	509.92	25.07	421,089	447,962
20	367,126	468.89	22.42	387,220	411,930

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
21	337,756	431.74	20.83	356,307	379,060
22	378,241	482.73	23.65	399,081	424,521
23	420,887	537.47	26.51	444,140	472,465
24	533,028	681.23	32.77	562,276	598,177
25	490,386	626.49	30.91	517,495	550,511
26	451,155	575.93	28.12	475,994	506,346
27	415,062	530.46	26.39	438,074	466,029
28	381,857	487.98	23.72	402,874	428,591
29	351,309	448.42	22.10	370,705	394,337
30	323,204	412.71	20.53	341,108	362,858
31	297,348	379.77	19.01	313,855	333,869
32	273,560	349.55	17.53	288,762	307,183
33	251,675	321.99	16.09	265,662	282,630
34	231,541	296.03	14.68	244,370	259,971
35	213,018	272.62	13.31	224,775	239,142
36	195,977	250.73	11.96	206,714	219,928
37	180,298	230.32	11.64	190,340	202,478
38	165,875	212.33	10.35	175,029	186,219
39	152,604	194.74	9.08	160,888	171,151
40	140,396	179.52	8.84	148,159	157,620
41	129,164	164.64	7.61	136,148	144,825
42	118,832	152.07	7.40	125,384	133,398
43	109,325	139.79	7.21	115,458	122,825
44	100,579	128.76	6.03	106,063	112,849
45	92,532	117.98	5.87	97,651	103,868
46	85,130	108.42	5.72	89,923	95,637
47	78,320	100.07	4.58	82,553	87,827
48	72,054	91.90	4.46	76,009	80,852
49	66,289	84.91	4.34	70,004	74,479
50	60,986	78.08	4.23	64,468	68,583
51	56,107	71.39	3.13	59,090	62,853
52	51,619	65.84	3.04	54,412	57,882
53	47,490	60.41	2.96	50,098	53,282
54	43,690	56.10	2.88	46,149	49,105
55	40,195	50.89	2.81	42,480	45,162
56	36,979	46.78	2.75	39,123	41,589
57	34,021	43.76	1.69	35,786	38,092
58	31,299	39.82	1.63	32,932	35,030
59	28,796	36.95	1.58	30,329	32,276
60	26,492	34.16	1.54	27,929	29,729
61	24,372	31.42	1.49	25,716	27,372

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
62	22,423	28.75	1.45	23,676	25,191
63	20,629	26.13	1.42	21,794	23,171
Total	**10,496,116**	**13,411**	**656**	**11,074,887**	**11,781,633**

Table 2-8. Annual Greenhouse Gases Emissions (in metric tons) from Oil Transportation and Processing under Alternative D

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	67,505	86.33	4.36	71,269	75,819
11	135,011	172.66	8.73	142,539	151,638
12	270,021	345.33	16.46	284,805	303,004
13	248,420	317.86	15.02	261,993	278,744
14	228,546	291.99	14.62	241,238	256,626
15	210,263	268.67	13.25	221,887	236,046
16	193,441	246.86	11.91	204,049	217,059
17	177,966	227.51	11.60	187,912	199,902
18	163,729	209.59	10.31	172,789	183,835
19	150,630	192.06	9.04	158,823	168,945
20	138,580	176.90	8.80	146,254	155,577
21	127,494	163.07	7.58	134,422	143,015
22	117,295	149.54	7.37	123,763	131,644
23	107,911	138.30	7.18	113,993	121,281
24	99,278	127.31	6.01	104,711	111,421
25	91,336	116.57	5.85	96,406	102,549
26	84,029	107.04	5.70	88,775	94,416
27	77,306	98.72	4.56	81,494	86,696
28	71,122	90.58	4.44	75,033	79,807
29	65,432	83.62	4.32	69,104	73,511
30	60,197	76.81	4.22	63,637	67,685
31	55,381	71.14	3.12	58,353	62,102
32	50,951	64.61	3.03	53,704	57,109
33	46,876	60.20	2.95	49,474	52,647
34	43,125	54.91	2.87	45,545	48,439

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
35	39,675	50.71	2.80	41,951	44,623
36	36,502	46.62	2.74	38,638	41,095
37	33,581	42.61	1.68	35,309	37,554
38	30,895	39.68	1.62	32,520	34,612
39	28,423	35.82	1.57	29,921	31,809
40	26,149	33.04	1.53	27,551	29,292
41	24,057	30.31	1.49	25,366	26,964
42	22,133	28.65	1.45	23,382	24,891
43	20,362	26.04	1.41	21,523	22,895
44	18,733	23.47	1.38	19,809	21,046
45	17,234	21.96	1.35	18,257	19,414
46	15,856	20.48	1.32	16,827	17,906
47	14,587	19.04	1.29	15,508	16,511
48	13,421	17.64	1.27	14,293	15,223
49	12,346	16.27	1.25	13,172	14,029
50	11,359	14.93	0.23	11,867	12,653
51	10,451	13.61	0.21	10,914	11,631
Total	**3,457,609**	**4,419**	**218**	**3,648,780**	**3,881,663**

Table 2-9. Annual Greenhouse Gases Emissions (in metric tons) from Downstream Combustion of Produced Oil under Alternative B

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,612,134	154	31	3,625,186	3,633,302
11	7,224,267	308	62	7,250,371	7,266,603
12	14,448,534	616	124	14,500,743	14,533,206
13	13,292,652	566	114	13,340,641	13,370,469
14	12,229,240	521	105	12,273,431	12,300,888
15	11,250,901	479	97	11,291,656	11,316,900
16	13,962,962	595	120	14,013,453	14,044,810
17	16,747,032	713	144	16,807,591	16,845,167
18	23,209,476	989	200	23,293,548	23,345,669
19	21,352,720	910	184	21,430,070	21,478,027

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
20	19,644,502	837	169	19,715,582	19,759,692
21	18,072,942	770	156	18,138,476	18,179,055
22	20,239,240	862	174	20,312,430	20,357,857
23	22,521,206	959	194	22,602,746	22,653,286
24	28,521,718	1,215	245	28,624,810	28,688,841
25	26,239,984	1,118	226	26,334,998	26,393,917
26	24,140,782	1,028	208	24,228,200	24,282,376
27	22,209,520	946	191	22,289,854	22,339,708
28	20,432,756	870	176	20,506,730	20,552,579
29	22,410,268	955	193	22,491,416	22,541,745
30	24,518,552	1,045	211	24,607,296	24,662,368
31	30,359,280	1,293	261	30,469,064	30,537,206
32	27,930,536	1,190	240	28,031,518	28,094,231
33	25,696,096	1,095	221	25,789,060	25,846,767
34	23,640,406	1,007	203	23,725,834	23,778,903
35	21,749,174	927	187	21,827,850	21,876,703
36	20,009,240	852	172	20,081,586	20,126,486
37	18,408,502	784	158	18,474,999	18,516,316
38	16,935,822	721	146	16,997,166	17,035,163
39	15,580,957	664	134	15,637,326	15,672,319
40	14,334,478	611	123	14,386,265	14,418,465
41	13,187,721	562	113	13,235,318	13,264,935
42	12,132,702	517	104	12,176,501	12,203,747
43	11,162,088	476	96	11,202,481	11,227,566
44	10,269,120	437	88	10,306,167	10,329,197
45	9,447,589	402	81	9,481,682	9,502,867
46	8,691,783	370	75	8,723,284	8,742,783
47	7,996,440	341	69	8,025,439	8,043,410
48	7,356,724	313	63	7,383,250	7,399,746
49	6,768,186	288	58	6,792,602	6,807,780
50	6,226,732	265	54	6,249,371	6,263,337
51	5,728,594	244	49	5,749,242	5,762,101
52	5,270,306	225	45	5,289,296	5,301,154
53	4,848,681	207	42	4,866,316	4,877,225
54	4,460,787	190	38	4,476,823	4,486,836
55	4,103,924	175	35	4,118,694	4,127,917
56	3,775,610	161	32	3,789,144	3,797,629
57	3,473,561	148	30	3,486,161	3,493,961
58	3,195,676	136	27	3,207,100	3,214,267
59	2,940,022	125	25	2,950,572	2,957,160
60	2,704,821	115	23	2,714,527	2,720,588

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
61	2,488,434	106	21	2,497,326	2,502,912
62	2,289,360	98	20	2,297,740	2,302,905
63	2,106,211	90	18	2,113,807	2,118,550
64	1,937,714	83	17	1,944,828	1,949,203
65	1,782,697	76	15	1,789,057	1,793,062
66	1,640,081	70	14	1,645,989	1,649,678
67	1,508,875	64	13	1,514,331	1,517,704
68	1,388,165	59	12	1,393,199	1,396,309
69	1,277,112	54	11	1,281,724	1,284,570
Total	**751,085,595**	**31,997**	**6,457**	**753,801,867**	**755,488,109**

Table 2-10. Annual Greenhouse Gases Emissions (in metric tons) from Downstream Combustion of Produced Oil under Alternative C

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,612,134	154	31	3,625,186	3,633,302
11	7,224,267	308	62	7,250,371	7,266,603
12	14,448,534	616	124	14,500,743	14,533,206
13	13,292,652	566	114	13,340,641	13,370,469
14	12,229,240	521	105	12,273,431	12,300,888
15	11,250,901	479	97	11,291,656	11,316,900
16	13,962,962	595	120	14,013,453	14,044,810
17	16,747,032	713	144	16,807,591	16,845,167
18	23,209,476	989	200	23,293,548	23,345,669
19	21,352,720	910	184	21,430,070	21,478,027
20	19,644,502	837	169	19,715,582	19,759,692
21	18,072,942	770	156	18,138,476	18,179,055
22	20,239,240	862	174	20,312,430	20,357,857
23	22,521,206	959	194	22,602,746	22,653,286
24	28,521,718	1,215	245	28,624,810	28,688,841
25	26,239,984	1,118	226	26,334,998	26,393,917
26	24,140,782	1,028	208	24,228,200	24,282,376
27	22,209,520	946	191	22,289,854	22,339,708

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
28	20,432,756	870	176	20,506,730	20,552,579
29	18,798,136	801	162	18,866,232	18,908,445
30	17,294,286	737	149	17,356,926	17,395,766
31	15,910,743	678	137	15,968,348	16,004,079
32	14,637,882	624	126	14,690,875	14,723,760
33	13,466,854	574	116	13,515,627	13,545,877
34	12,389,505	528	107	12,434,450	12,462,276
35	11,398,345	486	98	11,439,582	11,465,194
36	10,486,477	447	90	10,524,368	10,547,925
37	9,647,559	411	83	9,682,466	9,704,126
38	8,875,753	378	76	8,907,765	8,927,686
39	8,165,694	348	70	8,195,174	8,213,514
40	7,512,438	320	65	7,539,719	7,556,583
41	6,911,442	294	59	6,936,310	6,951,804
42	6,358,528	271	55	6,381,619	6,395,901
43	5,849,845	249	50	5,870,915	5,884,038
44	5,381,858	229	46	5,401,240	5,413,309
45	4,951,309	211	43	4,969,336	4,980,456
46	4,555,204	194	39	4,571,632	4,581,856
47	4,190,788	179	36	4,205,950	4,215,384
48	3,855,525	164	33	3,869,421	3,878,064
49	3,547,084	151	31	3,560,047	3,568,005
50	3,263,316	139	28	3,275,102	3,282,428
51	3,002,251	128	26	3,013,163	3,019,909
52	2,762,070	118	24	2,772,138	2,778,357
53	2,541,105	108	22	2,550,329	2,556,021
54	2,337,816	100	20	2,346,256	2,351,526
55	2,150,792	92	19	2,158,721	2,163,569
56	1,978,728	84	17	1,985,872	1,990,299
57	1,820,430	78	16	1,827,122	1,831,233
58	1,674,796	71	14	1,680,734	1,684,476
59	1,540,812	66	13	1,546,328	1,549,806
60	1,417,547	60	12	1,422,611	1,425,773
61	1,304,143	56	11	1,308,815	1,311,766
62	1,199,812	51	10	1,204,062	1,206,750
63	1,103,826	47	9	1,107,684	1,110,161
Total	**561,635,267**	**23,928**	**4,832**	**563,667,457**	**564,928,463**

Table 2-11. Annual Greenhouse Gases Emissions (in metric tons) from Downstream Combustion of Produced Oil under Alternative D

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,612,134	154	31	3,625,186	3,633,302
11	7,224,267	308	62	7,250,371	7,266,603
12	14,448,534	616	124	14,500,743	14,533,206
13	13,292,652	566	114	13,340,641	13,370,469
14	12,229,240	521	105	12,273,431	12,300,888
15	11,250,901	479	97	11,291,656	11,316,900
16	10,350,830	441	89	10,388,269	10,411,510
17	9,522,763	406	82	9,557,248	9,578,644
18	8,760,941	373	75	8,792,531	8,812,189
19	8,060,066	343	69	8,089,124	8,107,201
20	7,415,260	316	64	7,442,149	7,458,802
21	6,822,040	291	59	6,846,819	6,862,155
22	6,276,276	267	54	6,298,975	6,313,046
23	5,774,174	246	50	5,795,155	5,808,119
24	5,312,242	226	46	5,331,535	5,343,445
25	4,887,261	208	42	4,904,925	4,915,887
26	4,496,280	192	39	4,512,649	4,522,767
27	4,136,578	176	36	4,151,651	4,160,926
28	3,805,652	162	33	3,819,489	3,828,026
29	3,501,200	149	30	3,513,830	3,521,683
30	3,221,103	137	28	3,232,830	3,240,050
31	2,963,416	126	25	2,973,996	2,980,636
32	2,726,342	116	23	2,736,078	2,742,191
33	2,508,234	107	22	2,517,429	2,523,068
34	2,307,576	98	20	2,315,956	2,321,121
35	2,122,970	90	18	2,130,566	2,135,309
36	1,953,132	83	17	1,960,246	1,964,621
37	1,796,882	77	15	1,803,272	1,807,330
38	1,653,131	70	14	1,659,039	1,662,728
39	1,520,880	65	13	1,526,366	1,529,792
40	1,399,210	60	12	1,404,274	1,407,436

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
41	1,287,274	55	11	1,291,916	1,294,815
42	1,184,292	50	10	1,188,512	1,191,147
43	1,089,548	46	9	1,093,376	1,095,800
44	1,002,384	43	9	1,006,122	1,008,389
45	922,193	39	8	925,539	927,595
46	848,418	36	7	851,402	853,299
47	780,544	33	7	783,438	785,178
48	718,101	31	6	720,663	722,297
49	660,653	28	6	663,125	664,601
50	607,800	26	5	609,940	611,310
51	559,176	24	5	561,256	562,521
Total	**185,012,550**	**7,880**	**1,591**	**185,681,717**	**186,096,993**

2.2.3 GHG Emissions from Displaced Energy Sources

The oil produced in the program area and brought to market under the action alternatives would displace other sources of energy, such as oil, natural gas, other fossil fuels, and renewables. The BLM Energy Substitution Model (EnergySub) is used to estimate the quantity and type of energy sources that would be displaced by oil produced in the Coastal Plain under each action alternative, or the energy source that would fulfill energy demand in the absence of program area oil. The substitution rates from the EnergySub model are available for the first year of production (2032) through the year 2053, and thus results are presented for this period. Details on the methodology and results of the EnergySub modeling are provide in the BLM Energy Substitution Model appendix of the SEIS.

The energy substitution rates estimated by EnergySub for each action alternative are used as input to GLEEM to estimate GHG emissions that would result from displaced energy sources. GLEEM does not include development and production emissions, and thus these emissions are not included in the GHG emissions for displaced energy sources presented below.

The net GHG emissions for each alternative are then calculated by subtracting the GHG emissions from the displaced energy sources from the gross oil and gas emissions from the program area under each action alternative. The net emissions are reported in Section 3.2.1 of the SEIS.

The estimated GHG emissions from substitute energy sources under Alternative B, Alternative C, and Alternative D are presented in Table 2-12, Table 2-13, and Table 2-14, respectively.

Table 2-12. Annual Greenhouse Gases Emissions (in metric tons) from Displaced Energy Sources under Alternative B

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,033,686	236	28	3,048,363	3,060,800
11	6,067,374	472	56	6,096,728	6,121,602
12	12,134,747	945	111	12,193,211	12,243,013
13	11,163,971	869	103	11,217,986	11,263,783
14	10,270,853	800	95	10,320,628	10,362,788
15	9,449,185	735	87	9,494,839	9,533,574
16	11,726,935	913	108	11,783,626	11,831,742
17	14,065,164	1,095	130	14,133,285	14,190,992
18	19,492,714	1,517	180	19,587,061	19,667,007
19	17,933,299	1,396	165	18,019,945	18,093,514
20	16,498,636	1,284	152	16,578,395	16,646,062
21	15,178,742	1,182	140	15,252,186	15,314,477
22	16,998,132	1,323	156	17,080,145	17,149,868
23	18,914,666	1,472	175	19,006,307	19,083,881
24	23,954,254	1,865	220	24,069,891	24,168,177
25	22,037,914	1,715	203	22,144,440	22,234,821
26	20,274,882	1,578	187	20,372,957	20,456,118
27	18,652,892	1,452	171	18,742,845	18,819,365
28	17,160,659	1,336	158	17,243,606	17,314,013
29	18,821,493	1,465	174	18,912,652	18,989,858
30	20,592,158	1,603	190	20,691,797	20,776,276
31	25,497,550	1,985	235	25,620,858	25,725,468
Total	**349,919,906**	**27,238**	**3,224**	**351,611,750**	**353,047,193**

Table 2-13 Annual Greenhouse Gases Emissions (in metric tons) from Displaced Energy Source for Produced Oil under Alternative C

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,050,121	238	28	3,064,857	3,077,400
11	6,100,242	476	57	6,129,988	6,155,073
12	12,200,482	952	113	12,259,701	12,309,871
13	11,224,444	876	104	11,278,941	11,325,106
14	10,326,487	806	96	10,376,714	10,419,190
15	9,500,369	741	88	9,546,475	9,585,526
16	11,790,459	920	109	11,847,632	11,896,116
7	14,141,354	1,103	131	14,209,986	14,268,115
18	19,598,307	1,529	181	19,693,284	19,773,863
19	18,030,439	1,407	167	18,117,959	18,192,108
20	16,588,004	1,294	154	16,668,607	16,736,801
21	15,260,964	1,191	141	15,334,949	15,397,715
22	17,090,206	1,333	158	17,173,063	17,243,313
23	19,017,117	1,484	176	19,109,388	19,187,595
24	24,084,011	1,879	222	24,200,611	24,299,635
25	22,157,293	1,729	205	22,264,782	22,355,901
26	20,384,706	1,591	189	20,483,715	20,567,561
27	18,753,929	1,464	173	18,844,785	18,921,938
28	17,253,616	1,346	159	17,337,134	17,408,068
29	15,873,327	1,239	147	15,950,380	16,015,676
30	14,603,459	1,140	135	14,674,286	14,734,364
31	13,435,184	1,049	124	13,500,296	13,555,579
Total	**330,464,520**	**25,787**	**3,057**	**332,067,534**	**333,426,509**

Table 2-14 Annual Greenhouse Gases Emissions (in metric tons) from Displaced Energy Source for Produced Oil under Alternative D

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	3,056,342	239	28	3,071,108	3,083,704
11	6,112,687	478	57	6,142,492	6,167,683
12	12,225,372	956	113	12,284,710	12,335,091
13	11,247,342	879	104	11,301,928	11,348,252
14	10,347,555	809	96	10,397,871	10,440,506
15	9,519,751	744	88	9,565,946	9,605,155
16	8,758,171	685	81	8,800,697	8,836,797
17	8,057,516	630	74	8,096,492	8,129,693
18	7,412,915	580	69	7,449,036	7,479,602
19	6,819,882	534	63	6,852,994	6,881,136
20	6,274,292	491	58	6,304,758	6,330,634
21	5,772,349	451	53	5,800,258	5,824,026
22	5,310,559	415	49	5,336,303	5,358,174
23	4,885,715	382	45	4,909,384	4,929,515
24	4,494,859	351	41	4,516,512	4,535,010
25	4,135,270	323	38	4,155,269	4,172,292
26	3,804,448	297	35	3,822,854	3,838,506
27	3,500,092	273	33	3,517,236	3,531,624
28	3,220,084	251	29	3,235,481	3,248,709
29	2,962,477	231	27	2,976,732	2,988,906
30	2,725,479	213	25	2,738,651	2,749,877
31	2,507,440	196	23	2,519,560	2,529,889
Total	**133,150,597**	**10,408**	**1,229**	**133,796,272**	**134,344,774**

2.2.4 Downstream Combustion GHG Emissions from the Change in Foreign Oil Consumption

As oil is a global commodity with prices determined by global supply and demand, oil production in the program area under the action alternatives would increase the global oil supply and place downward pressure on global oil prices. Reductions in global oil prices would increase demand relative to the No Action Alternative resulting in additional GHG emissions. EnergySub is used to estimate the change in domestic and foreign oil consumption resulting from oil production in the program area. The EnergySub model results are available for the first year of production (2032) through the year 2053, and thus results are presented for this period. Emissions from the change in foreign oil consumption are estimated by applying EPA (2023d) emission factors for stationary combustion of petroleum products to the estimated change in foreign oil consumption. The highest EPA emission factors are used (11.91 kilograms of CO_2 per gallon, 0.47 grams of CH_4 per gallon, and 0.09 grams of N_2O per gallon) and it is assumed that all foreign oil is combusted due to the lack of information on the type and amount of petroleum products consumed in foreign markets. In reality, increased foreign oil consumption would include a wide variety of petroleum products with varying emission intensities including products that are not combusted (e.g., plastics). Thus, this approach likely results in a conservatively high estimate of these foreign downstream combustion emissions.

The estimated downstream combustion GHG emissions from the change in foreign oil consumption under Alternative B, Alternative C, and Alternative D are presented in Table 2-15, Table 2-16, and Table 2-17, respectively.

Table 2-15. Annual Greenhouse Gases Emissions (in metric tons) from Change in Foreign Oil Consumption under Alternative B.

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	129,313.39	5.10	0.98	129,732.23	130,001.16
12	260,554.53	10.28	1.97	261,398.46	261,940.33
13	523,921.71	20.68	3.96	525,618.67	526,708.26
14	483,298.59	19.07	3.65	484,863.98	485,869.08
15	444,032.28	17.52	3.36	445,470.48	446,393.93
16	407,871.68	16.10	3.08	409,192.75	410,041.00
17	507,884.44	20.04	3.84	509,529.46	510,585.69
18	603,382.66	23.81	4.56	605,336.99	606,591.83
19	836,756.53	33.02	6.32	839,466.75	841,206.94
20	770,117.10	30.39	5.82	772,611.48	774,213.07
21	707,409.84	27.92	5.35	709,701.11	711,172.29
22	648,436.02	25.59	4.90	650,536.28	651,884.82
23	721,943.94	28.49	5.46	724,282.28	725,783.70
24	791,468.45	31.23	5.98	794,031.98	795,677.98
25	989,969.88	39.07	7.48	993,176.35	995,235.17
26	907,279.59	35.80	6.86	910,218.23	912,105.08
27	828,545.52	32.70	6.26	831,229.15	832,952.26

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
28	746,550.26	29.46	5.64	748,968.31	750,520.89
29	686,701.67	27.10	5.19	688,925.86	690,353.98
30	753,121.24	29.72	5.69	755,560.57	757,126.82
31	823,942.26	32.51	6.23	826,610.98	828,324.52
Total	**13,572,502**	**536**	**103**	**13,616,462**	**13,644,689**

Table 2-16. Annual Greenhouse Gases Emissions (in metric tons) from Change in Foreign Oil Consumption under Alternative C.

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	129,313.39	5.10	0.98	129,732.23	130,001.16
12	260,554.53	10.28	1.97	261,398.46	261,940.33
13	523,921.71	20.68	3.96	525,618.67	526,708.26
14	483,298.59	19.07	3.65	484,863.98	485,869.08
15	444,032.28	17.52	3.36	445,470.48	446,393.93
16	407,871.68	16.10	3.08	409,192.75	410,041.00
17	507,884.44	20.04	3.84	509,529.46	510,585.69
18	603,382.66	23.81	4.56	605,336.99	606,591.83
19	836,756.53	33.02	6.32	839,466.75	841,206.94
20	770,117.10	30.39	5.82	772,611.48	774,213.07
21	707,409.84	27.92	5.35	709,701.11	711,172.29
22	648,436.02	25.59	4.90	650,536.28	651,884.82
23	721,943.94	28.49	5.46	724,282.28	725,783.70
24	791,468.45	31.23	5.98	794,031.98	795,677.98
25	989,969.88	39.07	7.48	993,176.35	995,235.17
26	907,279.59	35.80	6.86	910,218.23	912,105.08
27	828,545.52	32.70	6.26	831,229.15	832,952.26
28	746,550.26	29.46	5.64	748,968.31	750,520.89
29	686,701.67	27.10	5.19	688,925.86	690,353.98
30	631,785.13	24.93	4.77	633,831.46	635,145.37
31	581,260.66	22.94	4.39	583,143.33	584,352.17
Total	**13,208,484**	**521**	**100**	**13,251,266**	**13,278,735**

Table 2-17. Annual Greenhouse Gases Emissions (in metric tons) from Change in Foreign Oil Consumption under Alternative D

Year	CO_2	CH_4	N_2O	CO_2e 100-year	CO_2e 20-year
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-	-	-	-	-
10	-	-	-	-	-
11	129,313.39	5.10	0.98	129,732.23	130,001.16
12	260,554.53	10.28	1.97	261,398.46	261,940.33
13	523,921.71	20.68	3.96	525,618.67	526,708.26
14	483,298.59	19.07	3.65	484,863.98	485,869.08
15	444,032.28	17.52	3.36	445,470.48	446,393.93
16	407,871.68	16.10	3.08	409,192.75	410,041.00
17	376,511.94	14.86	2.85	377,731.45	378,514.47
18	343,124.17	13.54	2.59	344,235.53	344,949.12
19	315,903.04	12.47	2.39	316,926.23	317,583.21
20	290,738.97	11.47	2.20	291,680.67	292,285.31
21	267,058.25	10.54	2.02	267,923.24	268,478.63
22	244,788.27	9.66	1.85	245,581.13	246,090.21
23	223,905.94	8.84	1.69	224,631.16	225,096.81
24	202,956.25	8.01	1.53	203,613.62	204,035.70
25	184,417.84	7.28	1.39	185,015.16	185,398.69
26	169,011.77	6.67	1.28	169,559.19	169,910.68
27	154,333.60	6.09	1.17	154,833.48	155,154.44
28	139,064.24	5.49	1.05	139,514.66	139,803.87
29	127,972.43	5.05	0.97	128,386.92	128,653.07
30	117,708.98	4.65	0.89	118,090.23	118,335.03
31	108,330.33	4.28	0.82	108,681.21	108,906.50
Total	**5,514,818**	**218**	**42**	**5,532,680**	**5,544,150**

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APPENDIX A

Spatial plots of Modeled Cumulative and Indirect Impacts for Regional Modeling Scenarios

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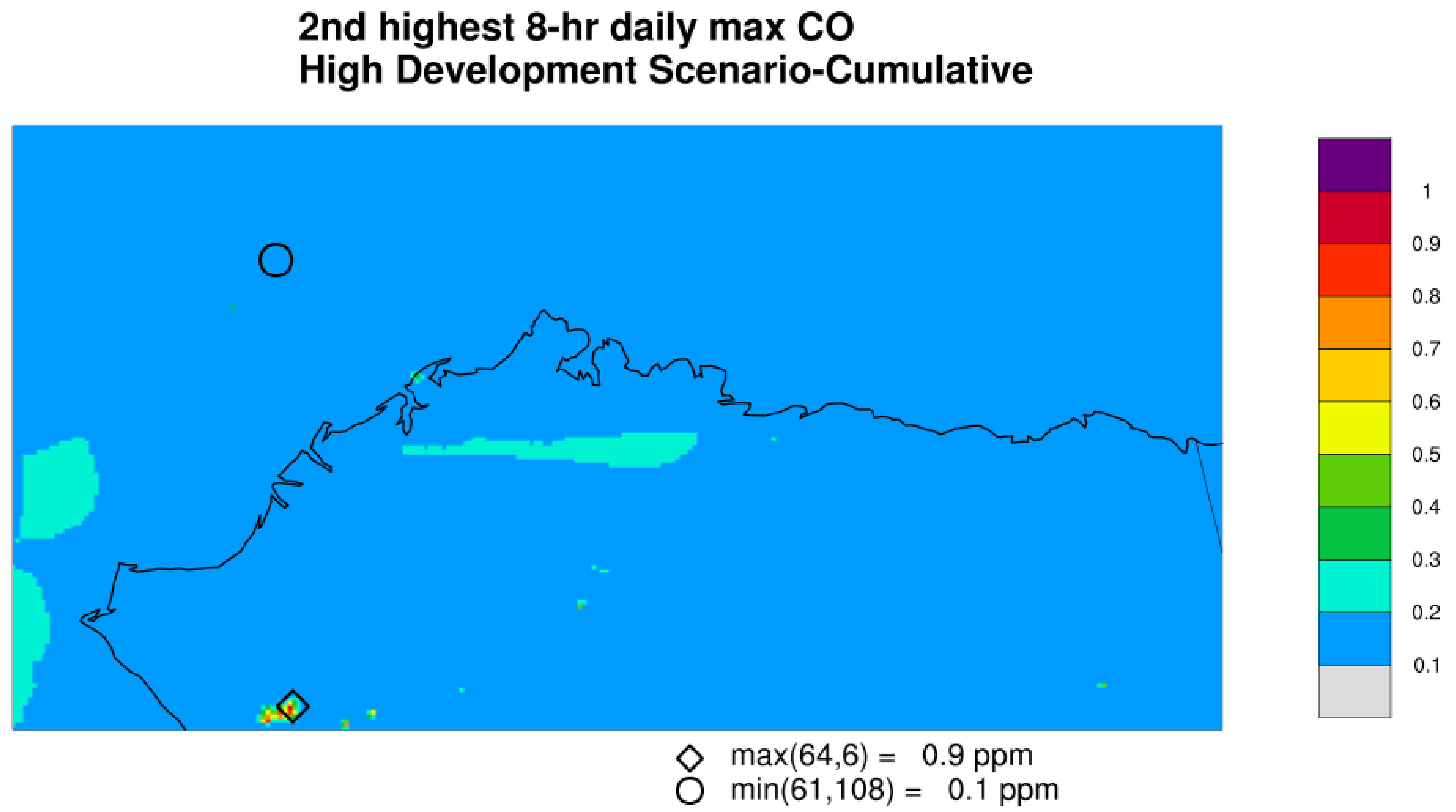
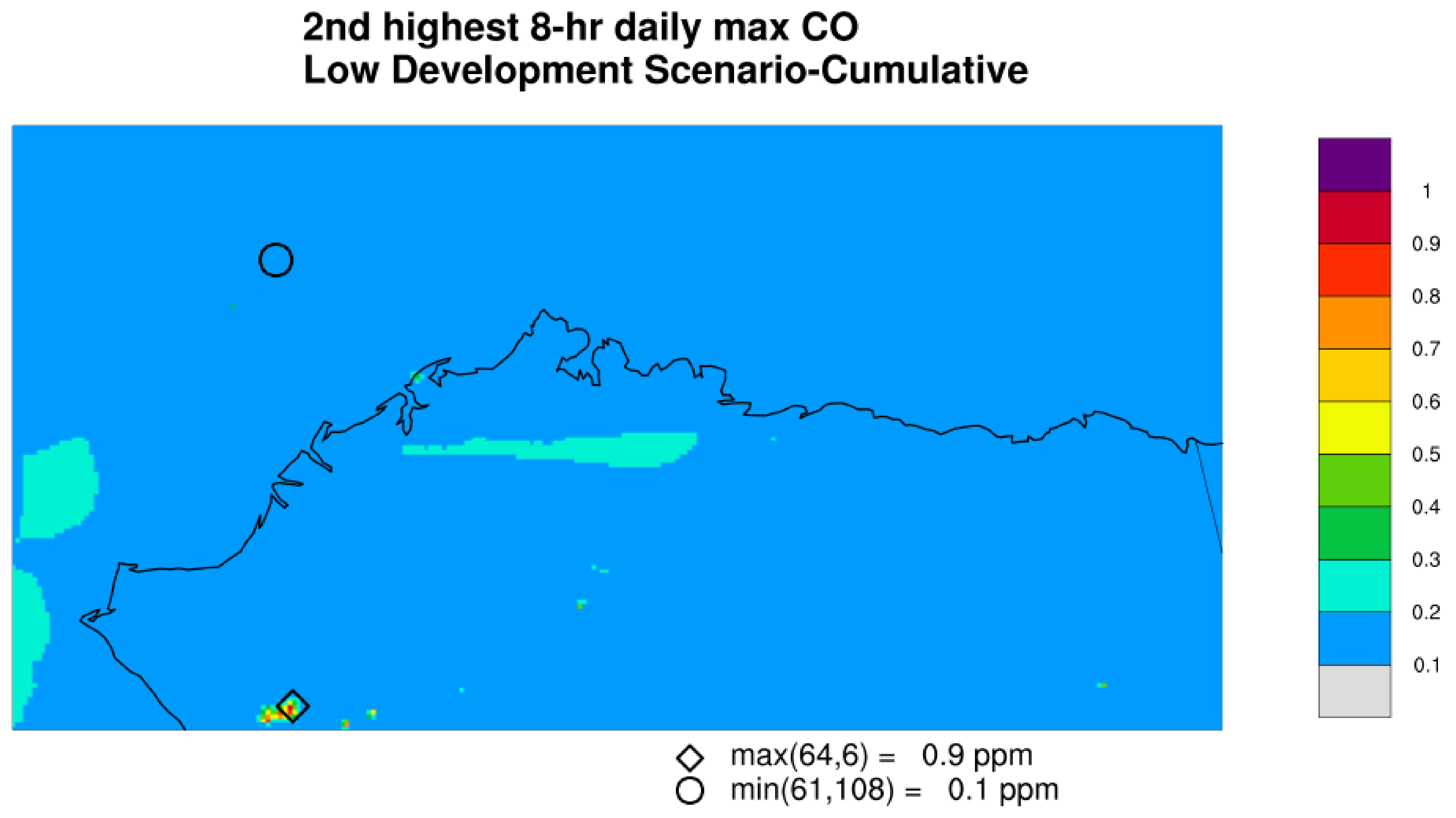
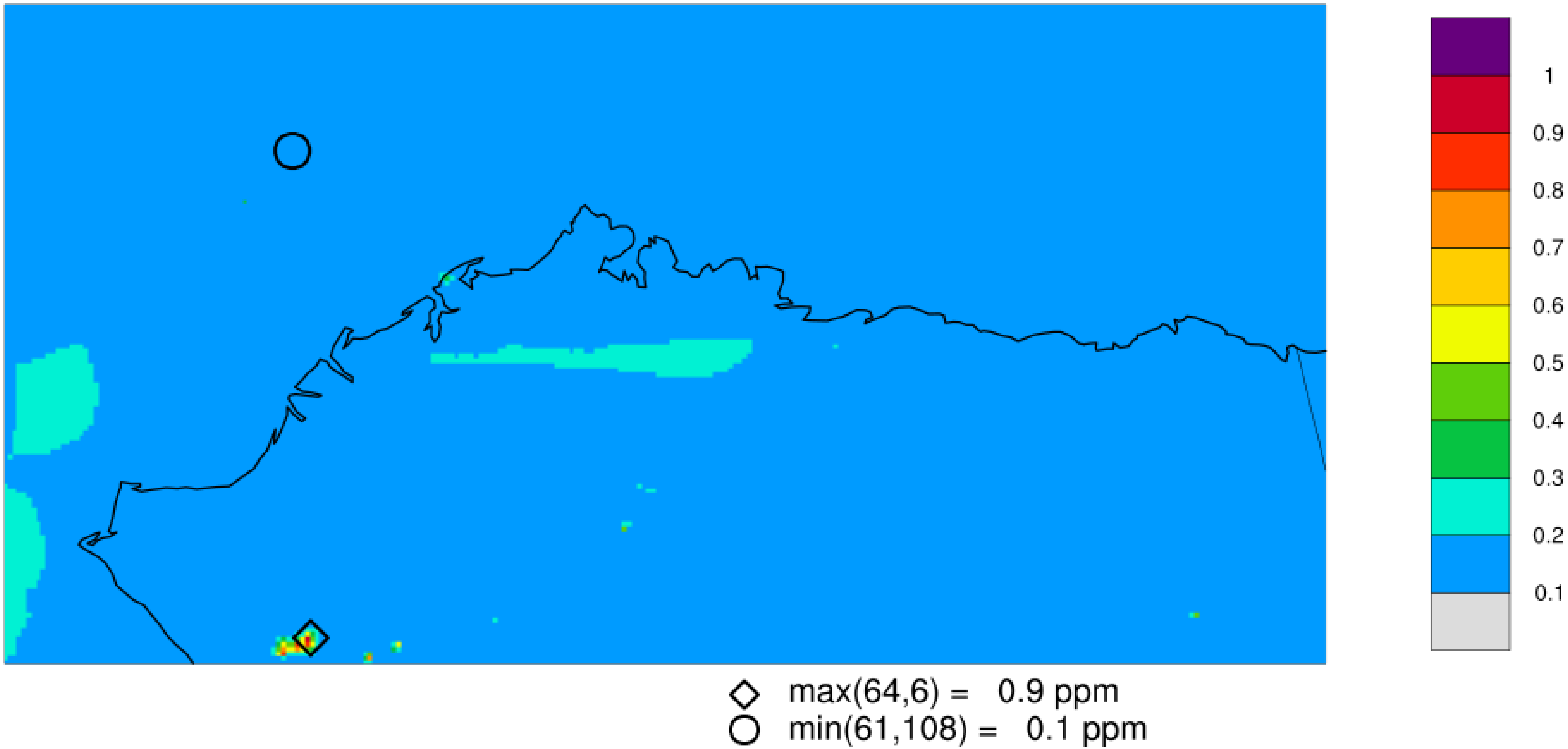
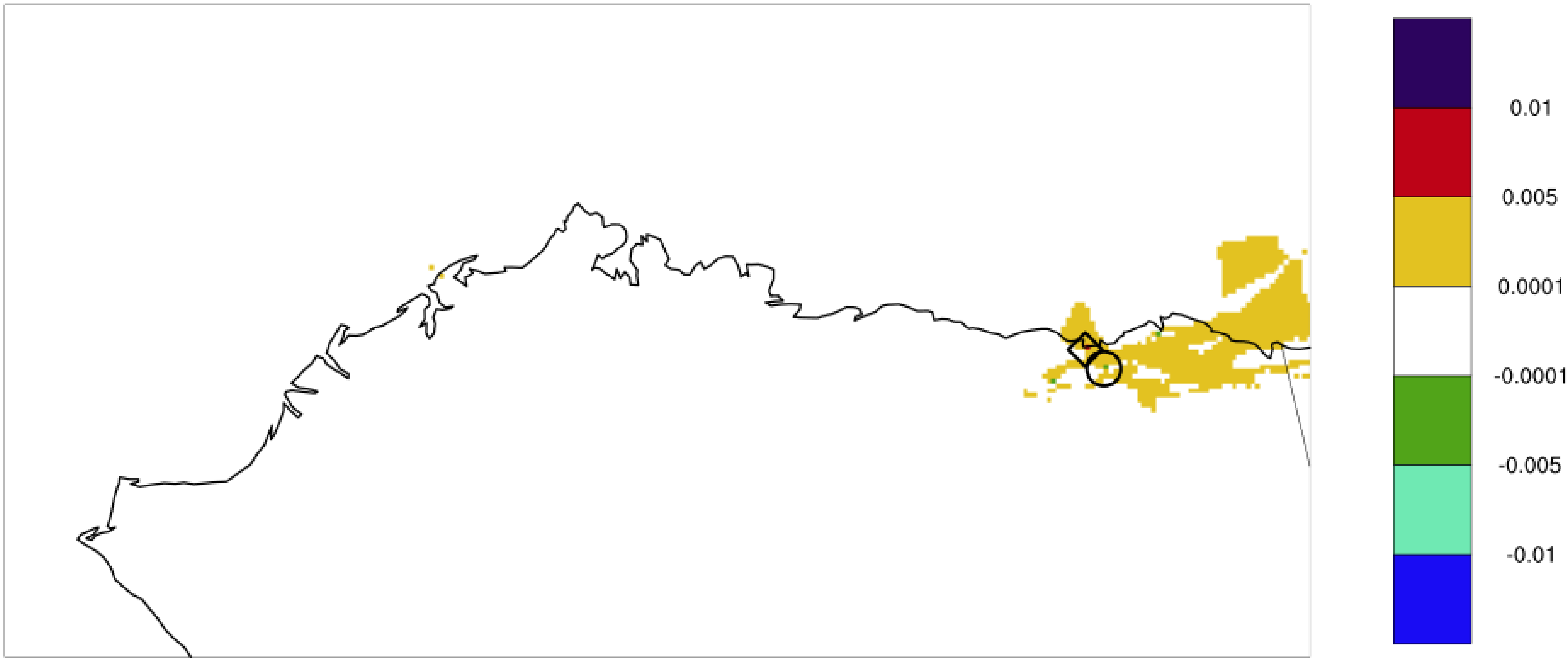

2nd highest 8-hr daily max CO
High Development Scenario-Cumulative
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
max(64,6) = 0.9 ppm
min(61,108) = 0.1 ppm


2nd highest 8-hr daily max CO
Low Development Scenario-Cumulative
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
max(64,6) = 0.9 ppm
min(61,108) = 0.1 ppm

2nd highest 8-hr daily max CO
No Action Alternative-Cumulative

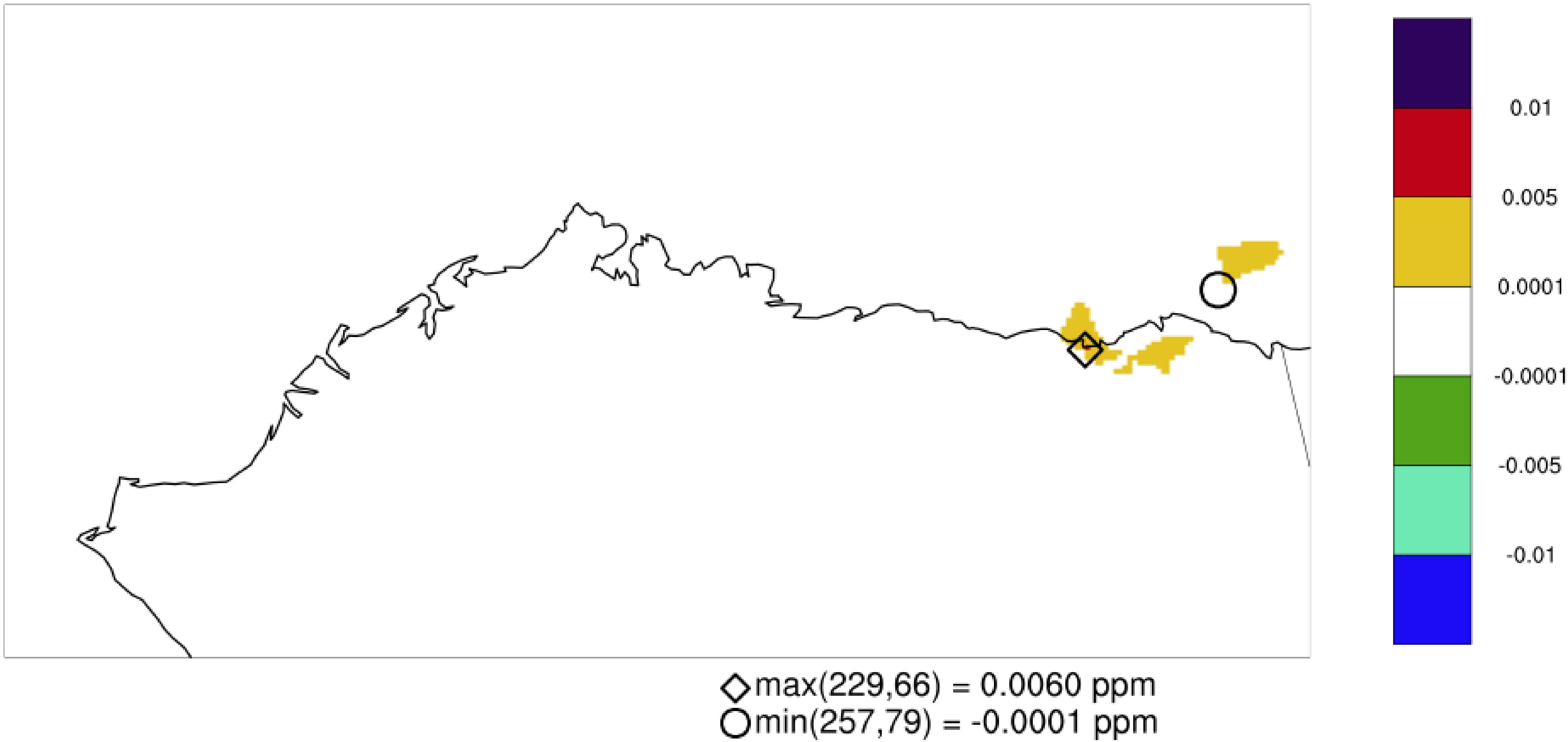


2nd highest 8-hr daily max CO
High Development Scenario-Indirect Impact

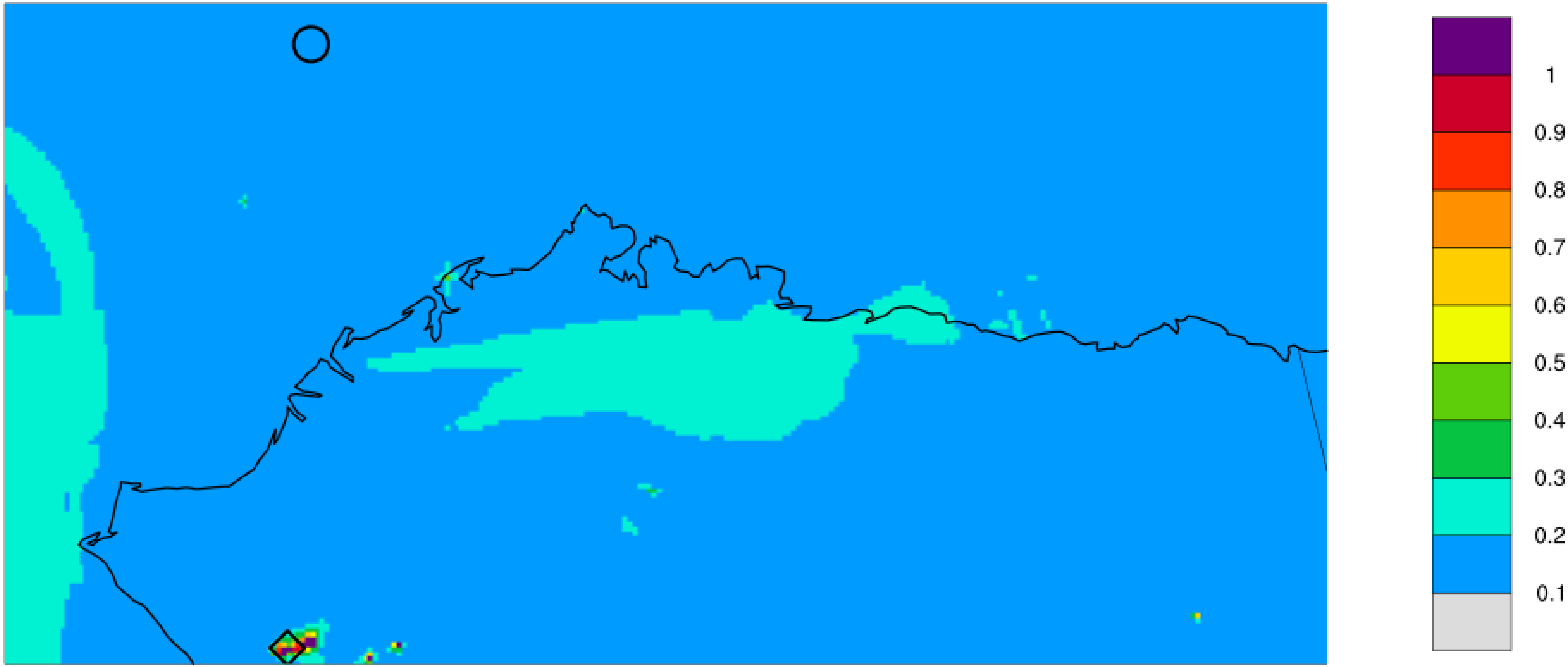


◇max(229,66) = 0.0061 ppm
○min(233,62) = -0.0002 ppm

2nd highest 8-hr daily max CO
Low Development Scenario-Indirect Impact

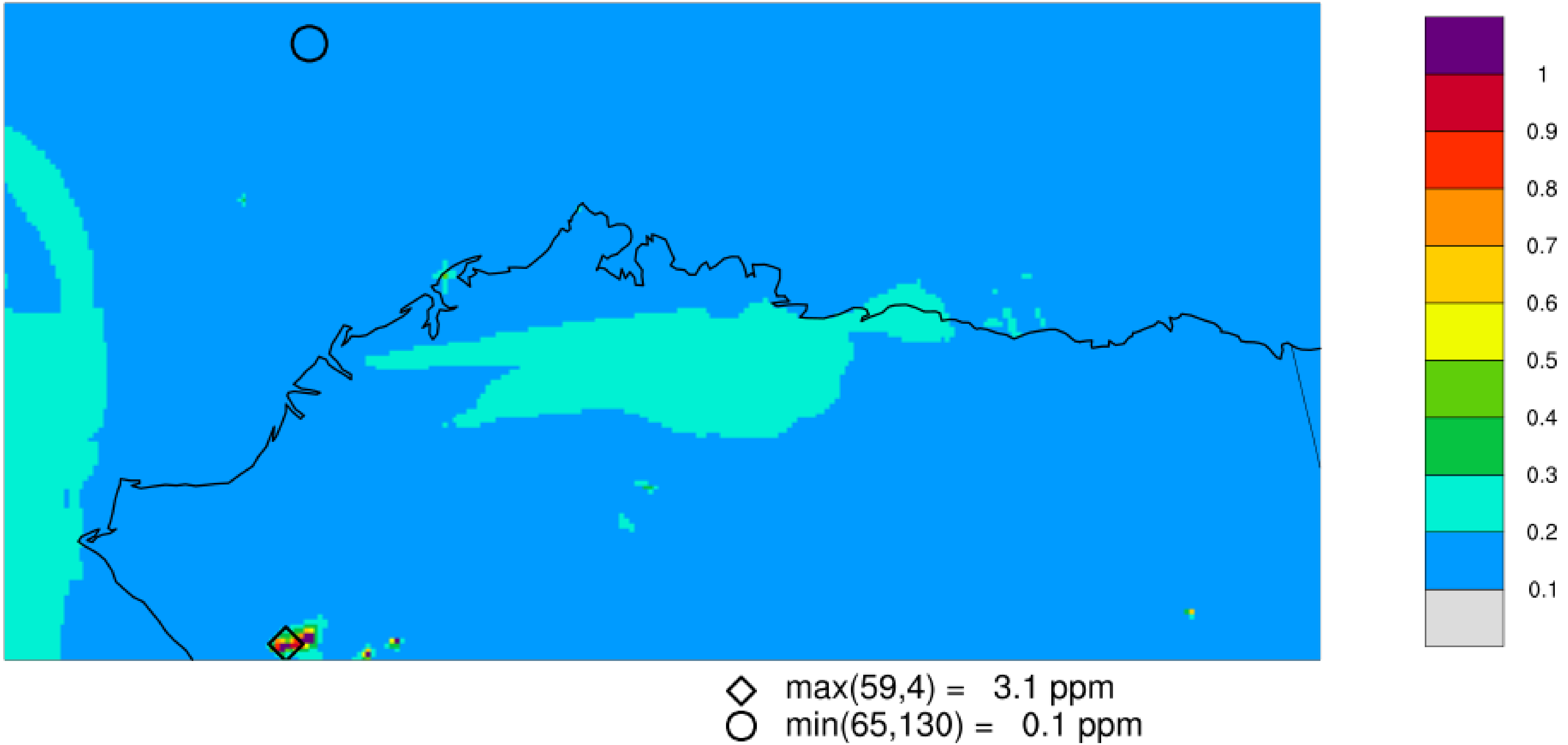


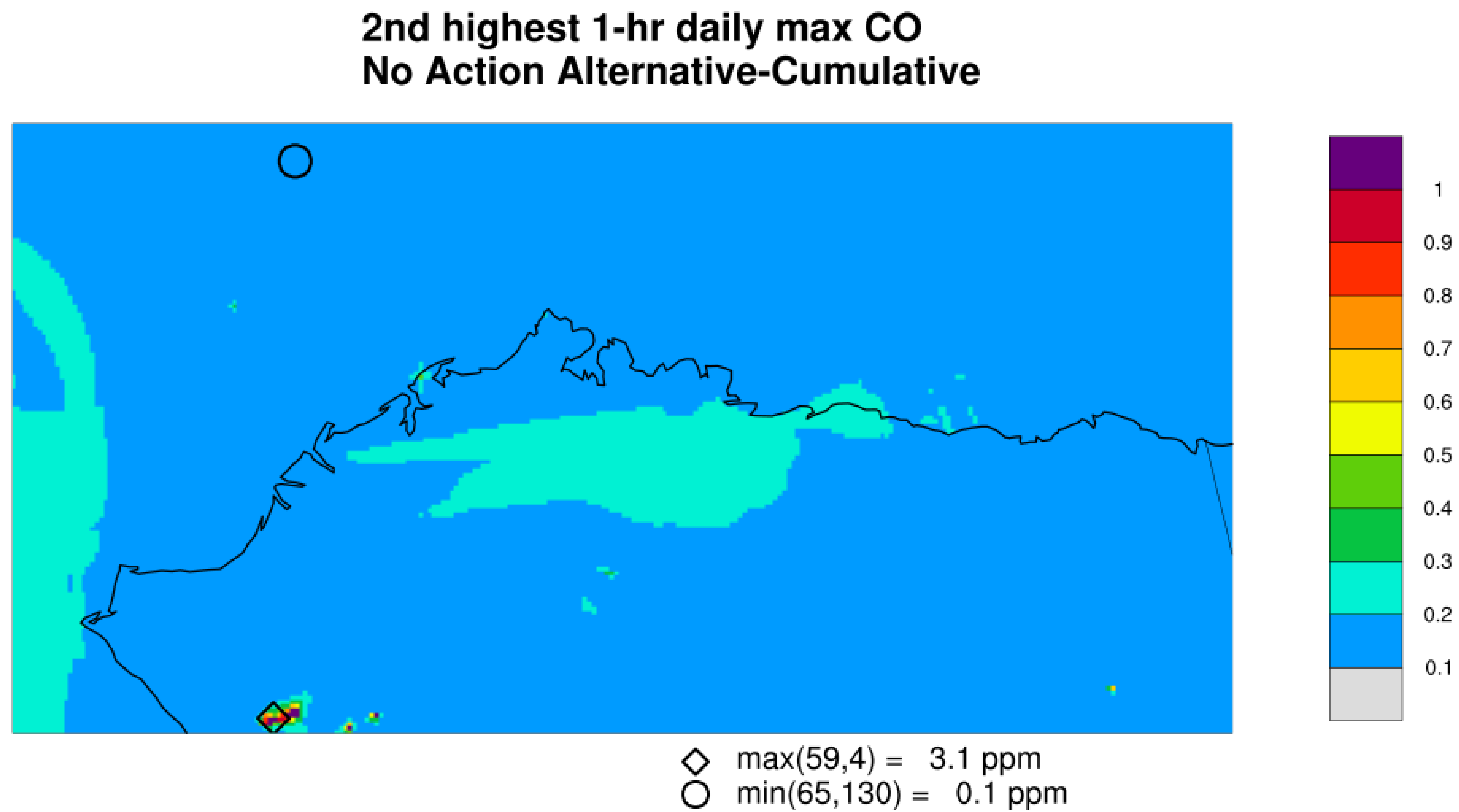
2nd highest 1-hr daily max CO
High Development Scenario-Cumulative



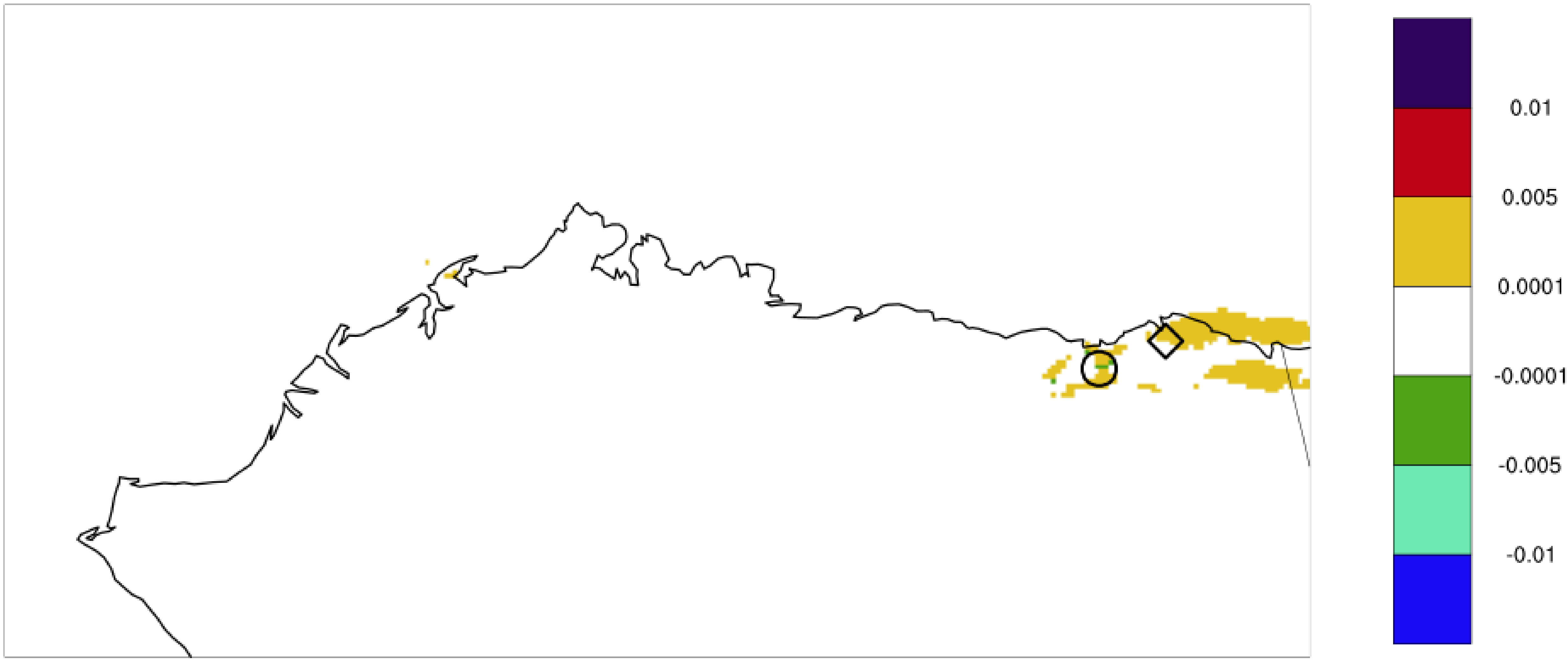
◇ max(59,4) = 3.1 ppm
○ min(65,130) = 0.1 ppm

2nd highest 1-hr daily max CO
Low Development Scenario-Cumulative



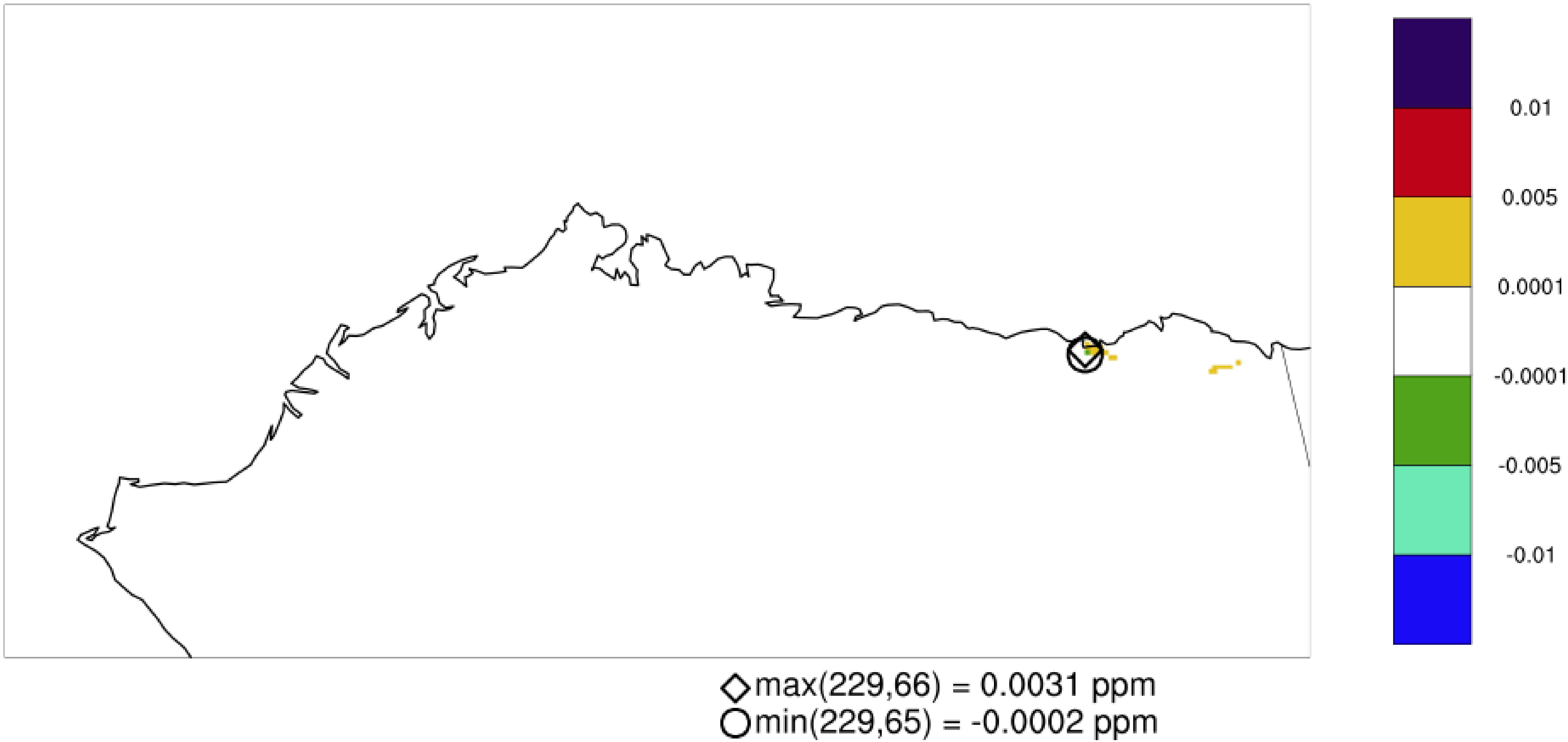

2nd highest 1-hr daily max CO
No Action Alternative-Cumulative
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
max(59,4) = 3.1 ppm
min(65,130) = 0.1 ppm

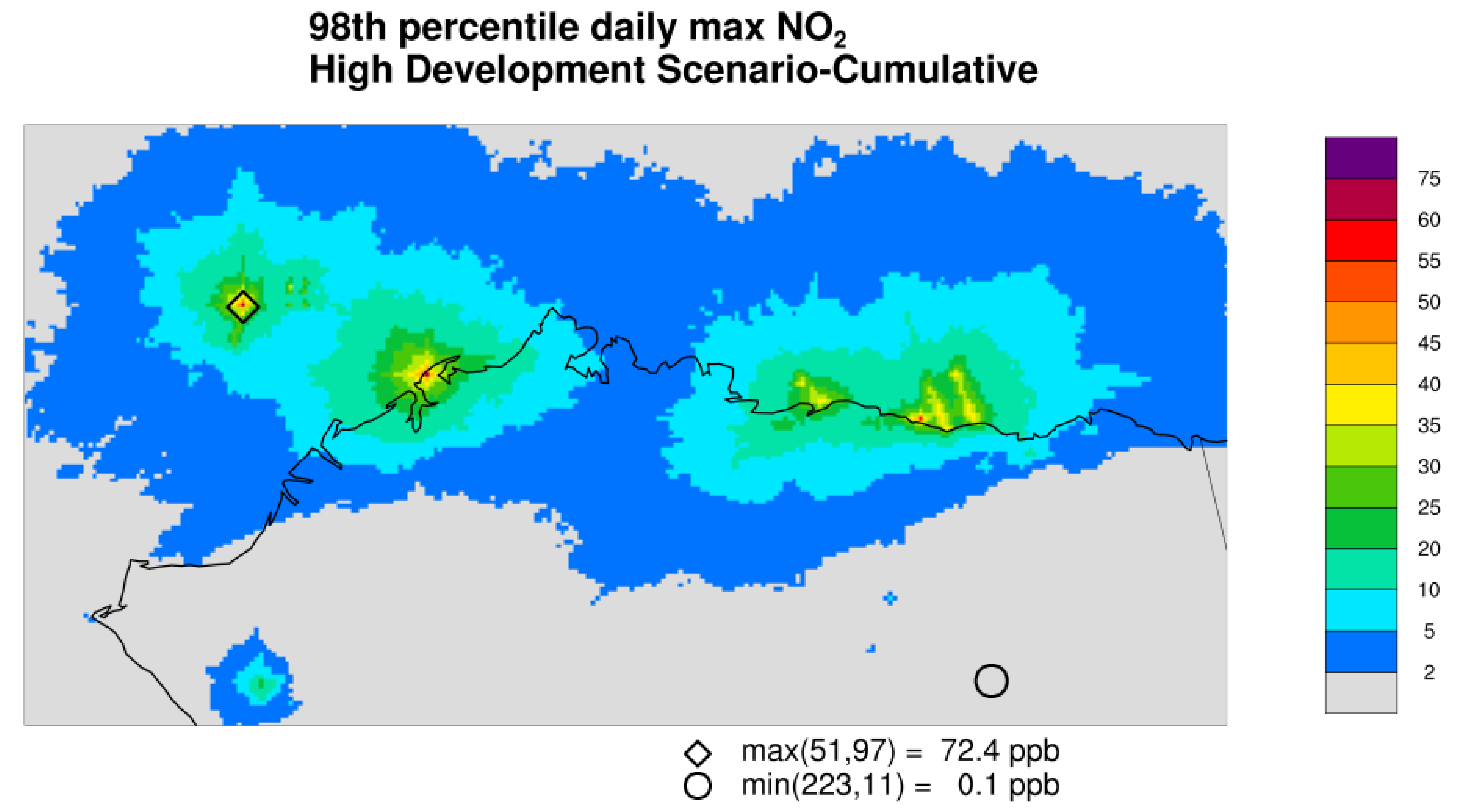
2nd highest 1-hr daily max CO
High Development Scenario-Indirect Impact



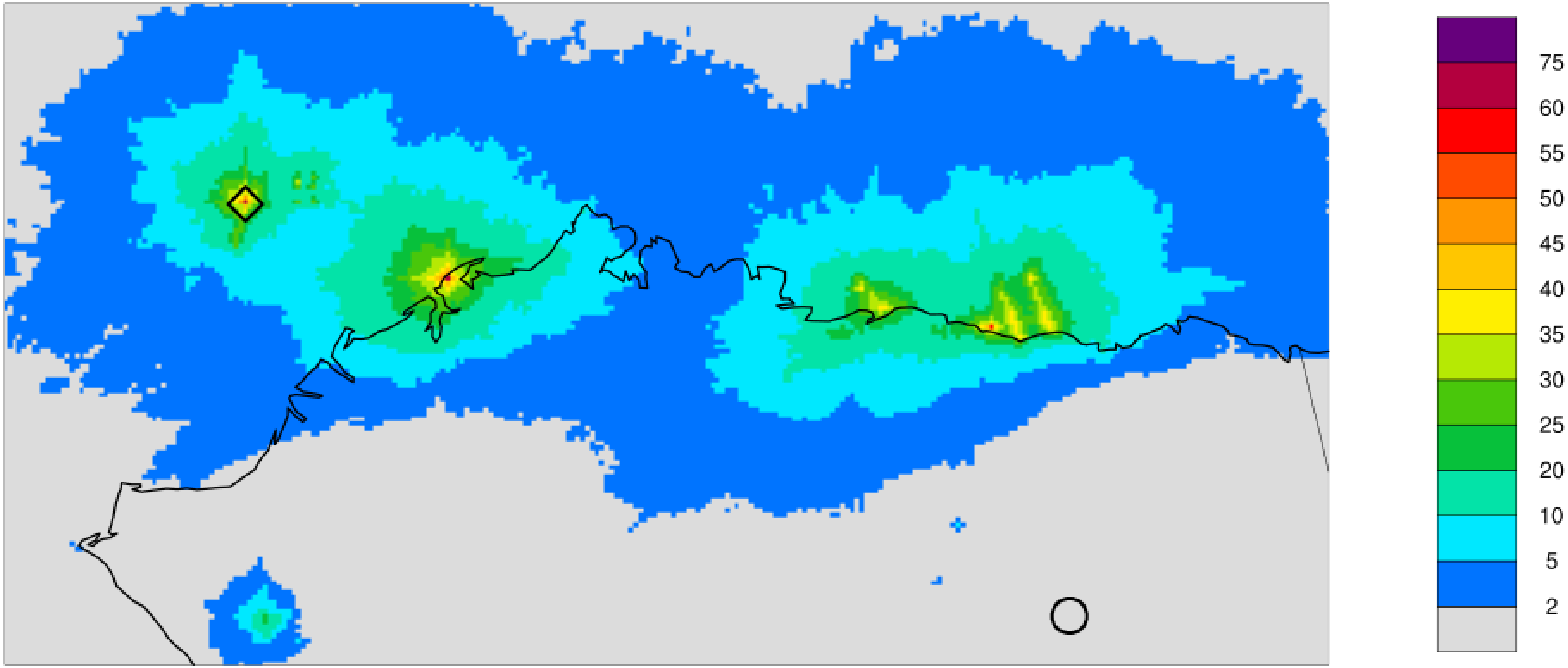
◇max(246,68) = 0.0050 ppm
○min(232,62) = -0.0005 ppm

2nd highest 1-hr daily max CO
Low Development Scenario-Indirect Impact

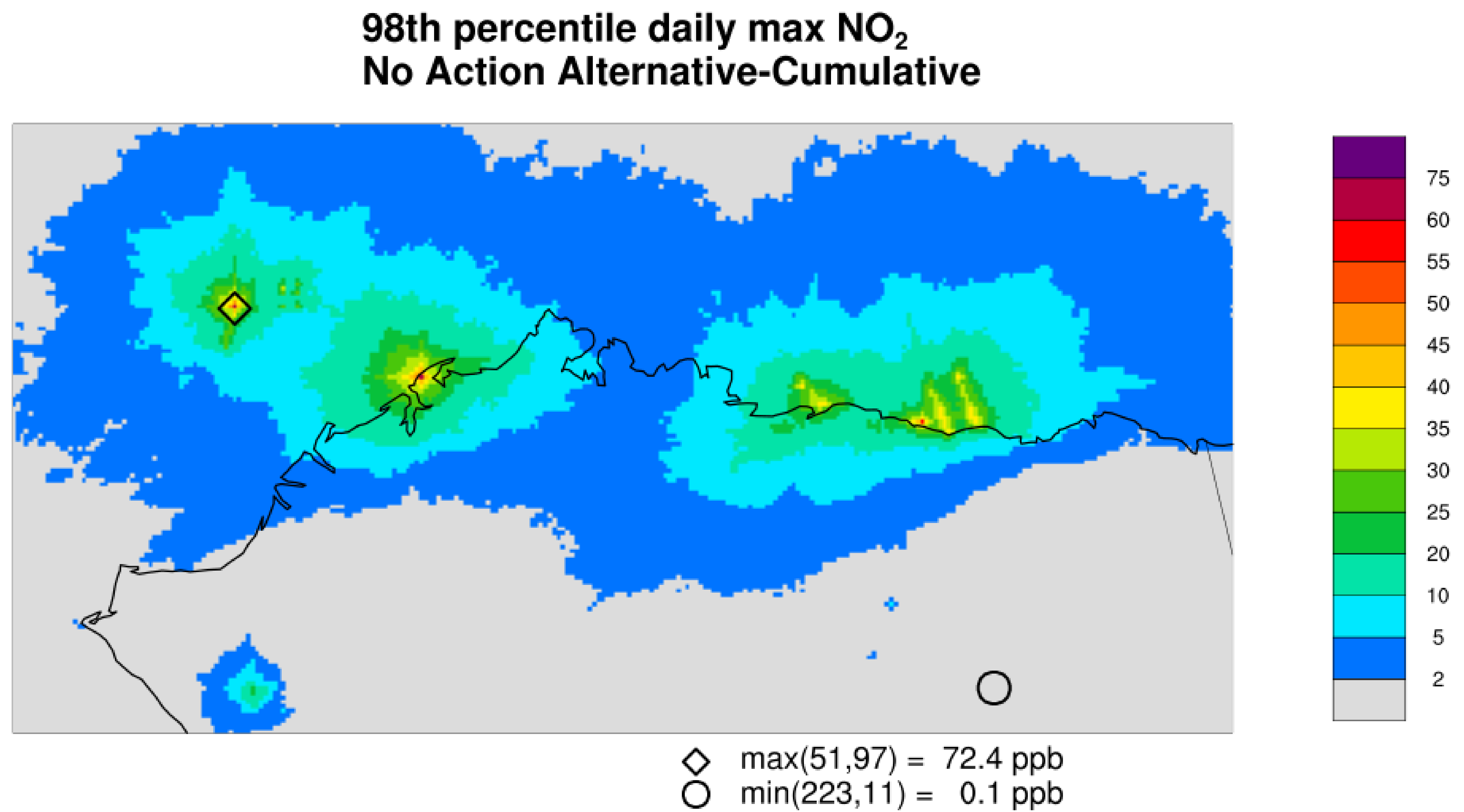



98th percentile daily max NO_2
High Development Scenario-Cumulative
75
60
55
50
45
40
35
30
25
20
10
5
2
max(51,97) = 72.4 ppb
min(223,11) = 0.1 ppb

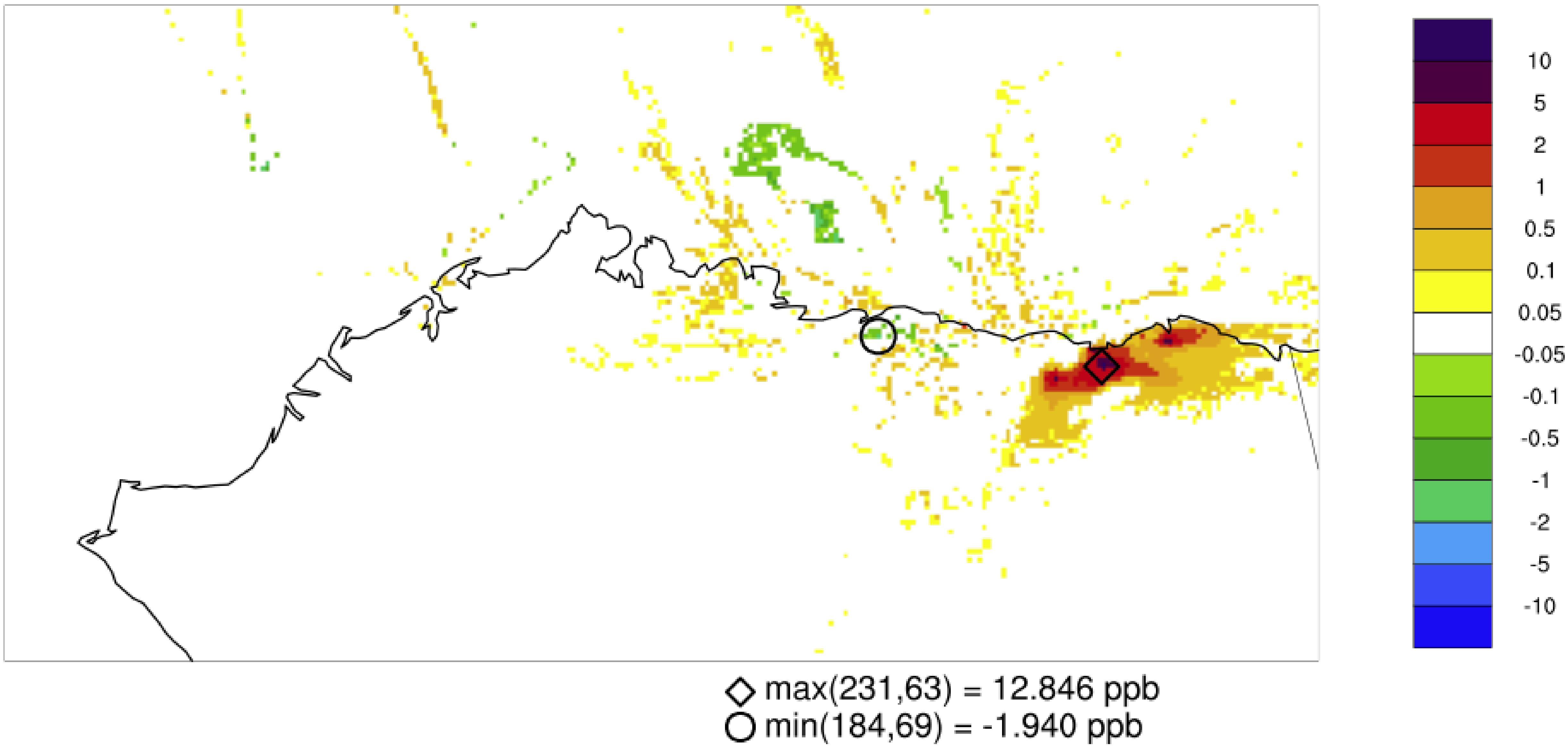
98th percentile daily max NO_2
Low Development Scenario-Cumulative

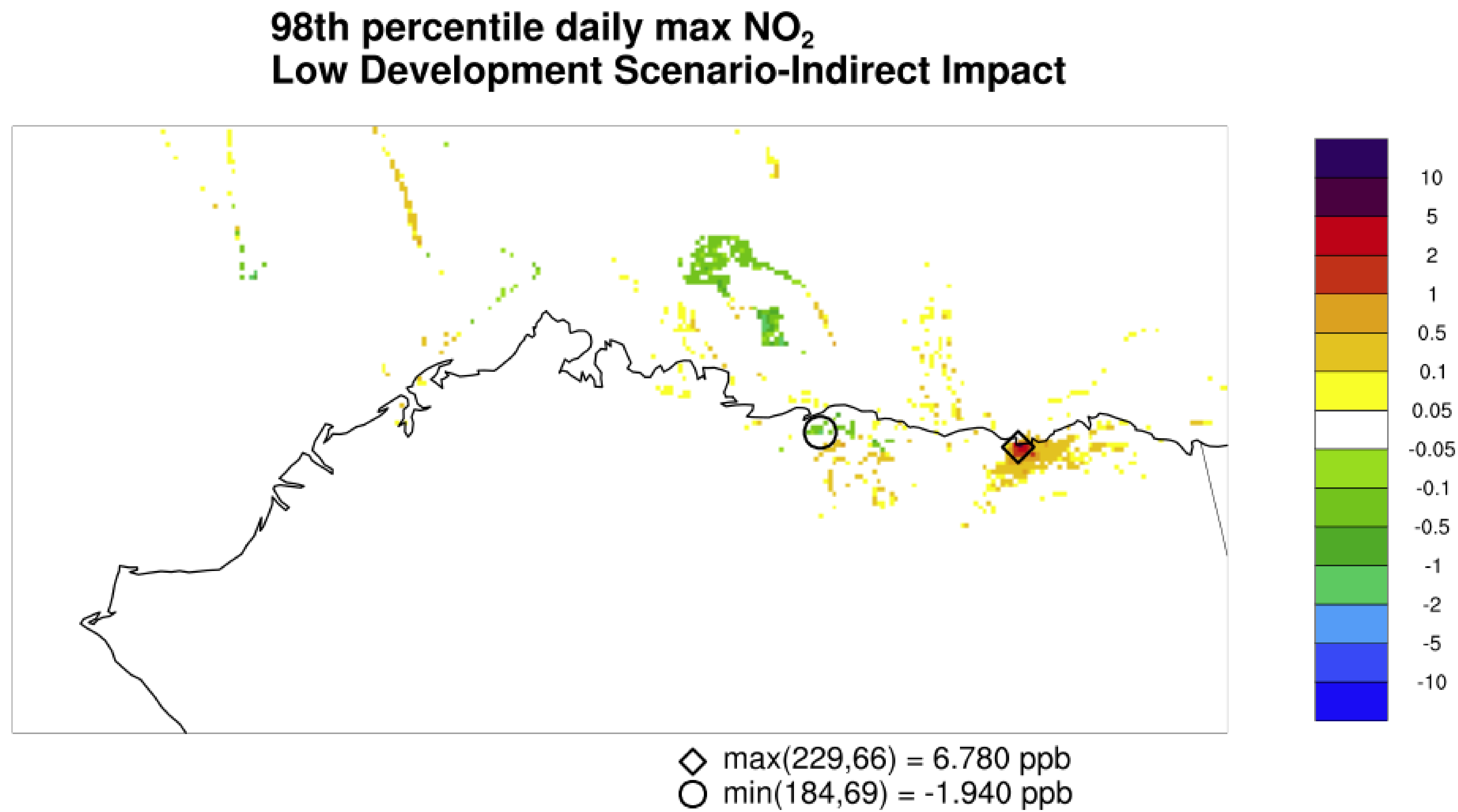


◇ max(51,97) = 72.4 ppb
○ min(223,11) = 0.1 ppb

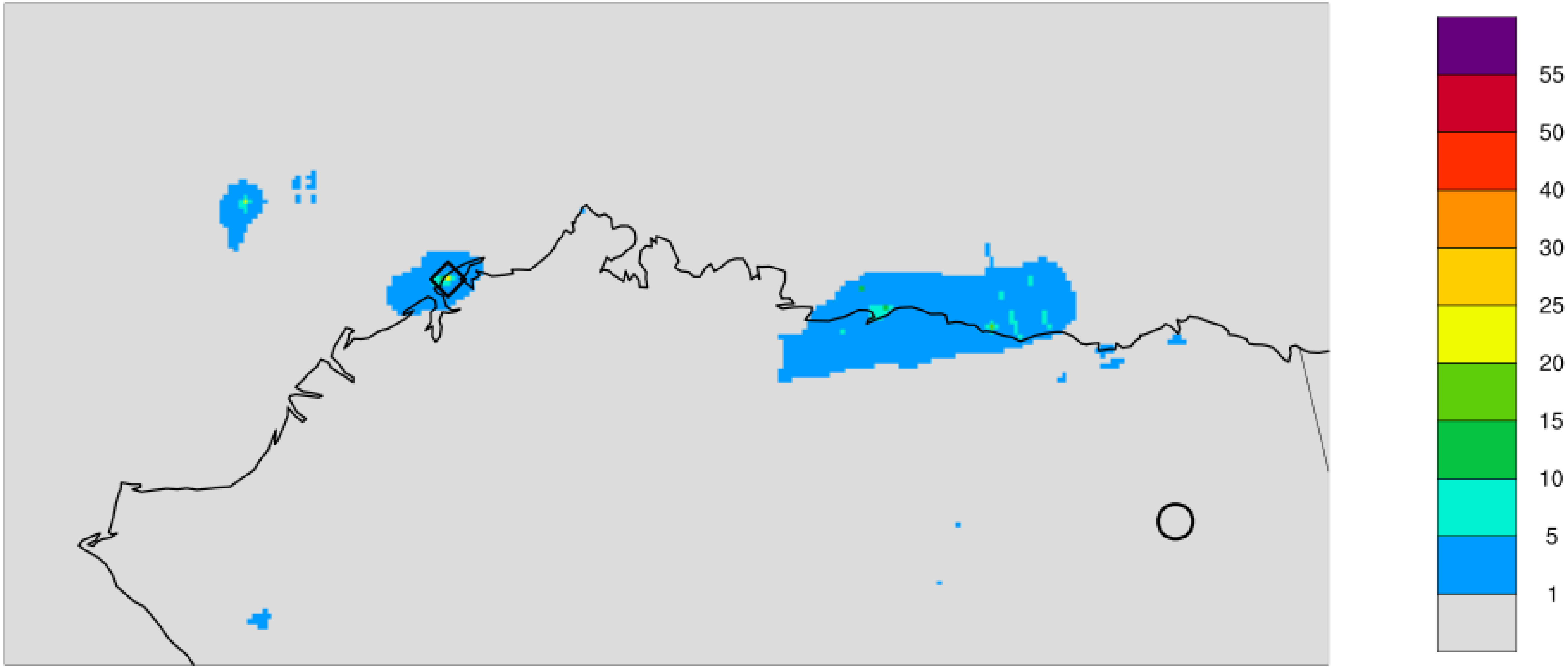

98th percentile daily max NO_2
No Action Alternative-Cumulative
75
60
55
50
45
40
35
30
25
20
10
5
2
max(51,97) = 72.4 ppb
min(223,11) = 0.1 ppb

98th percentile daily max NO_2
High Development Scenario-Indirect Impact



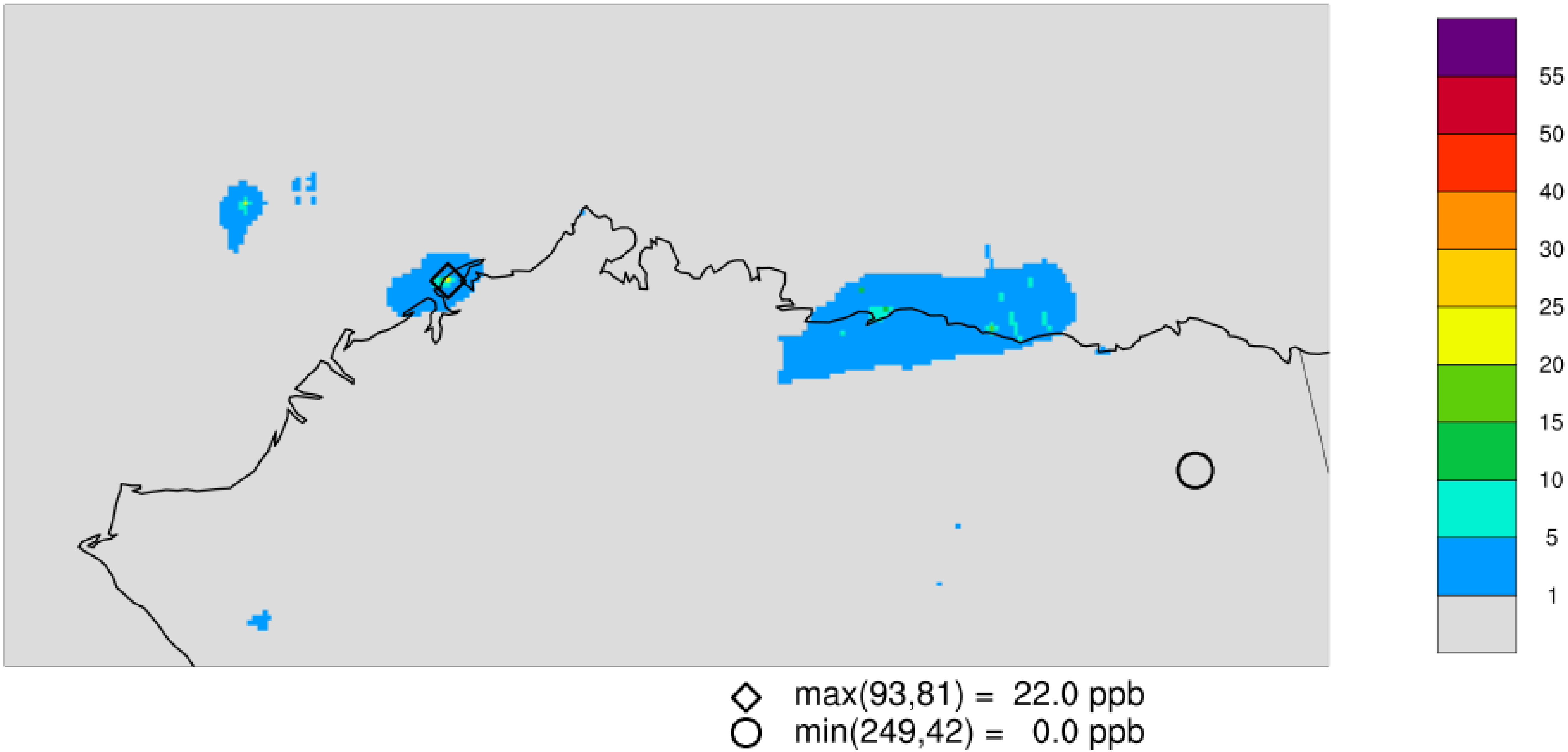

98th percentile daily max NO2
Low Development Scenario-Indirect Impact
10
5
2
1
0.5
0.1
0.05
-0.05
-0.1
-0.5
-1
-2
-5
-10
max(229,66) = 6.780 ppb
min(184,69) = -1.940 ppb

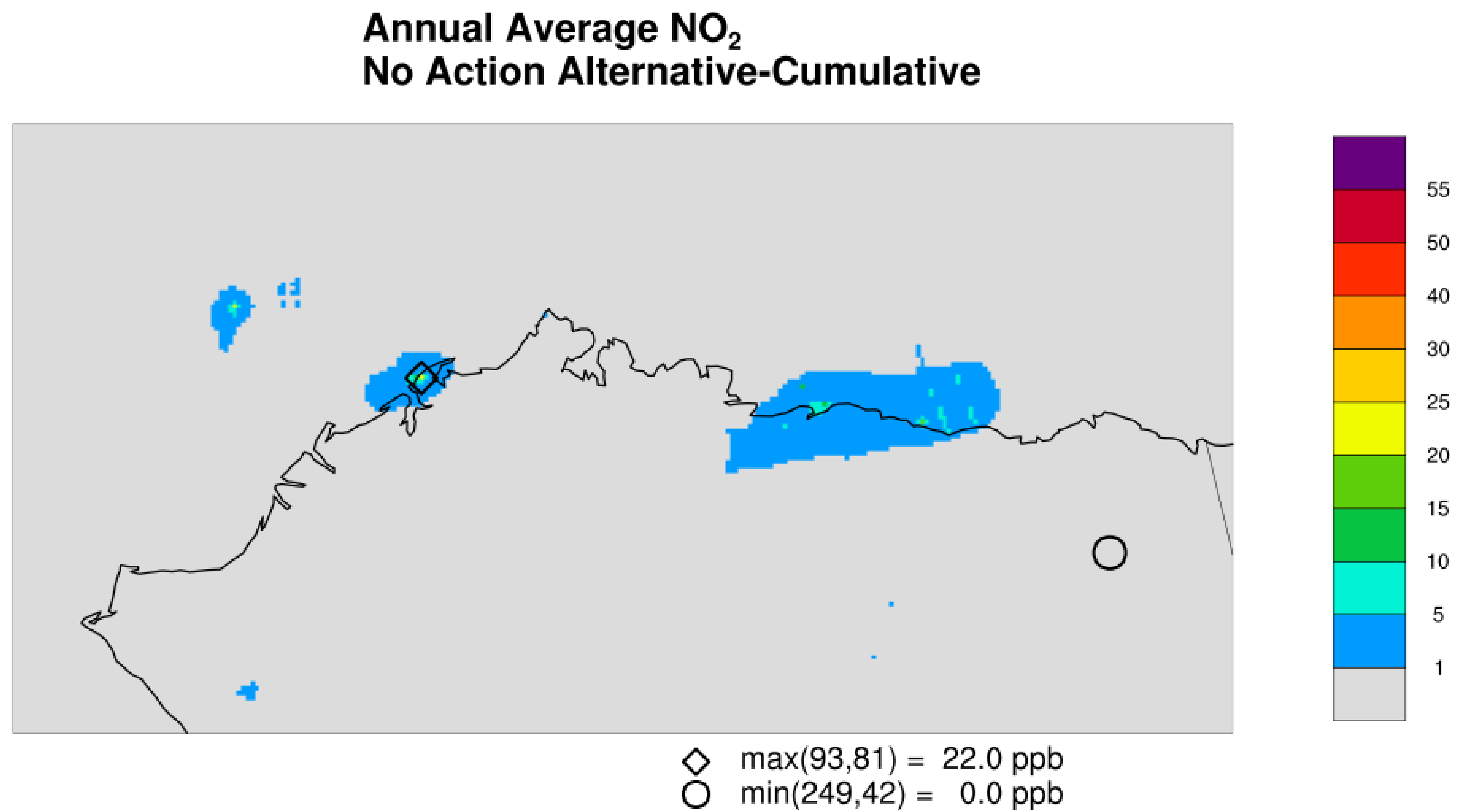
Annual Average NO_2
High Development Scenario-Cumulative



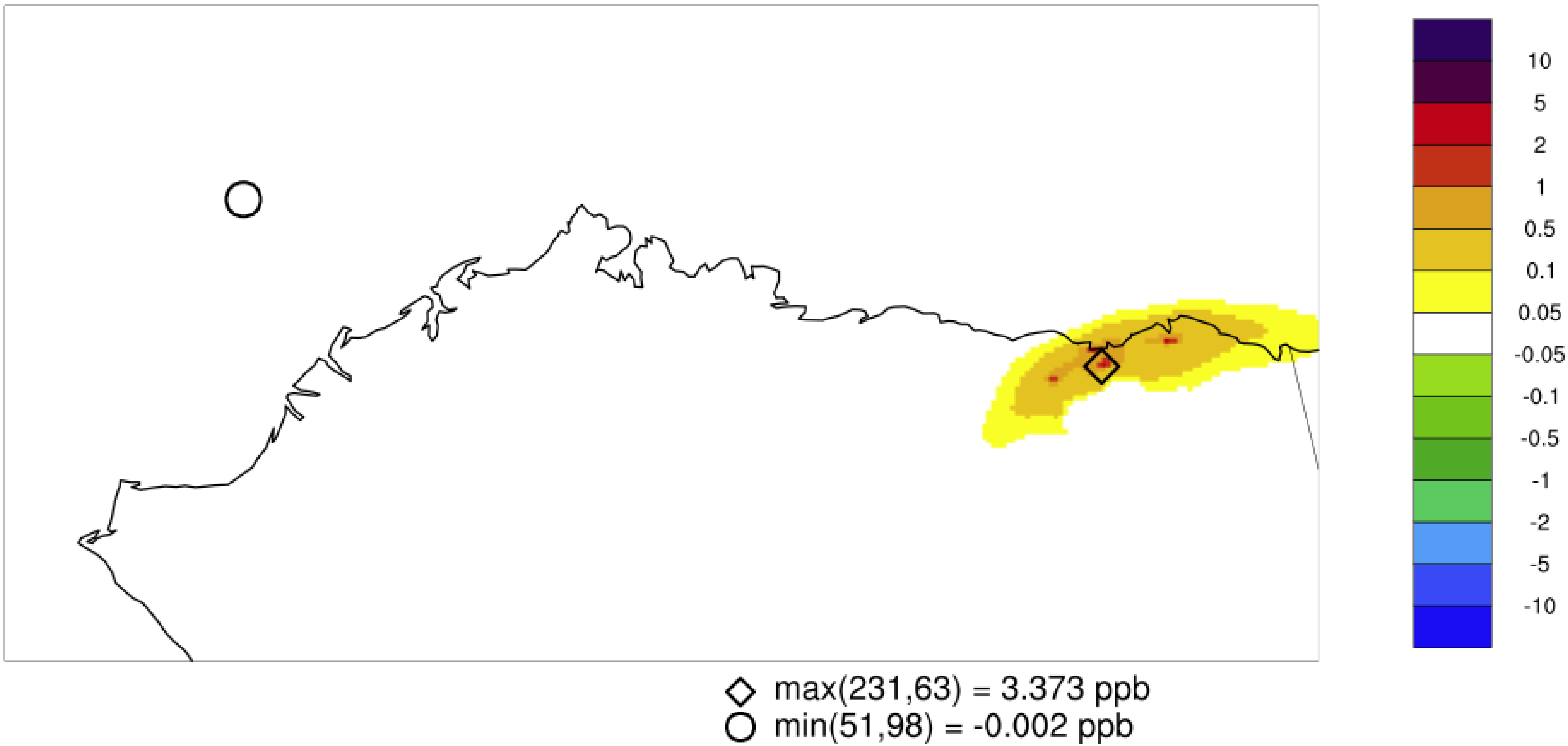
◇ max(93,81) = 22.0 ppb
○ min(245,31) = 0.0 ppb

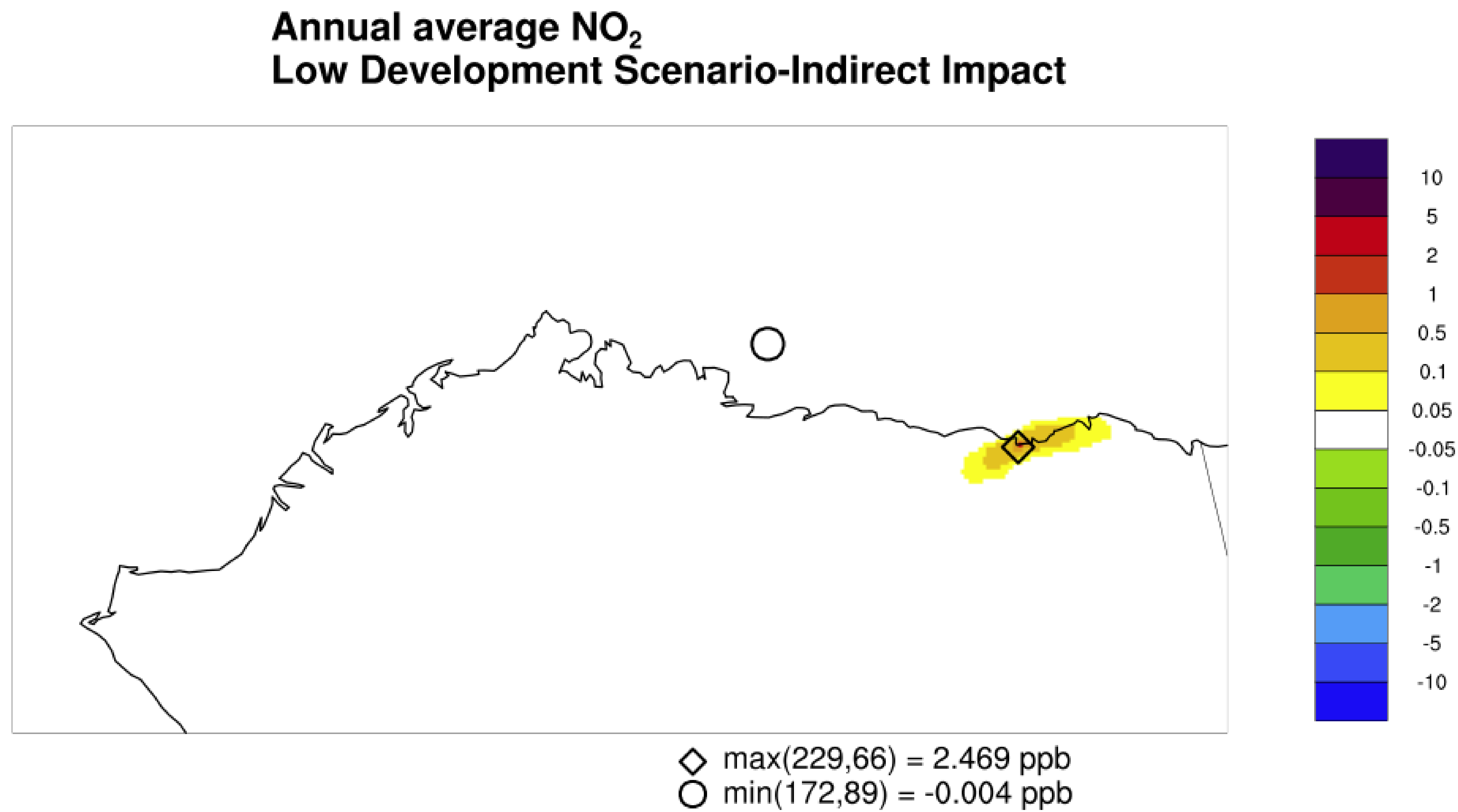
Annual Average NO_2
Low Development Scenario-Cumulative



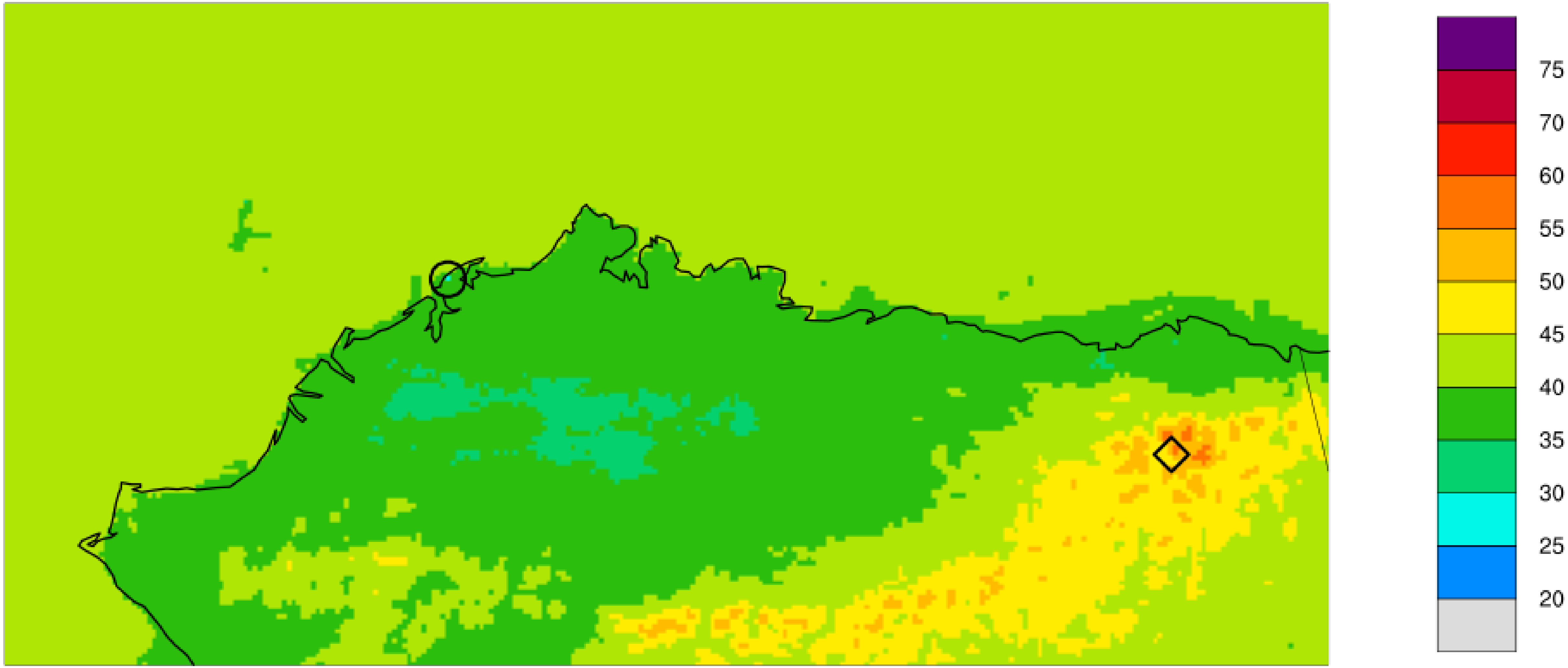

Annual Average NO_2
No Action Alternative-Cumulative
55
50
40
30
25
20
15
10
5
1
max(93,81) = 22.0 ppb
min(249,42) = 0.0 ppb

Annual average NO_2
High Development Scenario-Indirect Impact



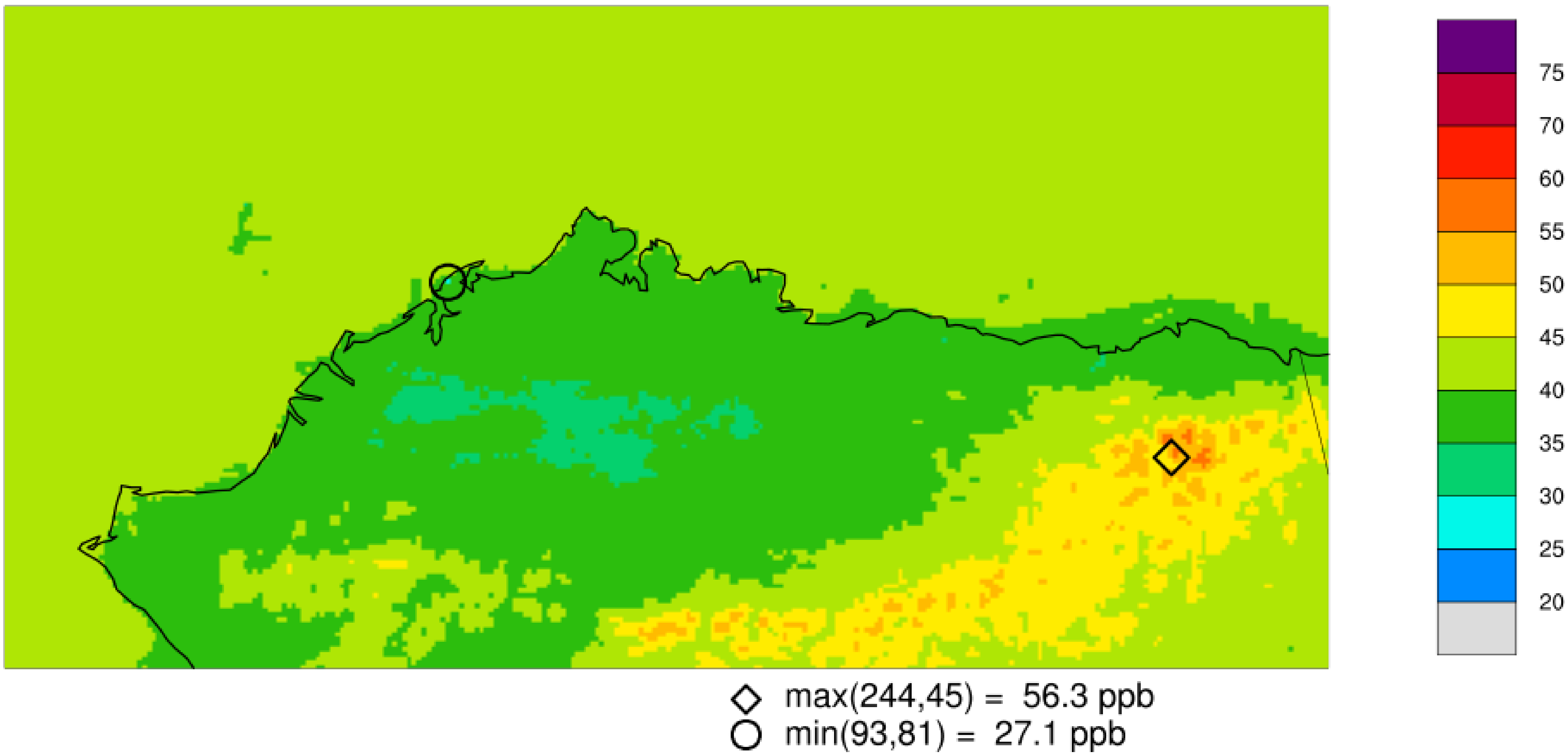

Annual average NO_2
Low Development Scenario-Indirect Impact
10
5
2
1
0.5
0.1
0.05
-0.05
-0.1
-0.5
-1
-2
-5
-10
max(229,66) = 2.469 ppb
min(172,89) = -0.004 ppb

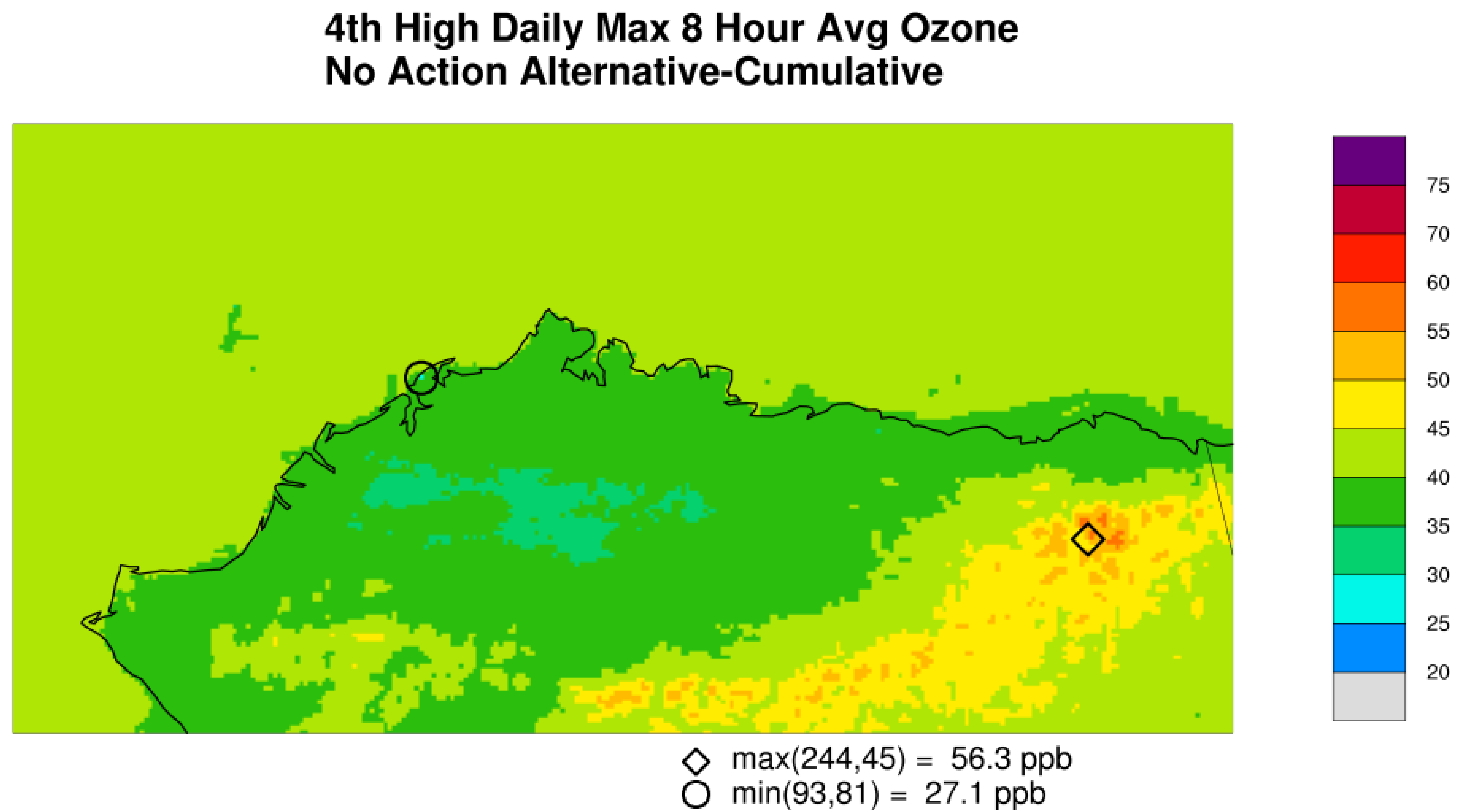
4th High Daily Max 8 Hour Avg Ozone
High Development Scenario-Cumulative



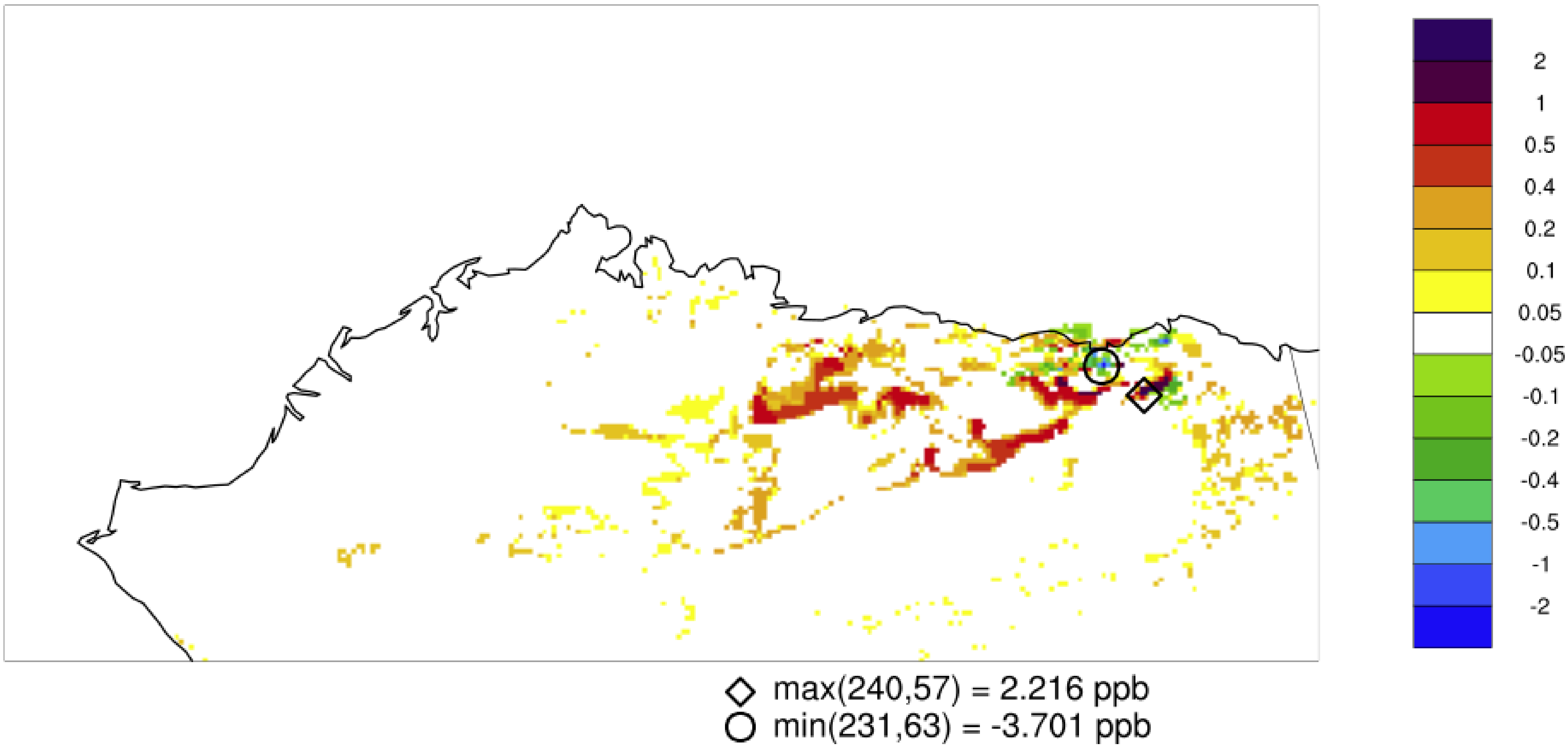
◇ max(244,45) = 56.3 ppb
○ min(93,81) = 27.1 ppb

4th High Daily Max 8 Hour Avg Ozone
Low Development Scenario-Cumulative

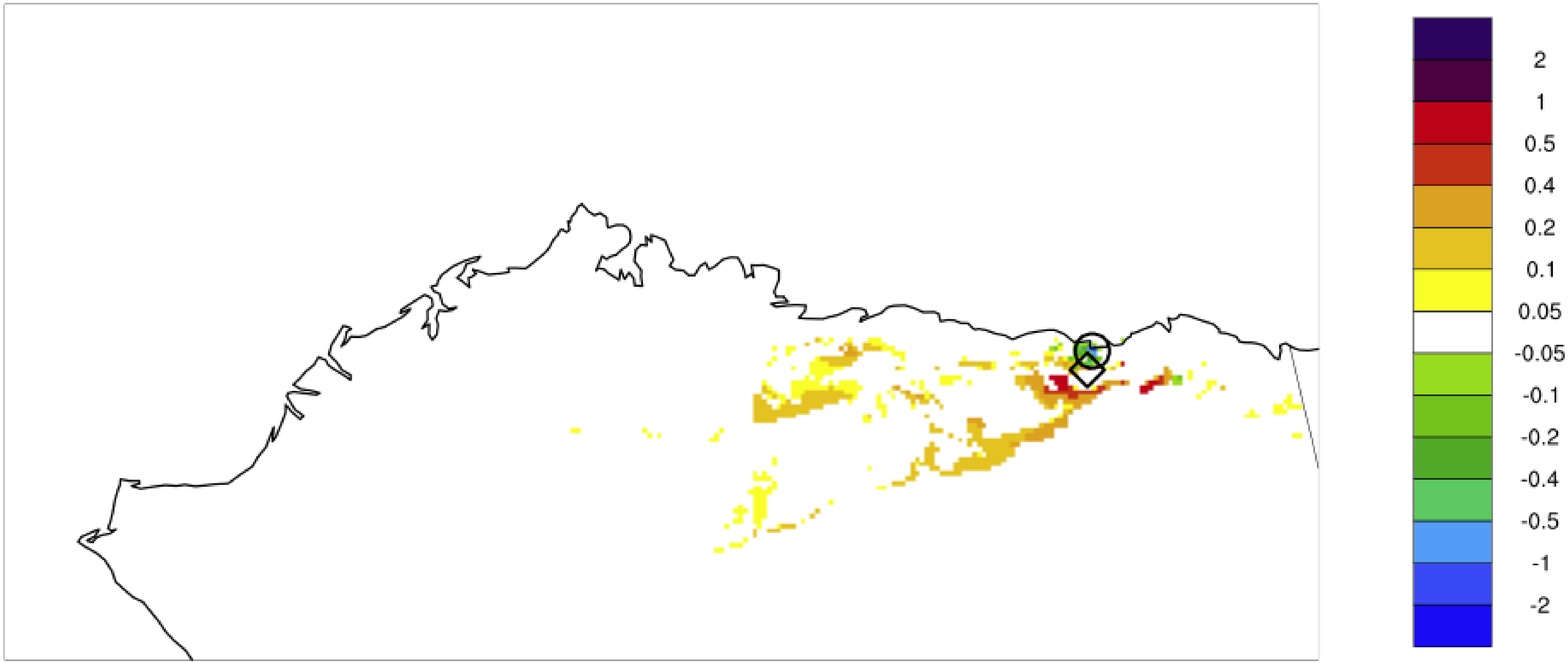



4th High Daily Max 8 Hour Avg Ozone
No Action Alternative-Cumulative
75
70
60
55
50
45
40
35
30
25
20
max(244,45) = 56.3 ppb
min(93,81) = 27.1 ppb

4th High Daily Max 8 Hour Avg Ozone
High Development Scenario-Indirect Impact

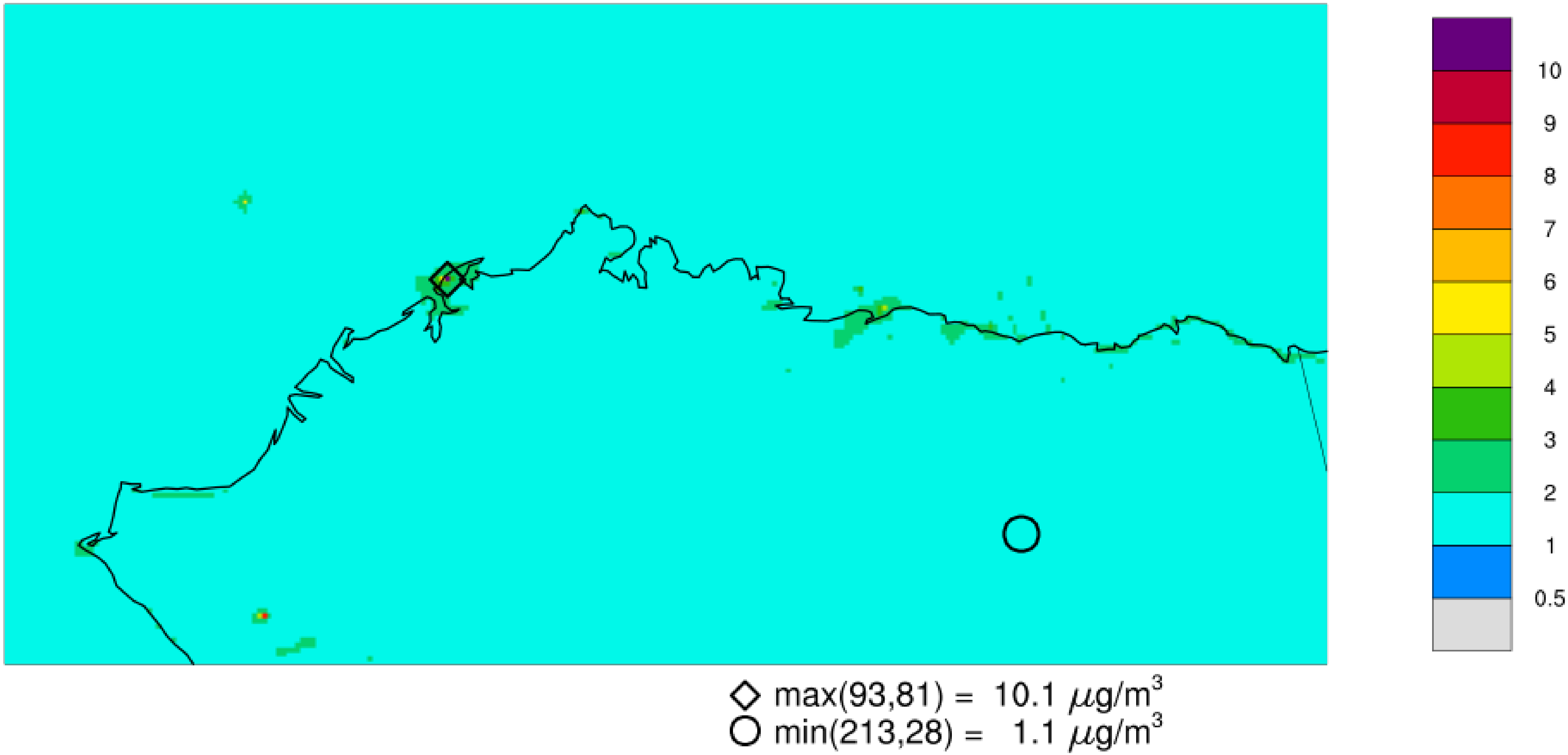


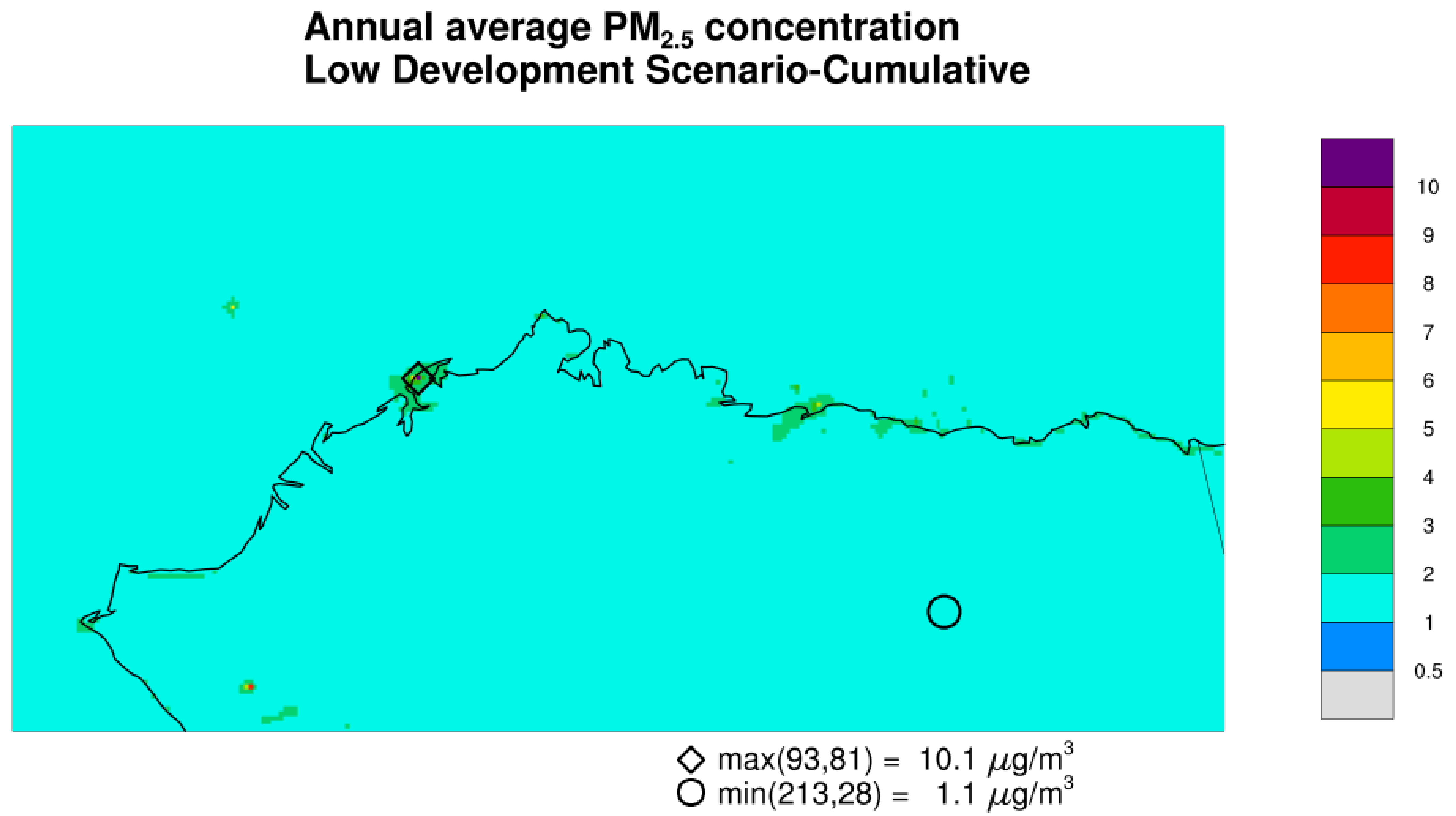
4th High Daily Max 8 Hour Avg Ozone
Low Development Scenario-Indirect Impact



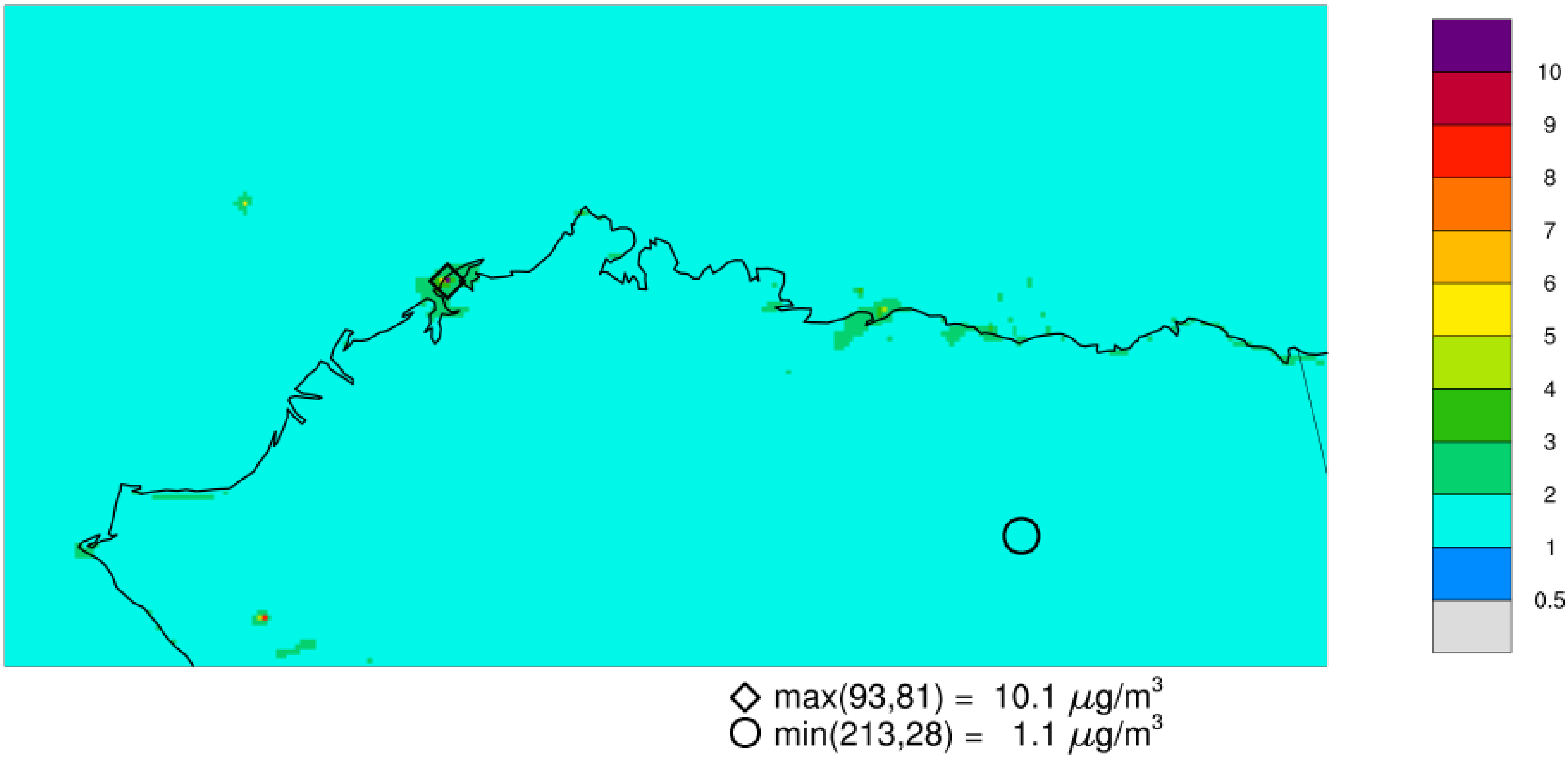
◇ max(228,62) = 0.826 ppb
○ min(229,66) = -1.591 ppb

Annual average $PM_{2.5}$ concentration
High Development Scenario-Cumulative

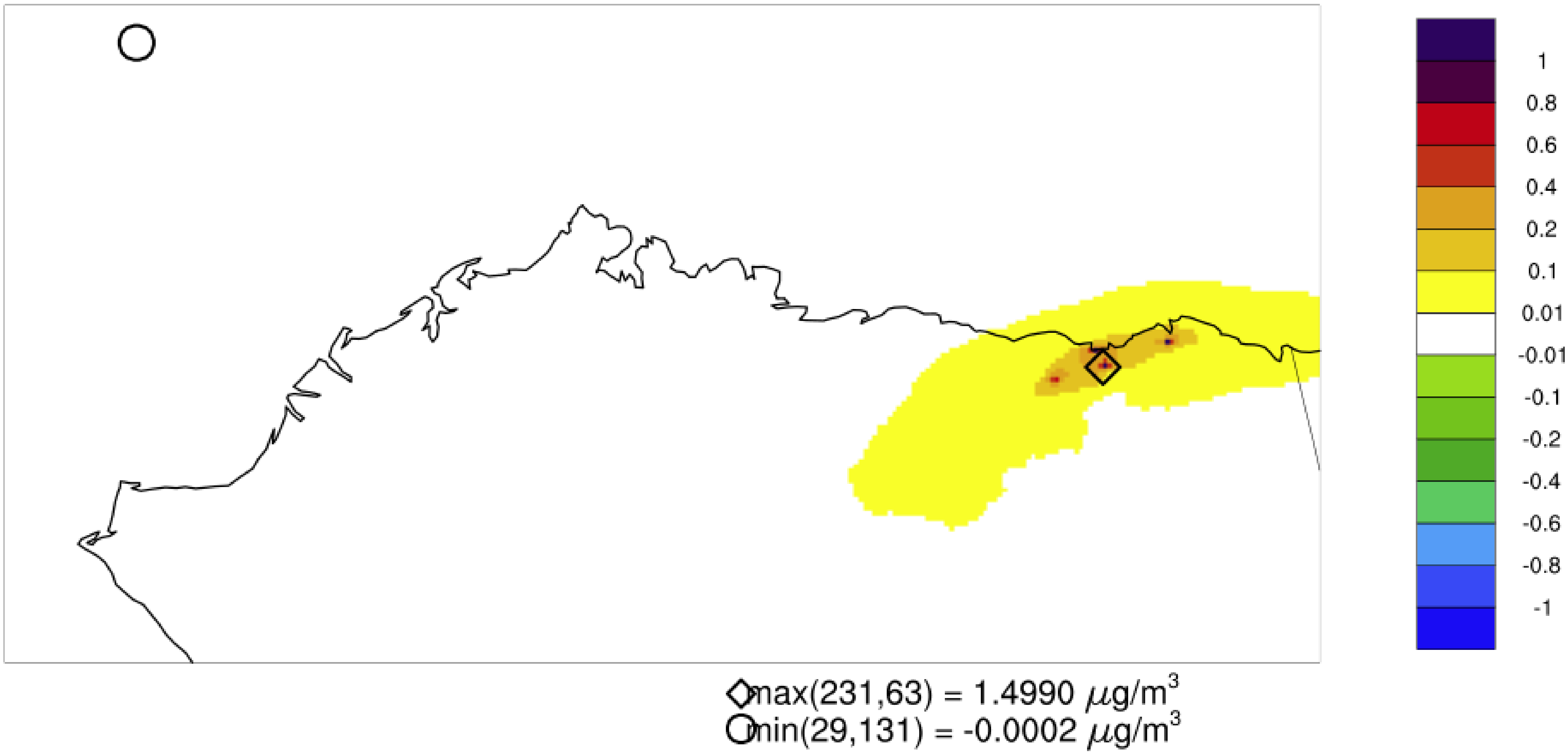


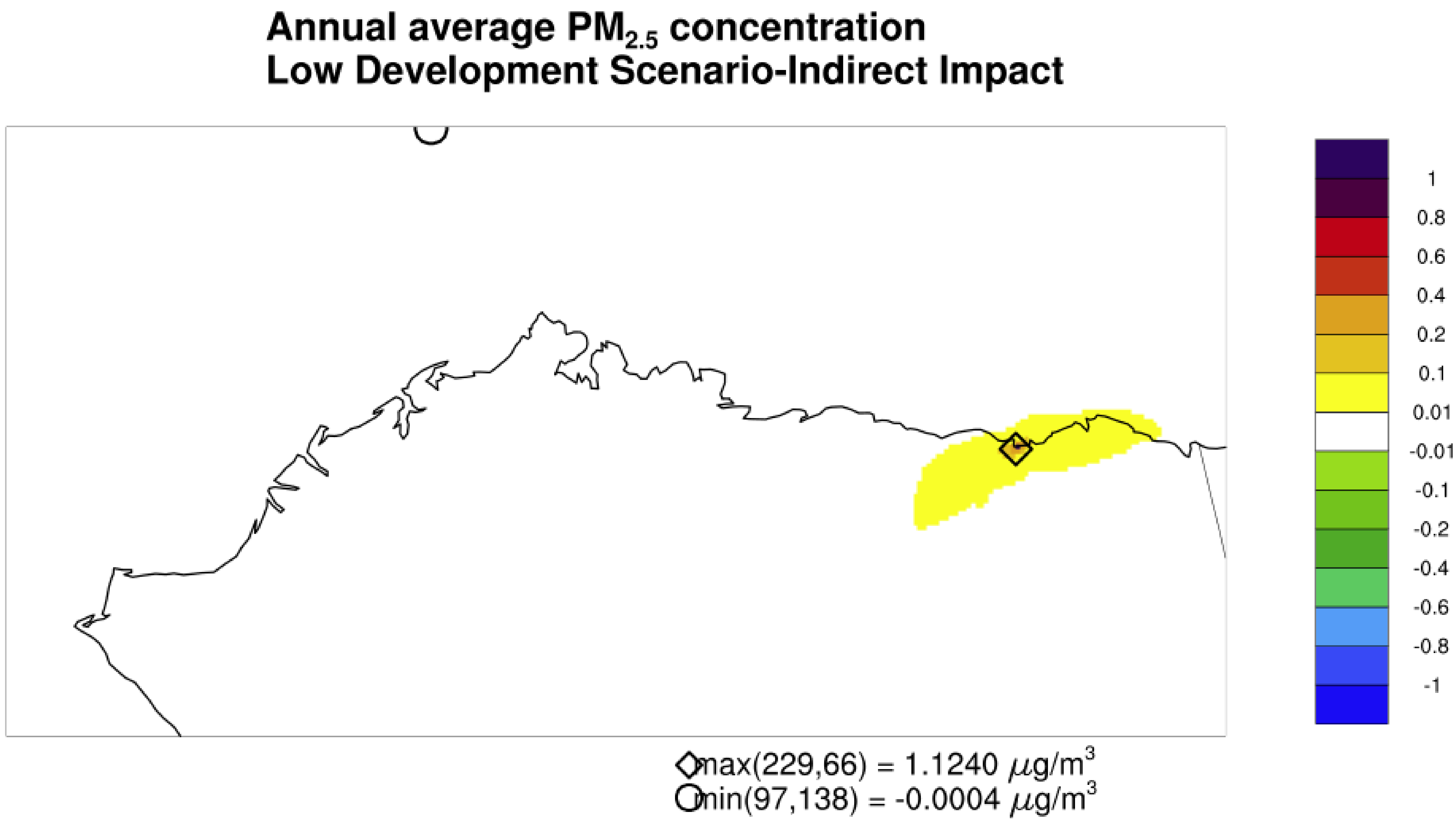

Annual average $PM_{2.5}$ concentration
Low Development Scenario-Cumulative
10
9
8
7
6
5
4
3
2
1
0.5
◇ max(93,81) = 10.1 $\mu g/m^3$
○ min(213,28) = 1.1 $\mu g/m^3$

Annual average $PM_{2.5}$ concentration
No Action Alternative-Cumulative

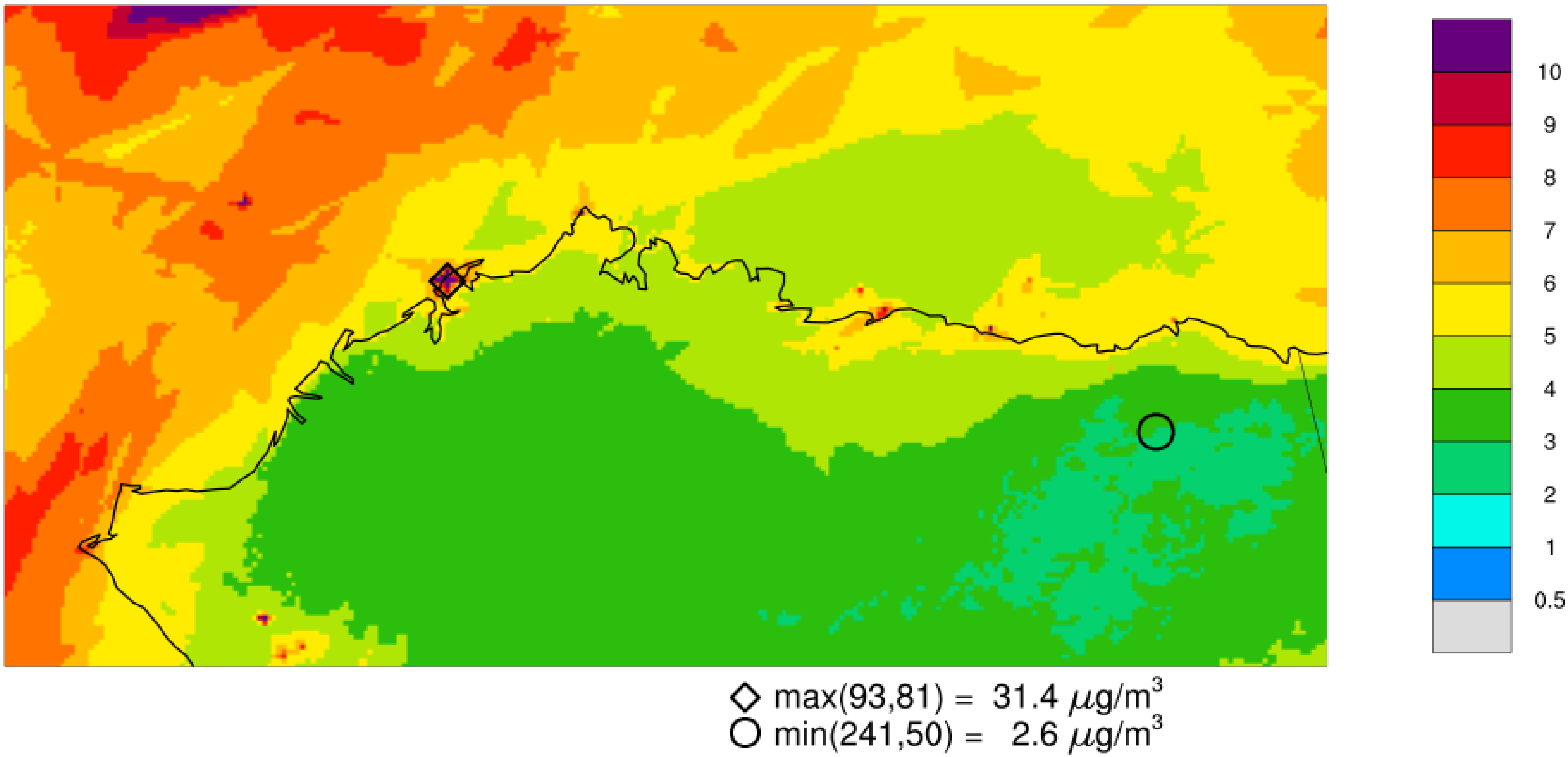


Annual average $PM_{2.5}$ concentration
High Development Scenario-Indirect Impact

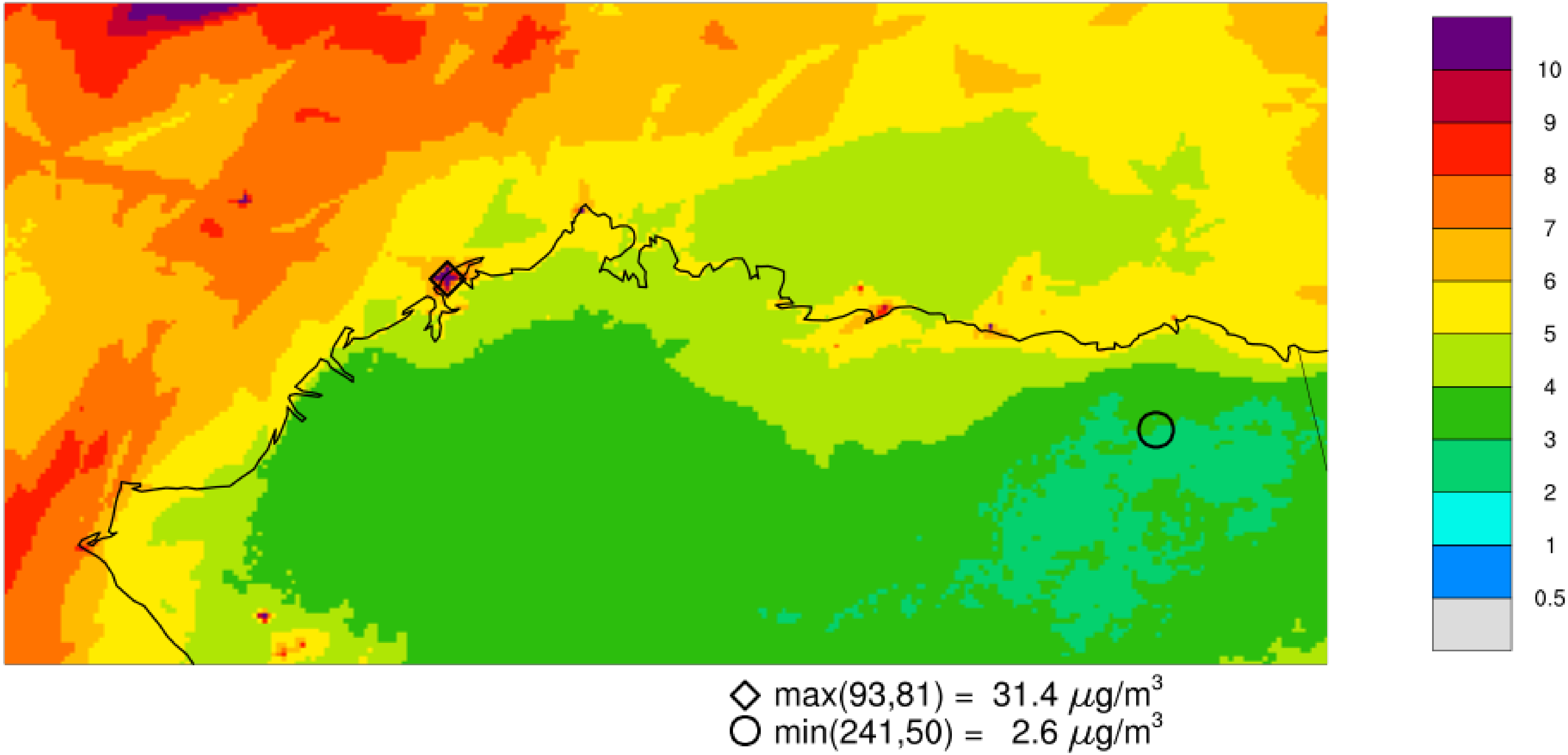



Annual average PM2.5 concentration
Low Development Scenario-Indirect Impact
1
0.8
0.6
0.4
0.2
0.1
0.01
-0.01
-0.1
-0.2
-0.4
-0.6
-0.8
-1
max(229,66) = 1.1240 μg/m3
min(97,138) = -0.0004 μg/m3

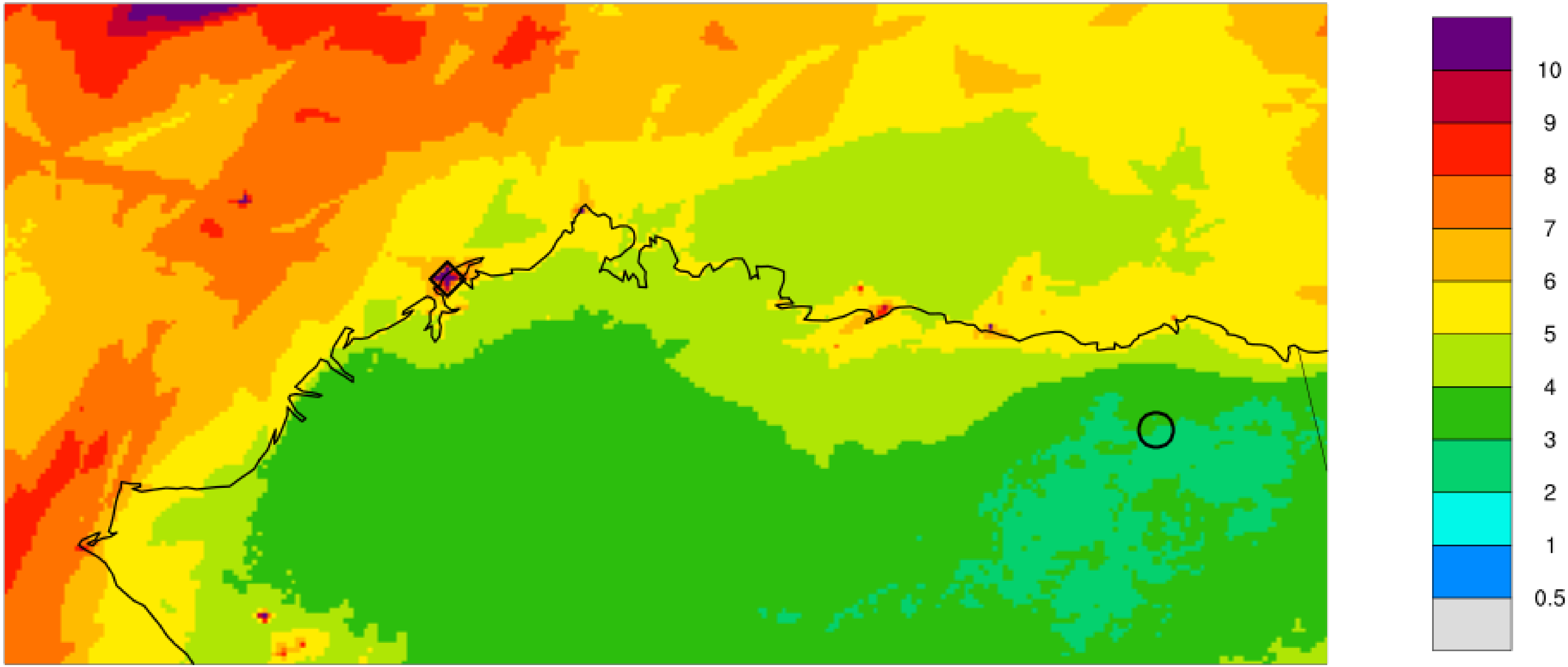
8th highest daily average $PM_{2.5}$ concentration
High Development Scenario-Cumulative



8th highest daily average $PM_{2.5}$ concentration
Low Development Scenario-Cumulative

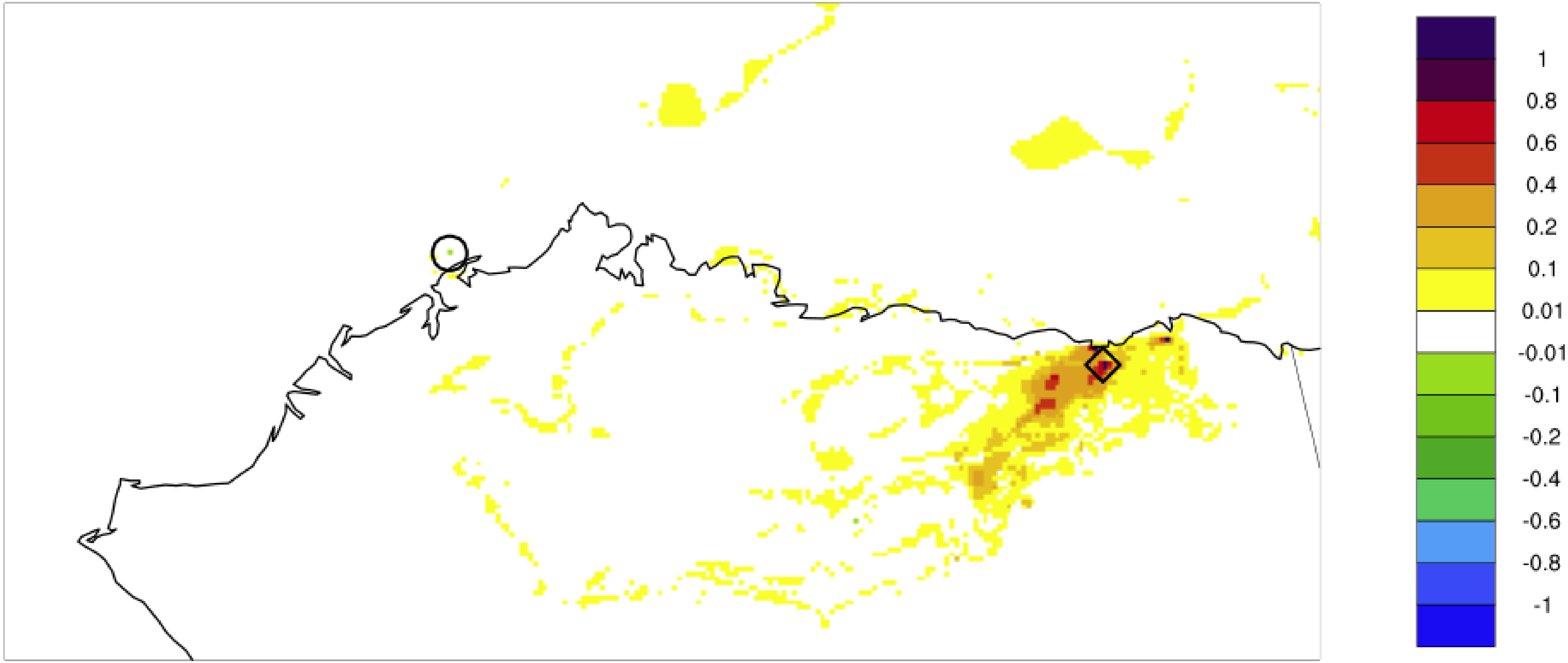


8th highest daily average $PM_{2.5}$ concentration
No Action Alternative-Cumulative



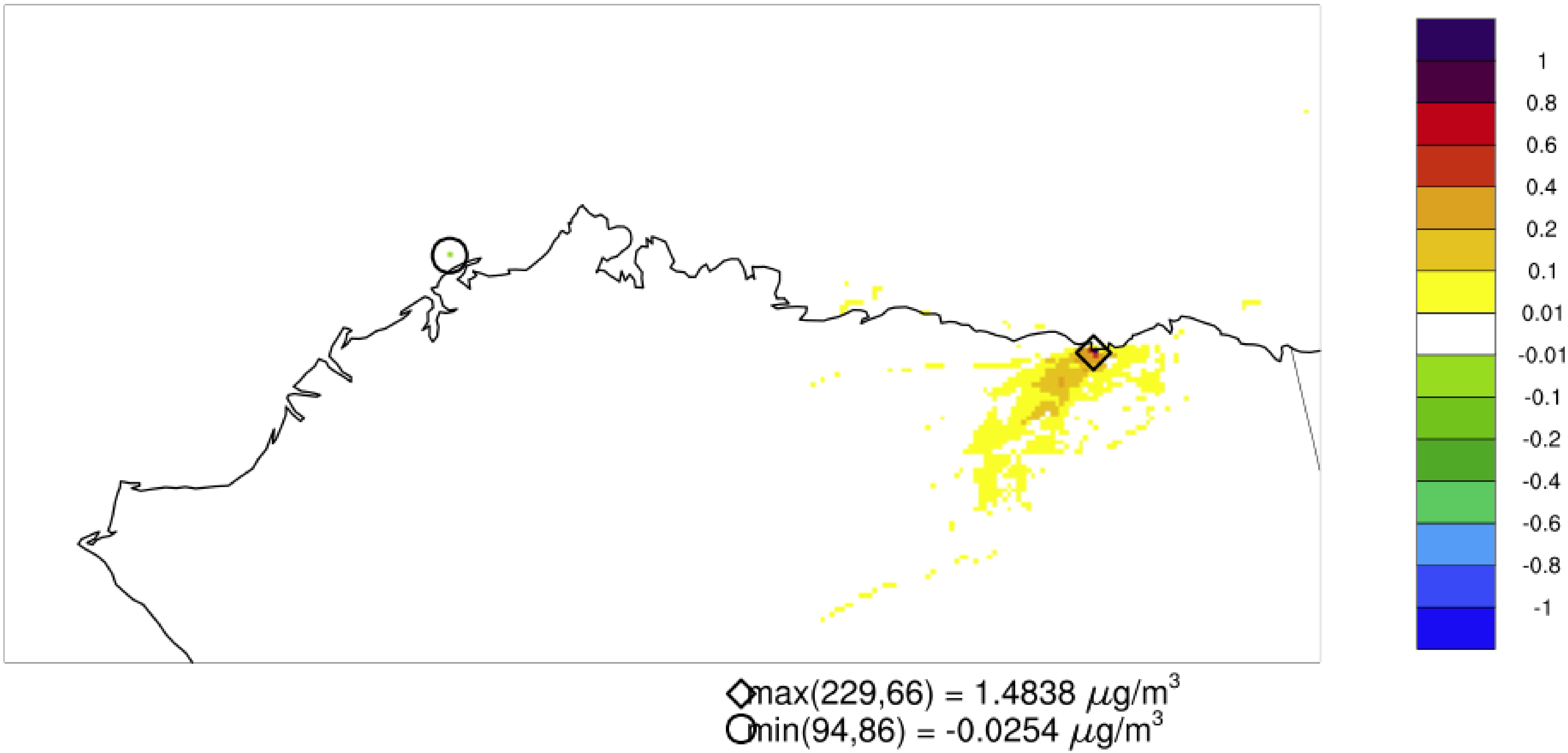
◇ max(93,81) = 31.4 $\mu g/m^3$
○ min(241,50) = 2.6 $\mu g/m^3$

8th highest daily average $PM_{2.5}$ concentration
High Development Scenario-Indirect Impact

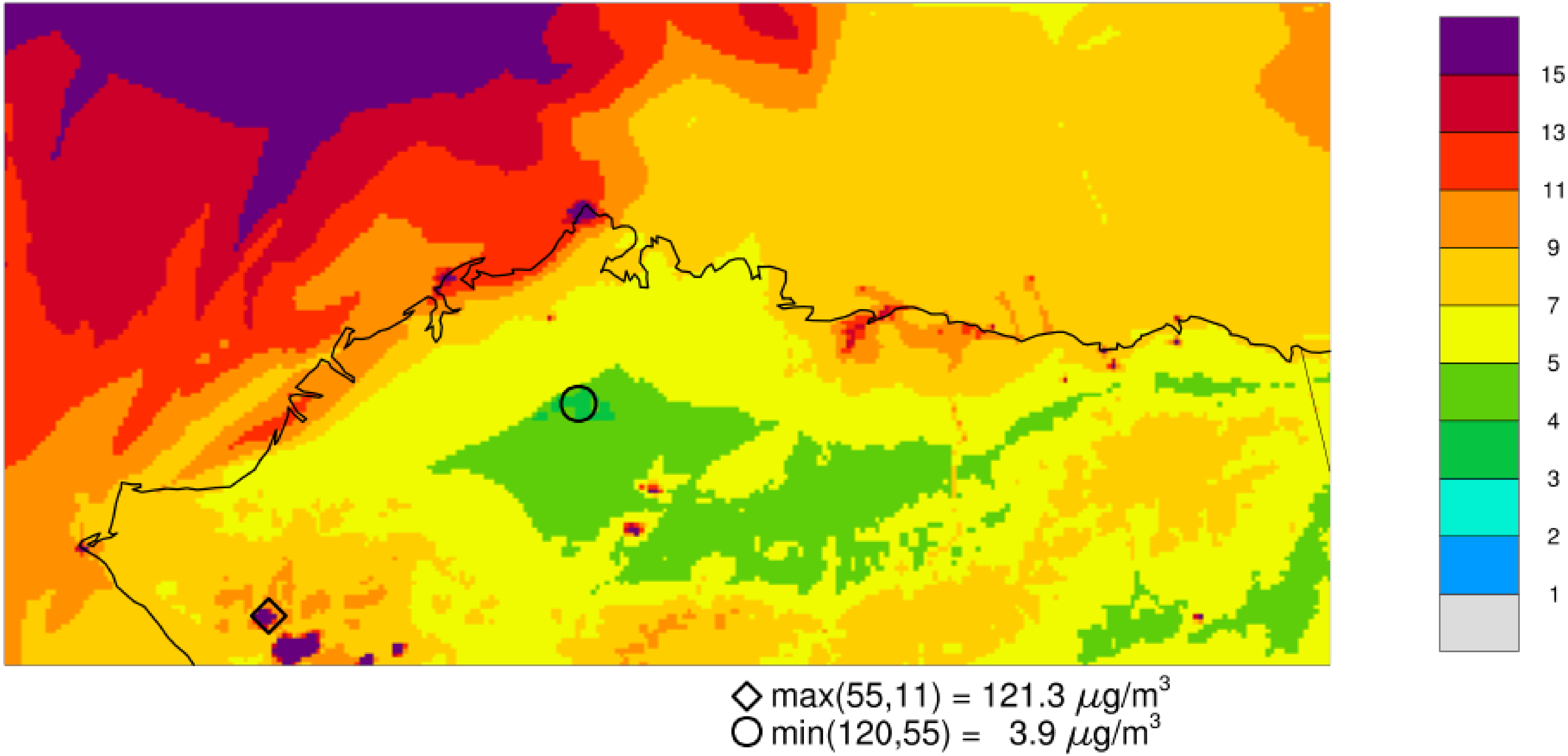


max(231,63) = 2.1494 $\mu g/m^3$
min(94,86) = -0.0254 $\mu g/m^3$

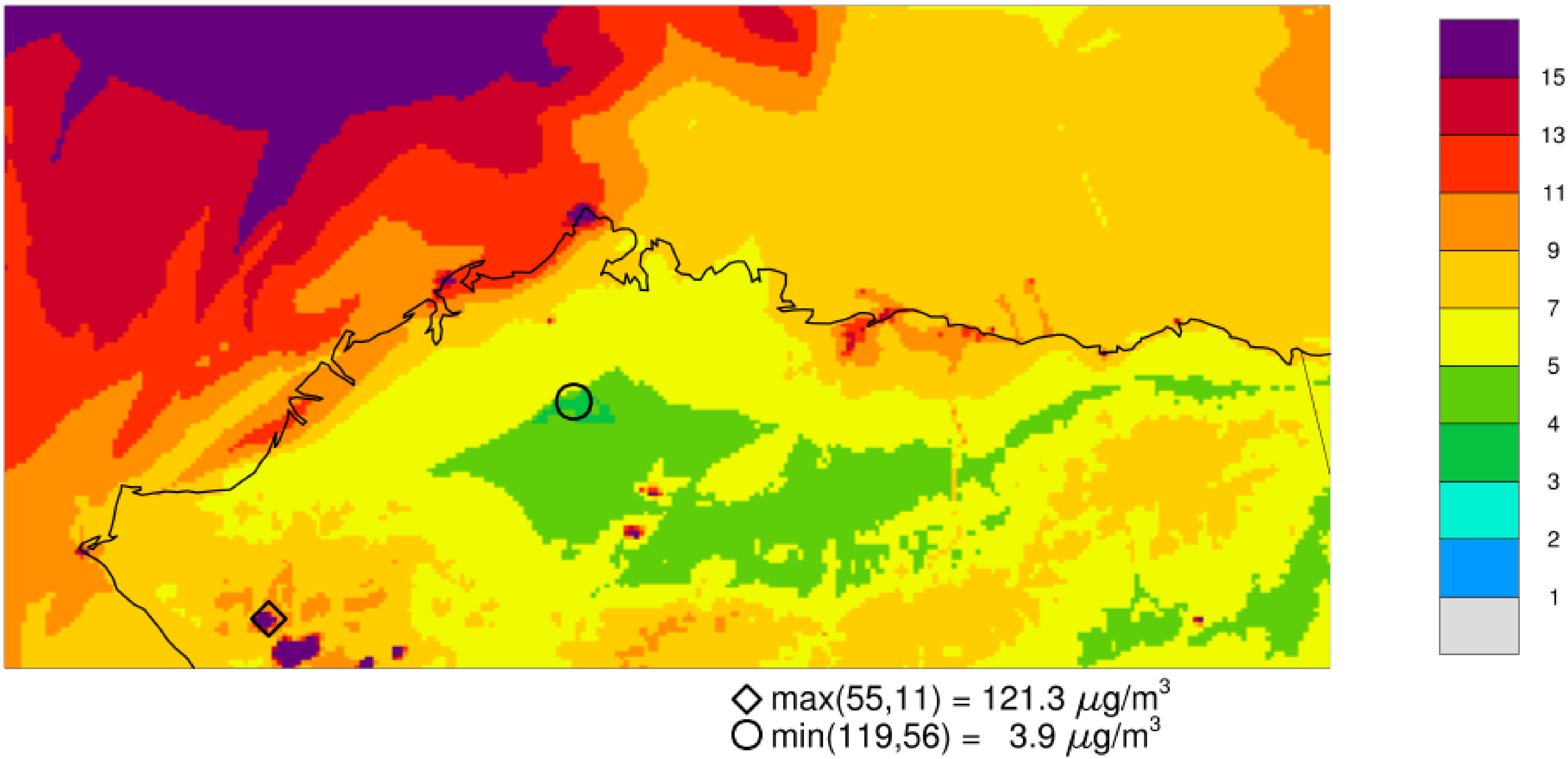
8th highest daily average $PM_{2.5}$ concentration
Low Development Scenario-Indirect Impact



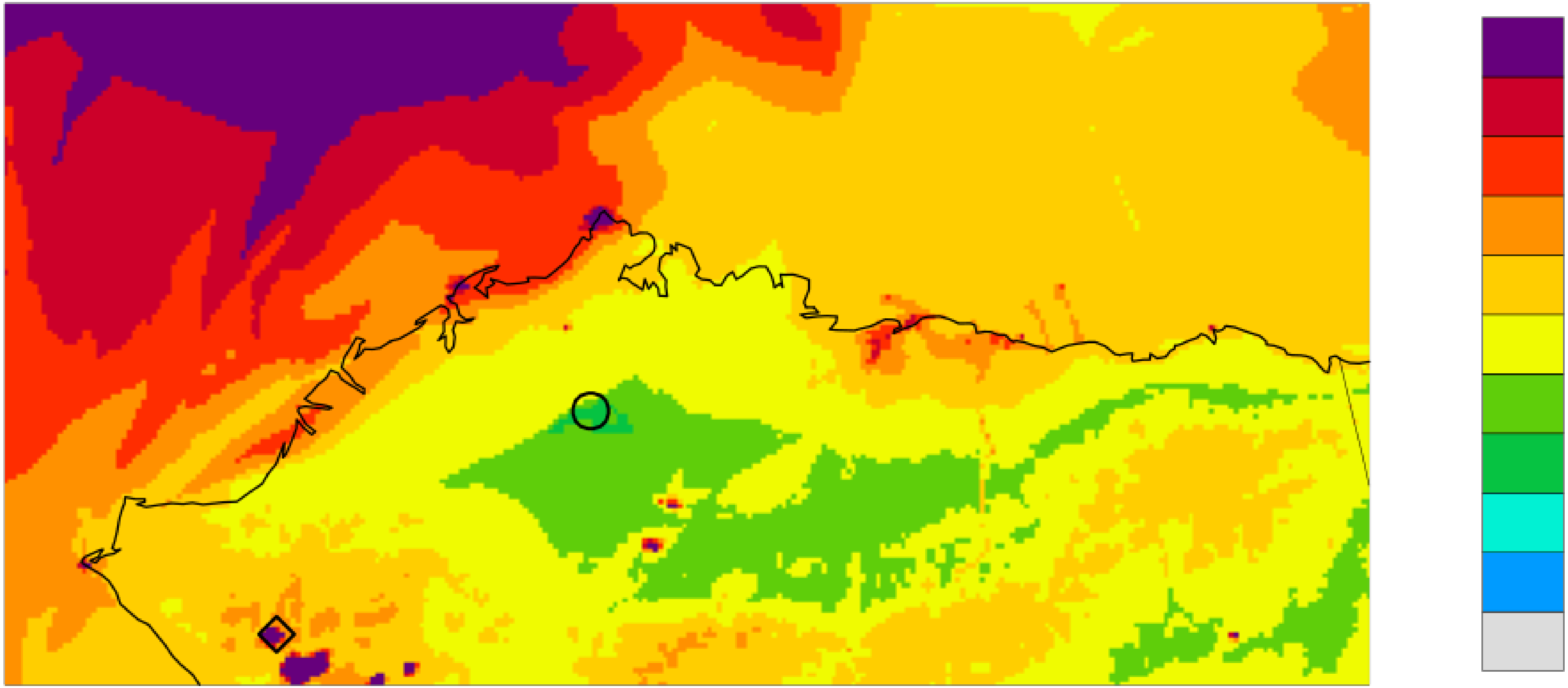
2nd highest daily average PM_{10} concentration
High Development Scenario-Cumulative



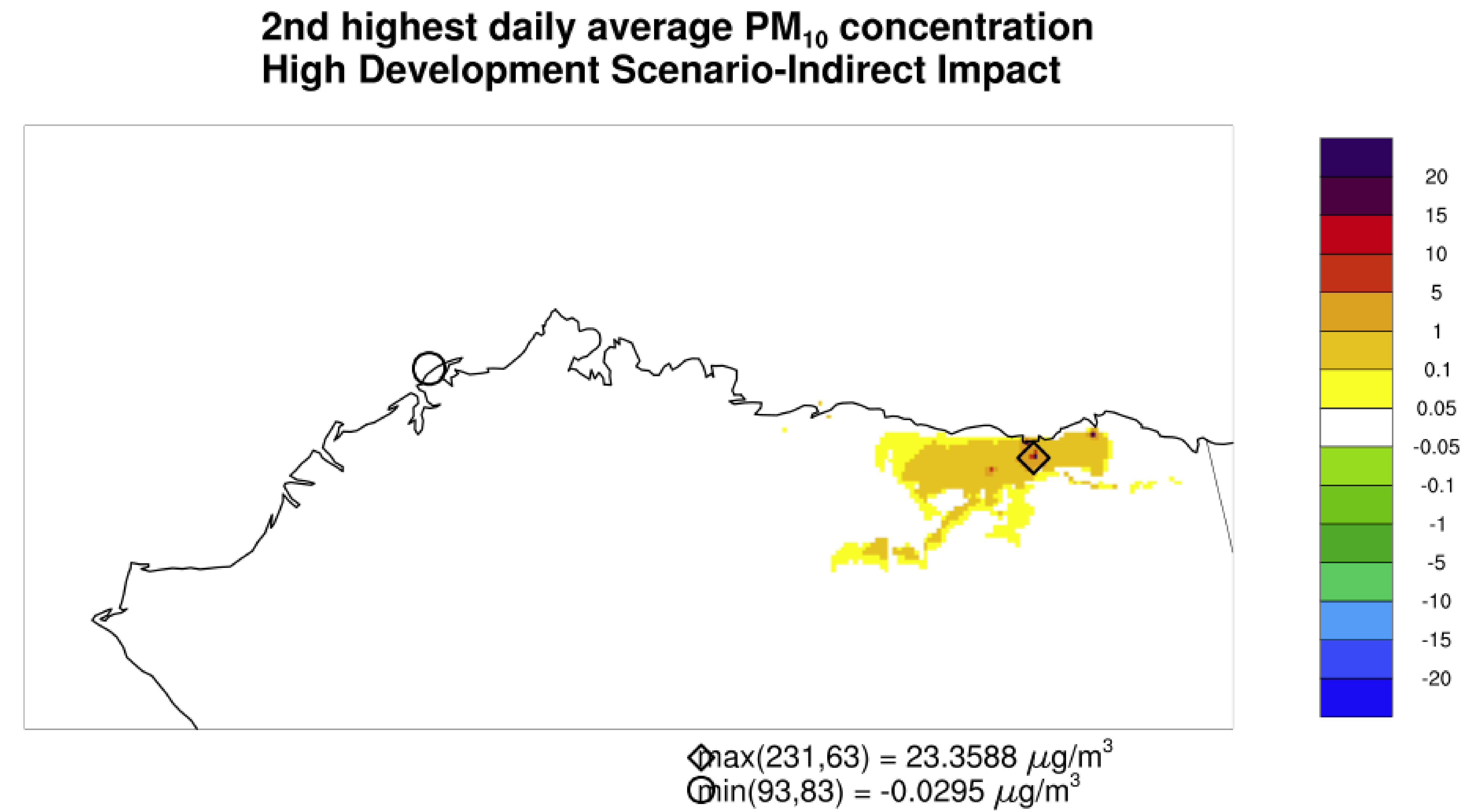
2nd highest daily average PM_{10} concentration
Low Development Scenario-Cumulative



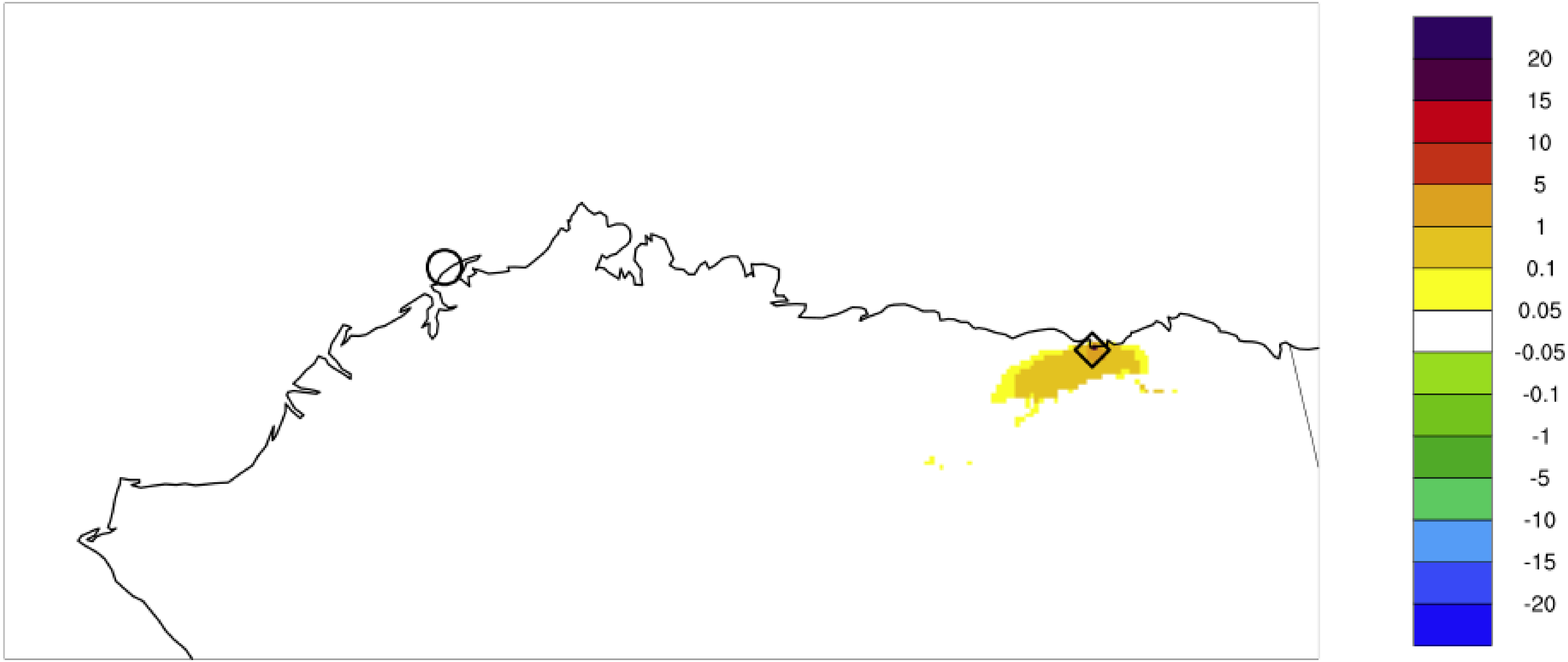
2nd highest daily average PM_{10} concentration
No Action Alternative-Cumulative



◇ max(55,11) = 121.3 $\mu g/m^3$
○ min(119,56) = 3.9 $\mu g/m^3$

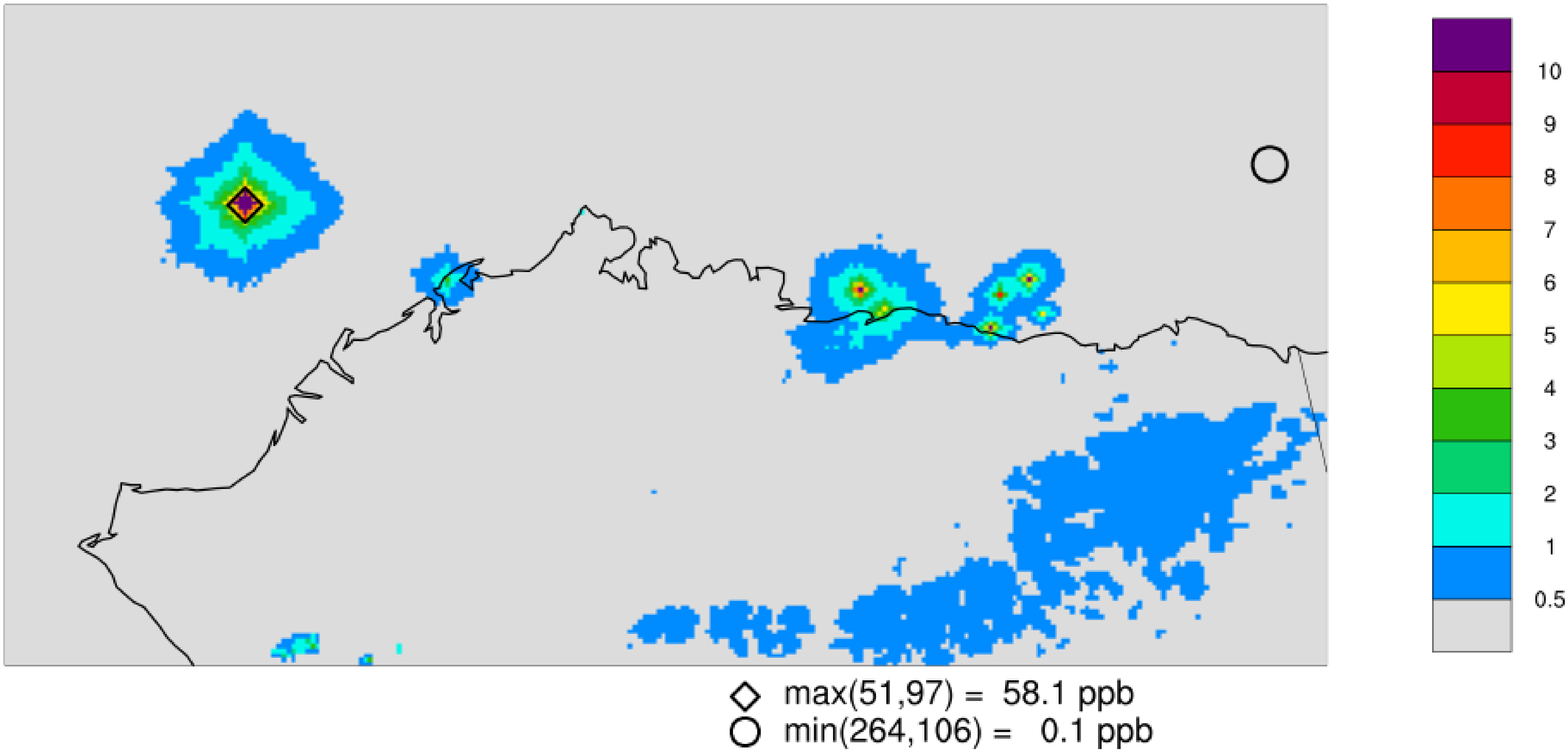

2nd highest daily average PM_{10} concentration
High Development Scenario-Indirect Impact
20
15
10
5
1
0.1
0.05
-0.05
-0.1
-1
-5
-10
-15
-20
max(231,63) = 23.3588 $\mu g/m^3$
min(93,83) = -0.0295 $\mu g/m^3$

2nd highest daily average PM_{10} concentration
Low Development Scenario-Indirect Impact

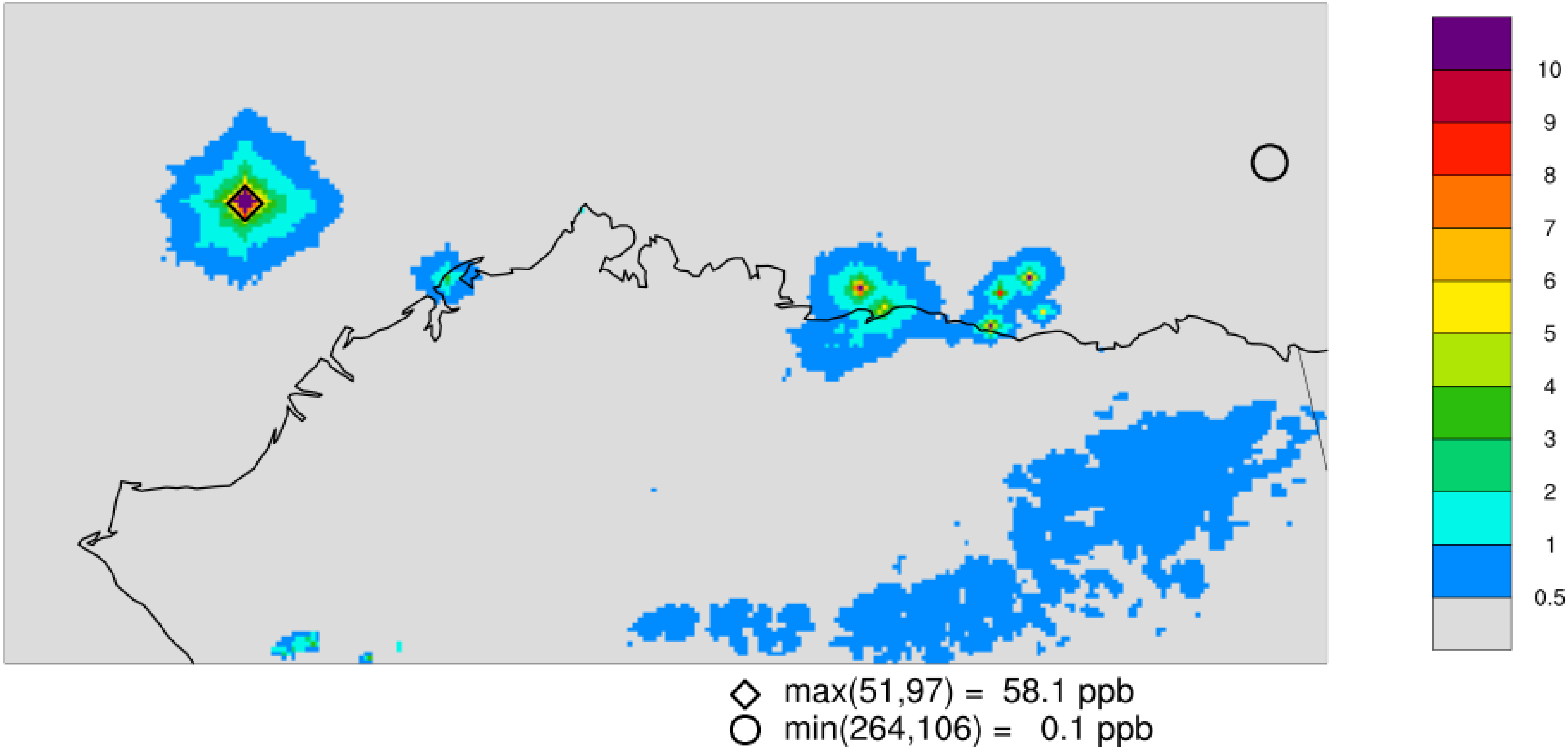


◇ max(229,66) = 16.3591 $\mu g/m^3$
○ min(93,83) = -0.0295 $\mu g/m^3$

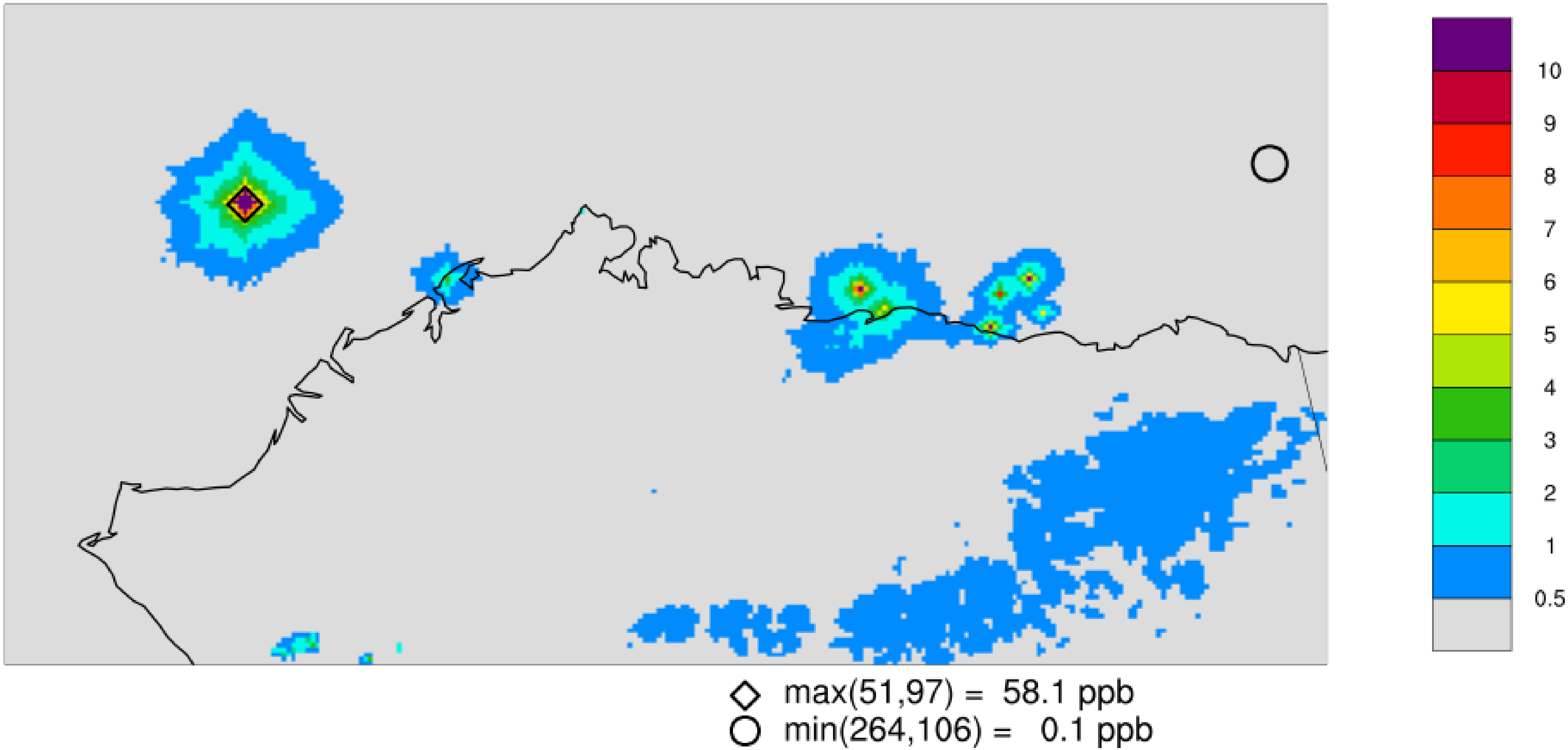
The 4th highest 1 hour daily max SO_2 concentration
High Development Scenario-Cumulative



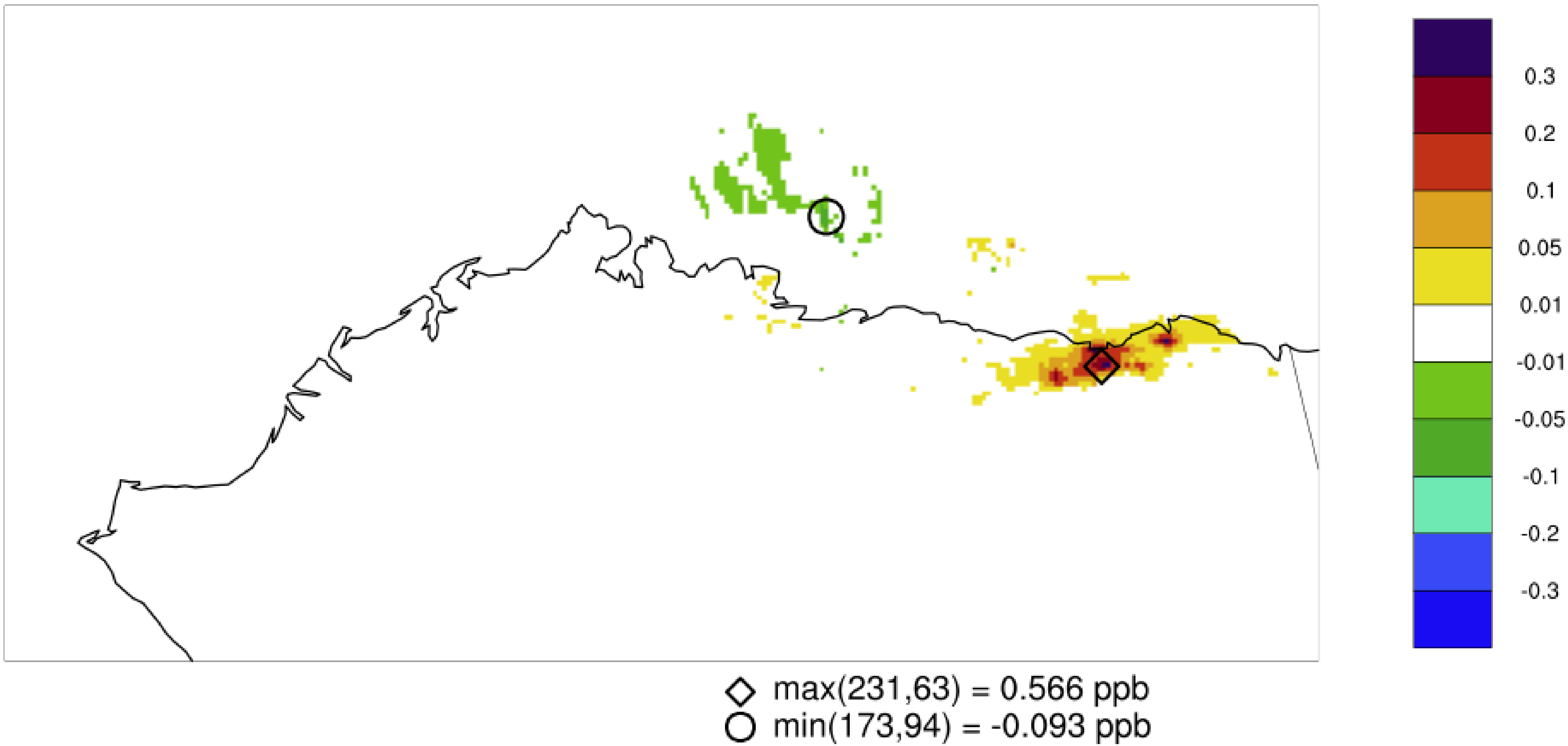
The 4th highest 1 hour daily max SO_2 concentration
Low Development Scenario-Cumulative

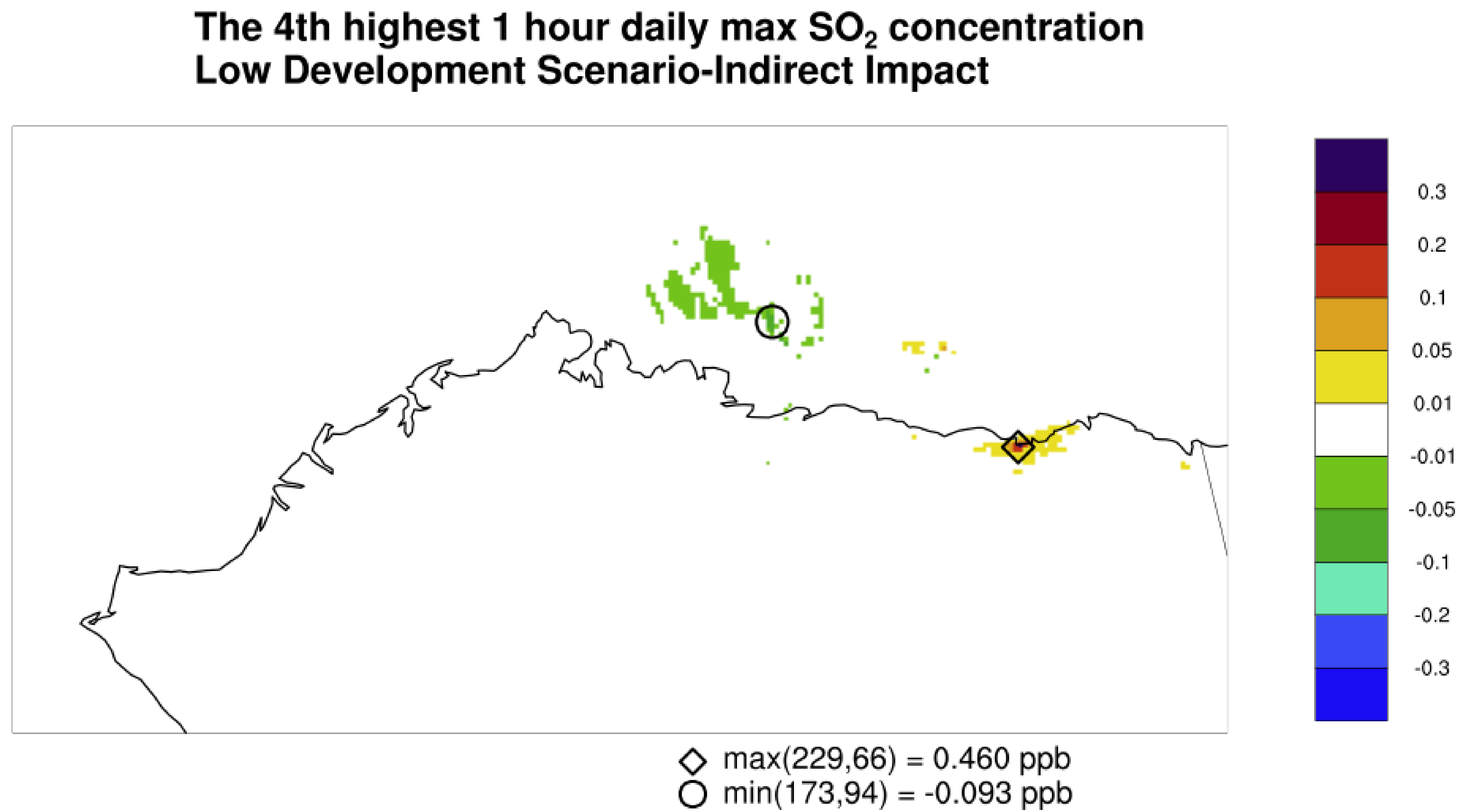


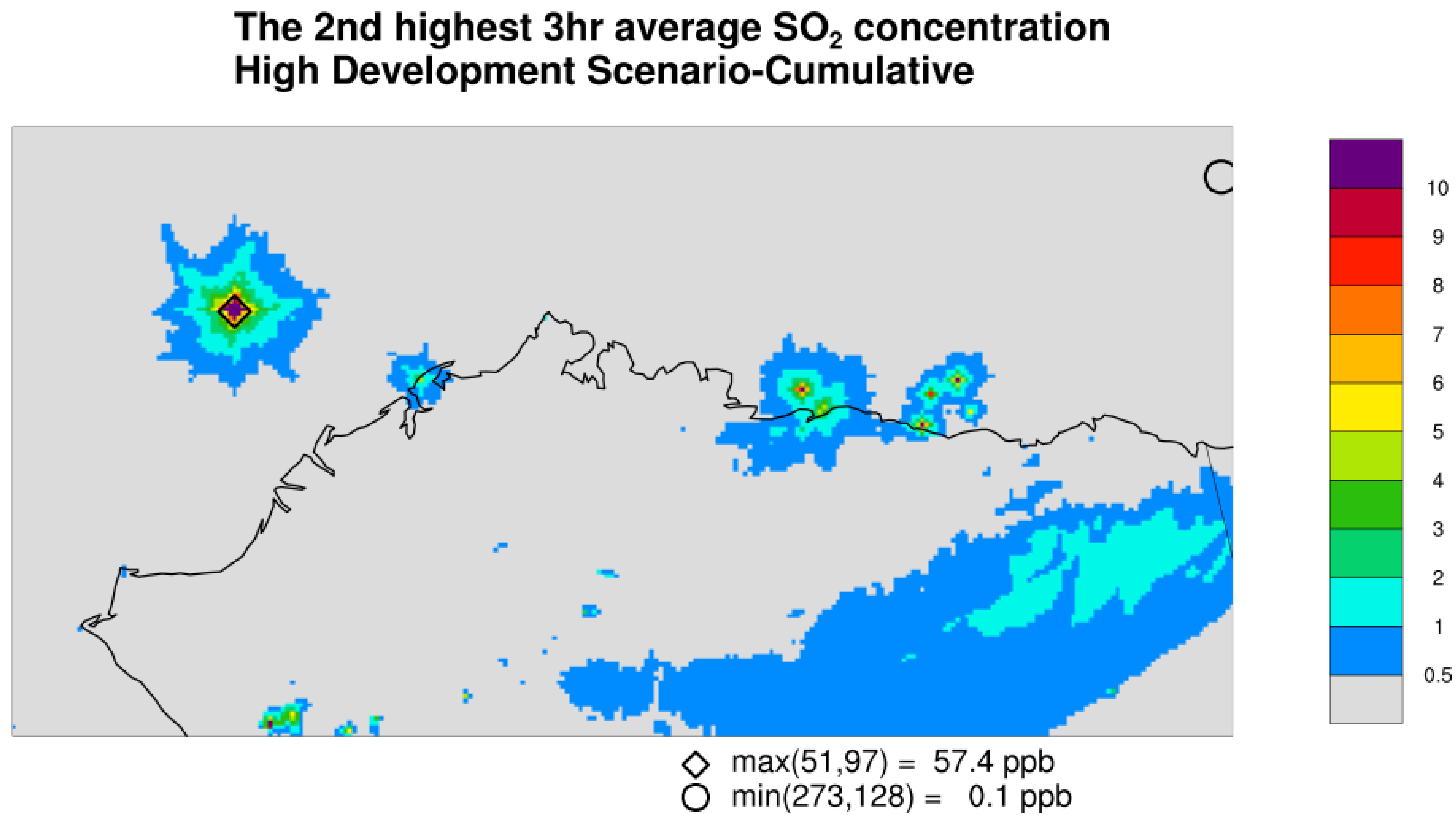
The 4th highest 1 hour daily max SO_2 concentration
No Action Alternative-Cumulative



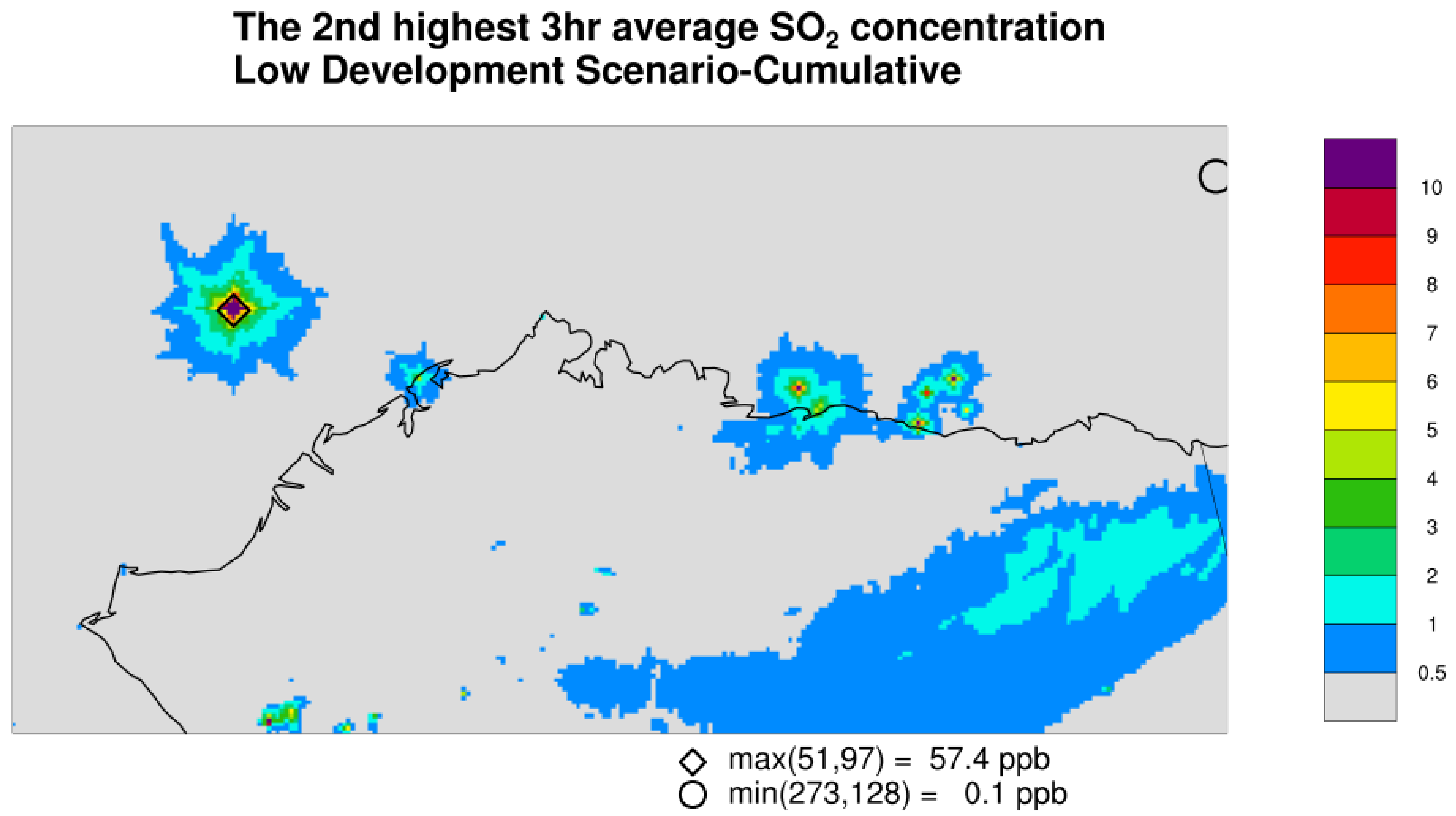
The 4th highest 1 hour daily max SO_2 concentration
High Development Scenario-Indirect Impact




The 4th highest 1 hour daily max SO_2 concentration
Low Development Scenario-Indirect Impact
0.3
0.2
0.1
0.05
0.01
-0.01
-0.05
-0.1
-0.2
-0.3
max(229,66) = 0.460 ppb
min(173,94) = -0.093 ppb

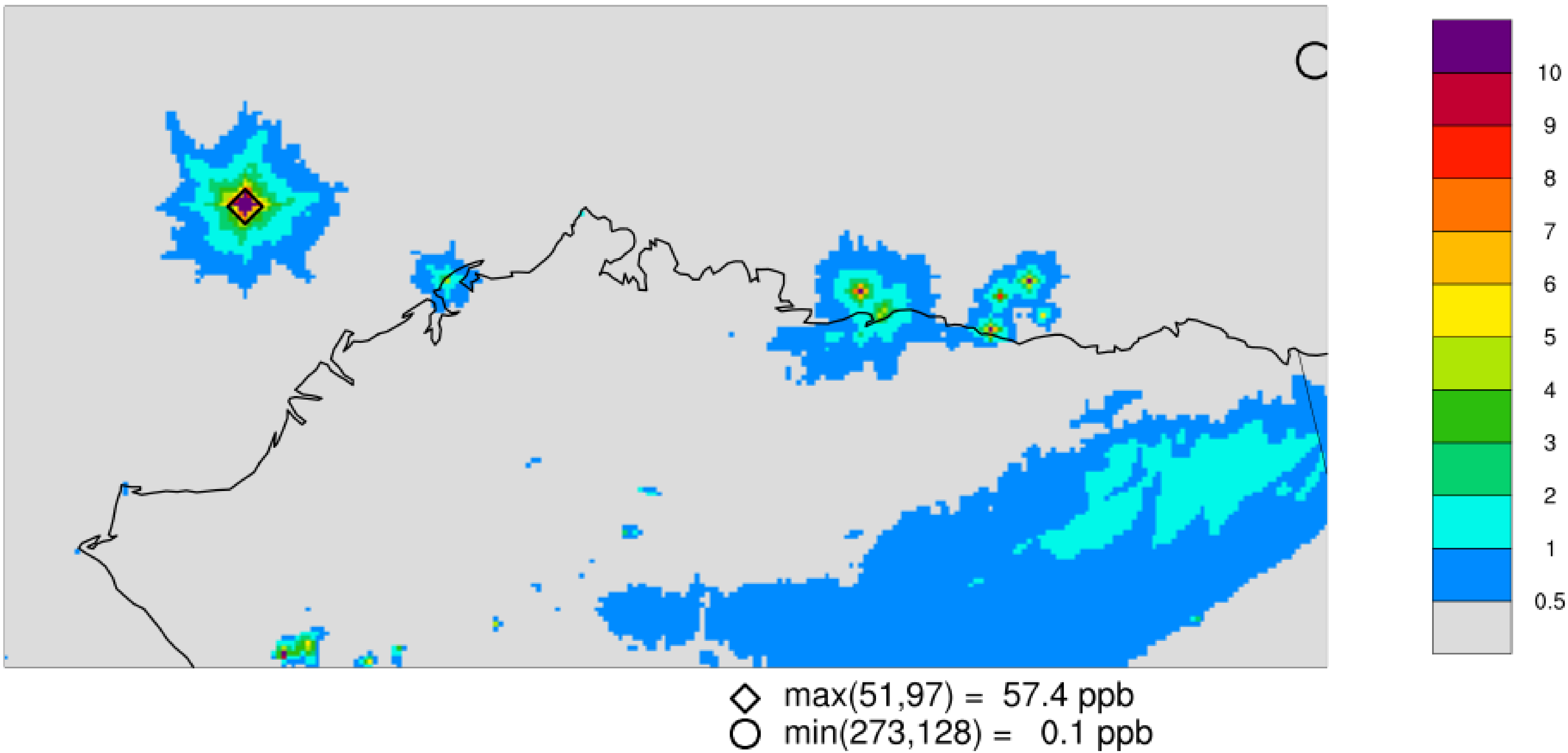


The 2nd highest 3hr average SO_2 concentration
High Development Scenario-Cumulative
10
9
8
7
6
5
4
3
2
1
0.5
max(51,97) = 57.4 ppb
min(273,128) = 0.1 ppb

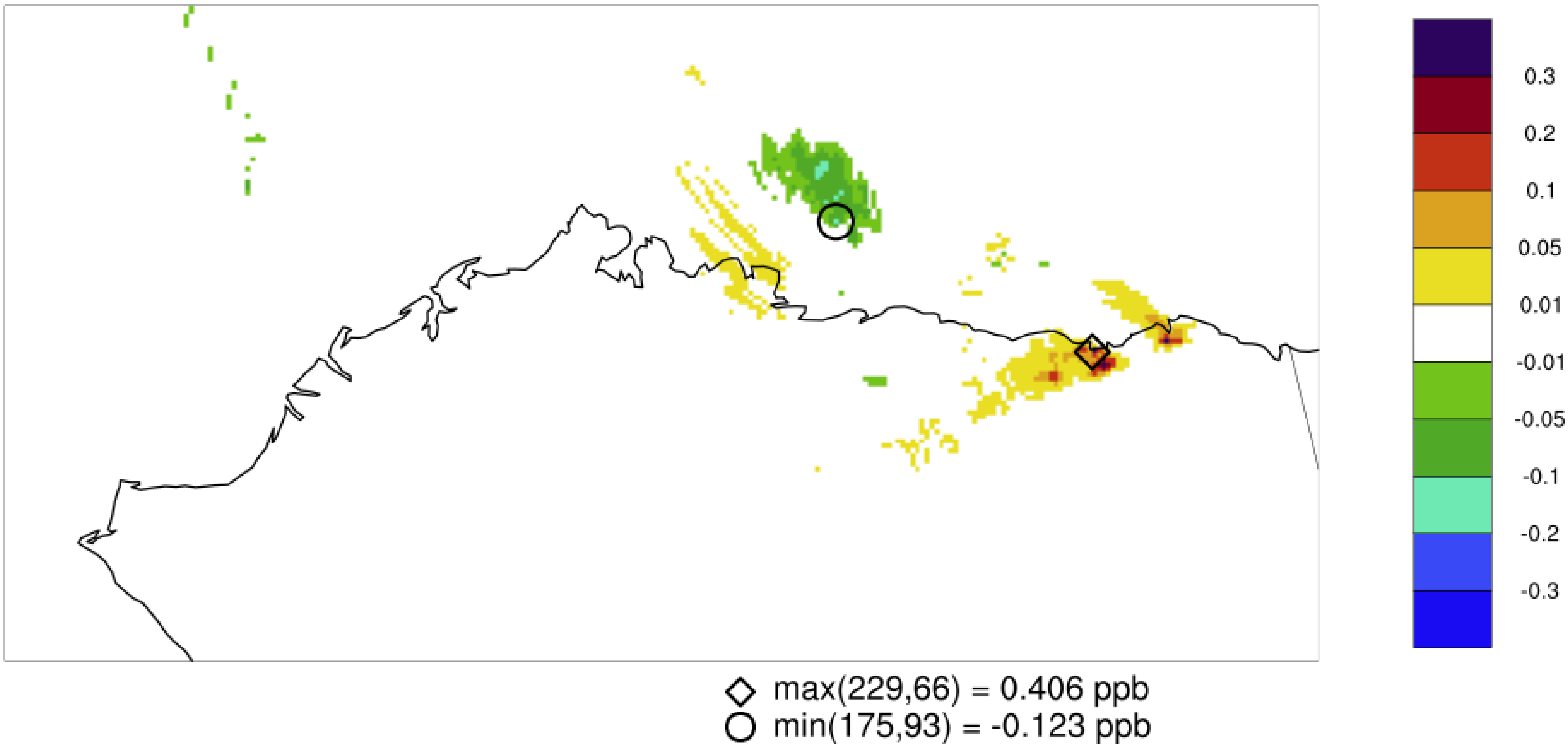


The 2nd highest 3hr average SO_2 concentration
Low Development Scenario-Cumulative
10
9
8
7
6
5
4
3
2
1
0.5
max(51,97) = 57.4 ppb
min(273,128) = 0.1 ppb

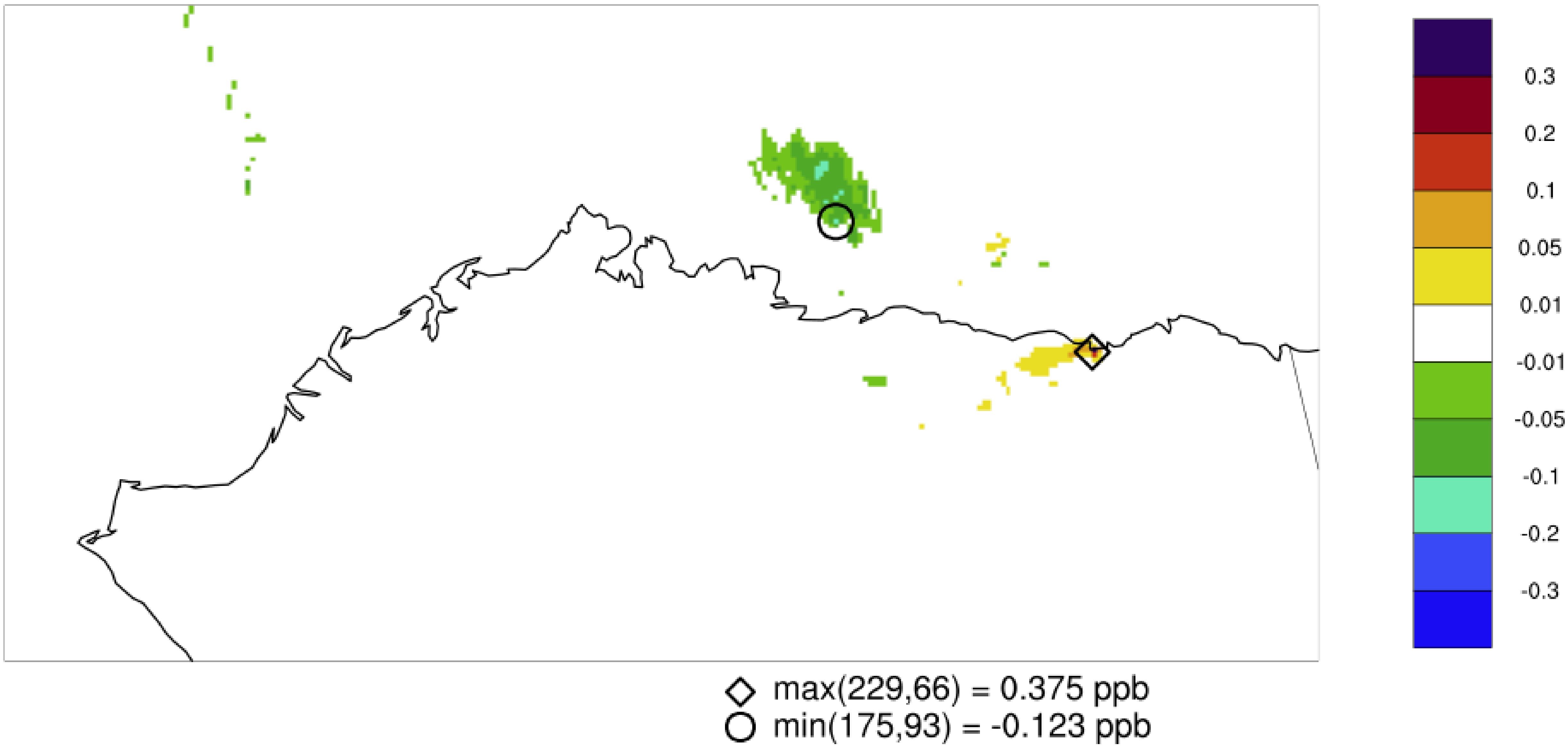
The 2nd highest 3hr average SO_2 concentration
No Action Alternative-Cumulative

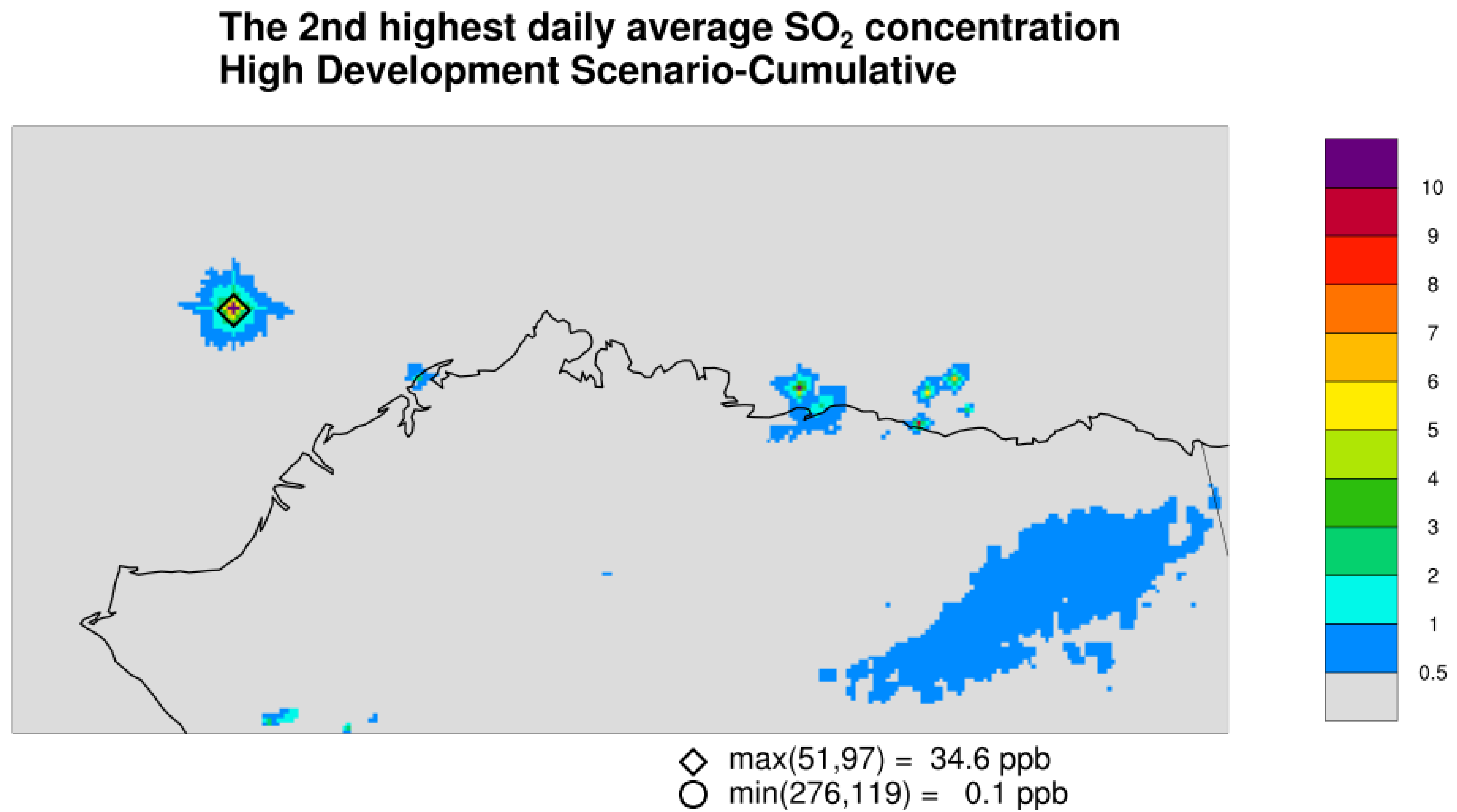


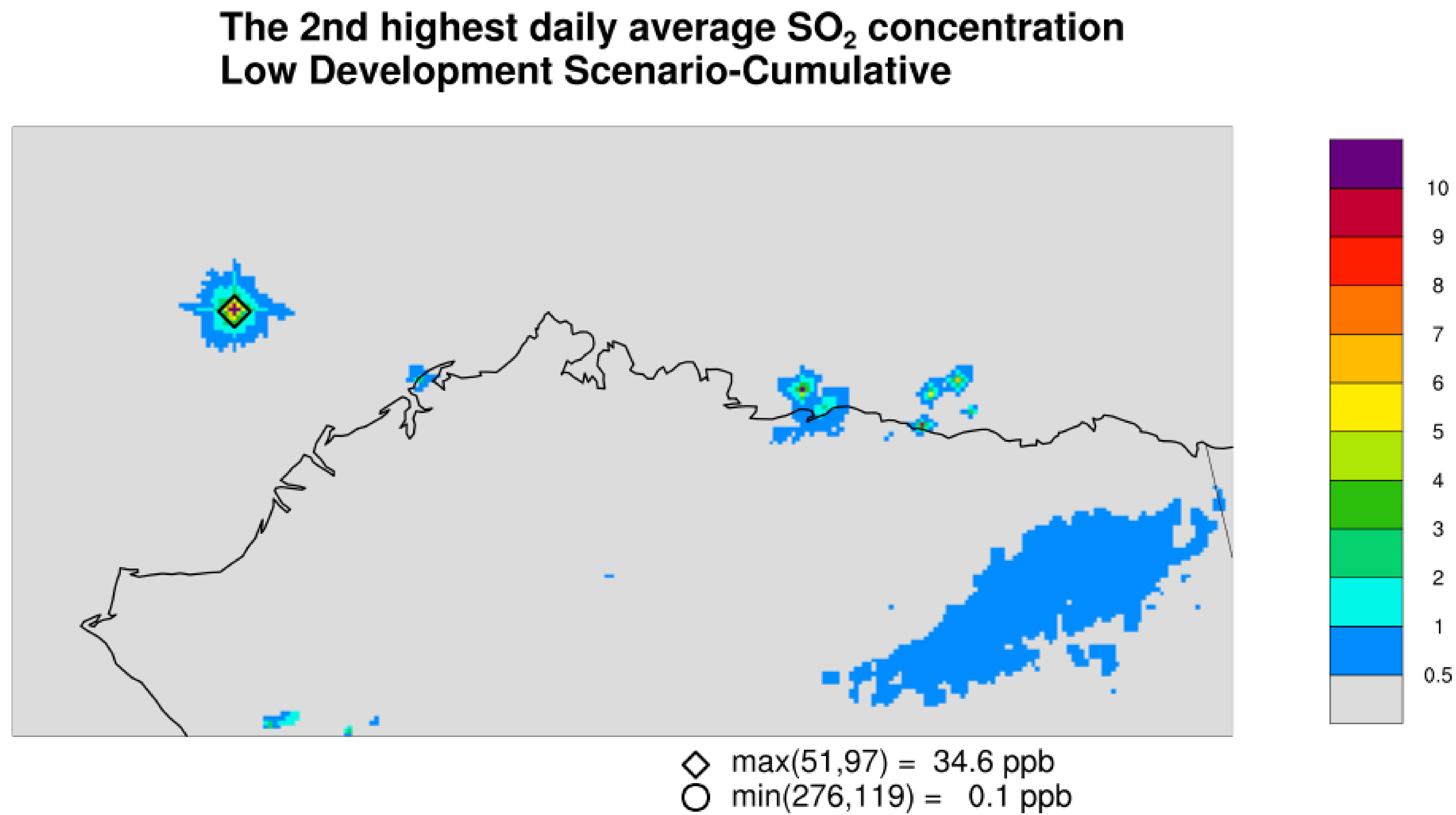
The 2nd highest 3hr average SO_2 concentration
High Development Scenario-Indirect Impact



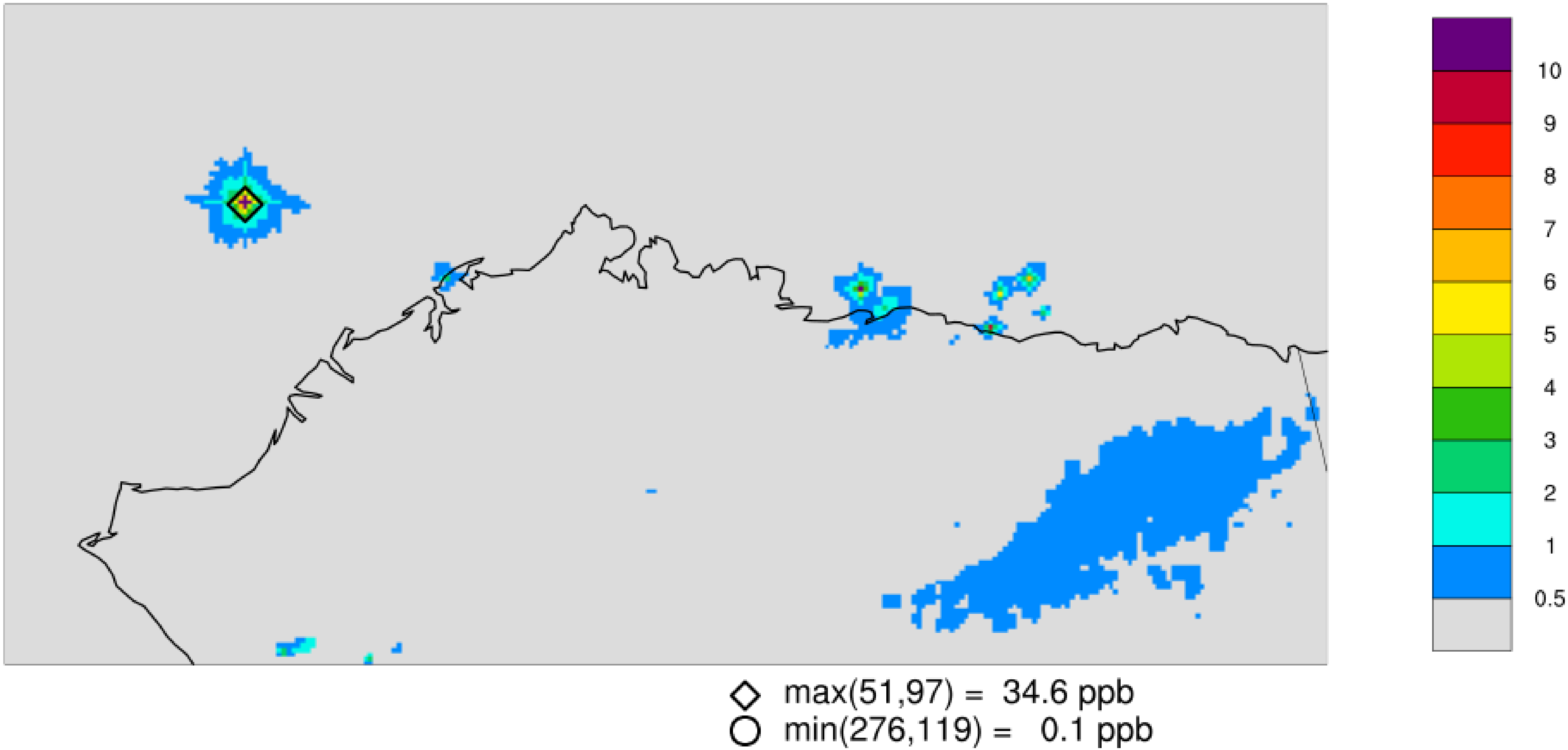
The 2nd highest 3hr average SO_2 concentration
Low Development Scenario-Indirect Impact



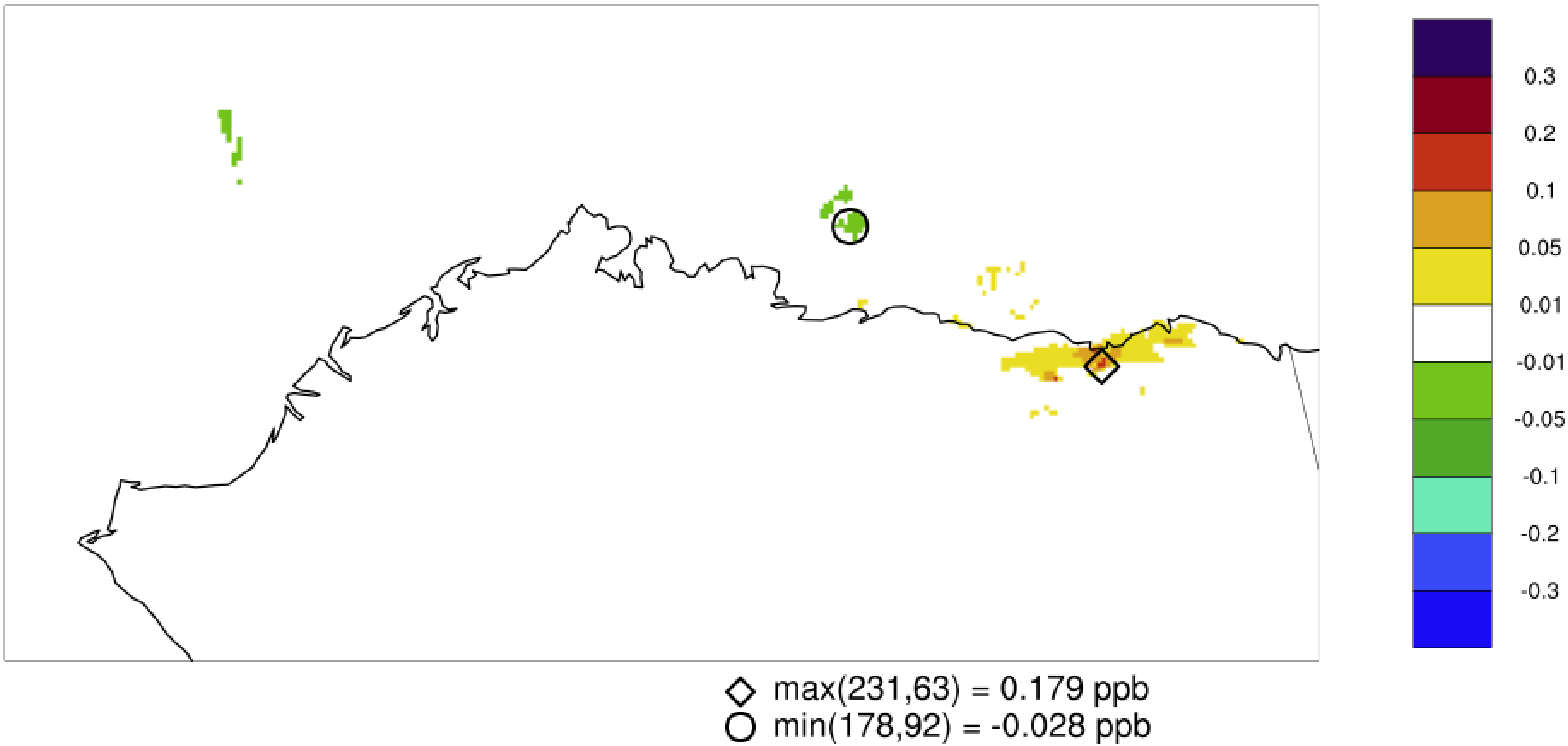

The 2nd highest daily average SO_2 concentration
High Development Scenario-Cumulative
10
9
8
7
6
5
4
3
2
1
0.5
max(51,97) = 34.6 ppb
min(276,119) = 0.1 ppb

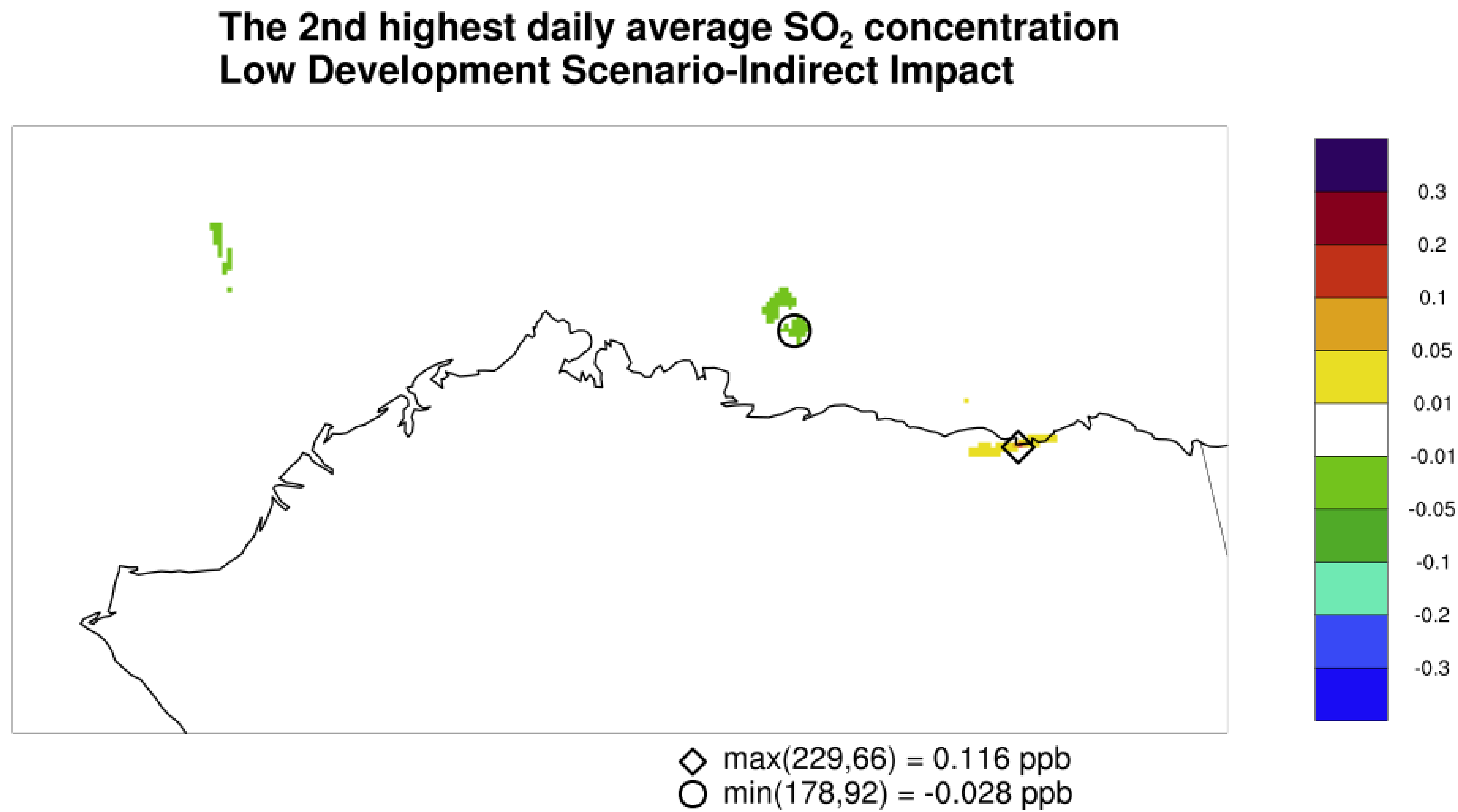

The 2nd highest daily average SO2 concentration
Low Development Scenario-Cumulative
10
9
8
7
6
5
4
3
2
1
0.5
max(51,97) = 34.6 ppb
min(276,119) = 0.1 ppb

The 2nd highest daily average SO_2 concentration
No Action Alternative-Cumulative

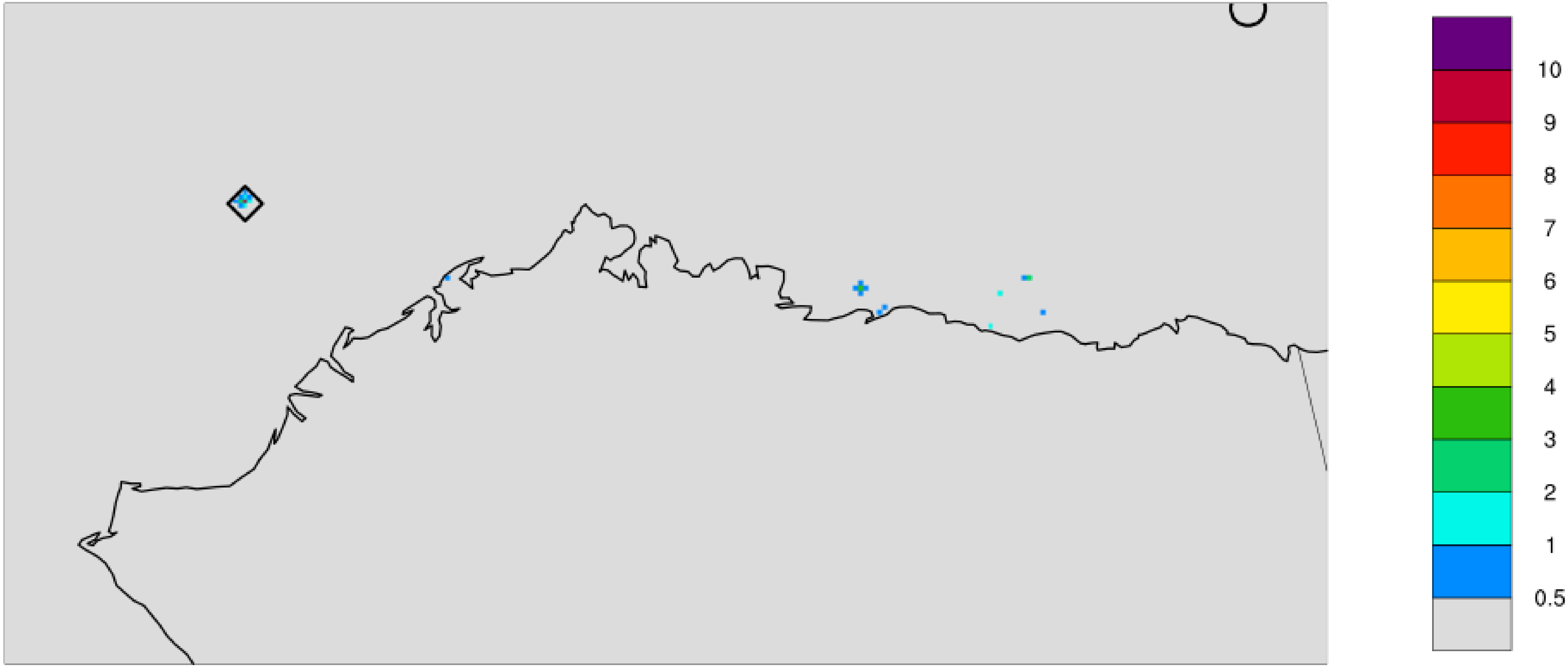


The 2nd highest daily average SO_2 concentration
High Development Scenario-Indirect Impact



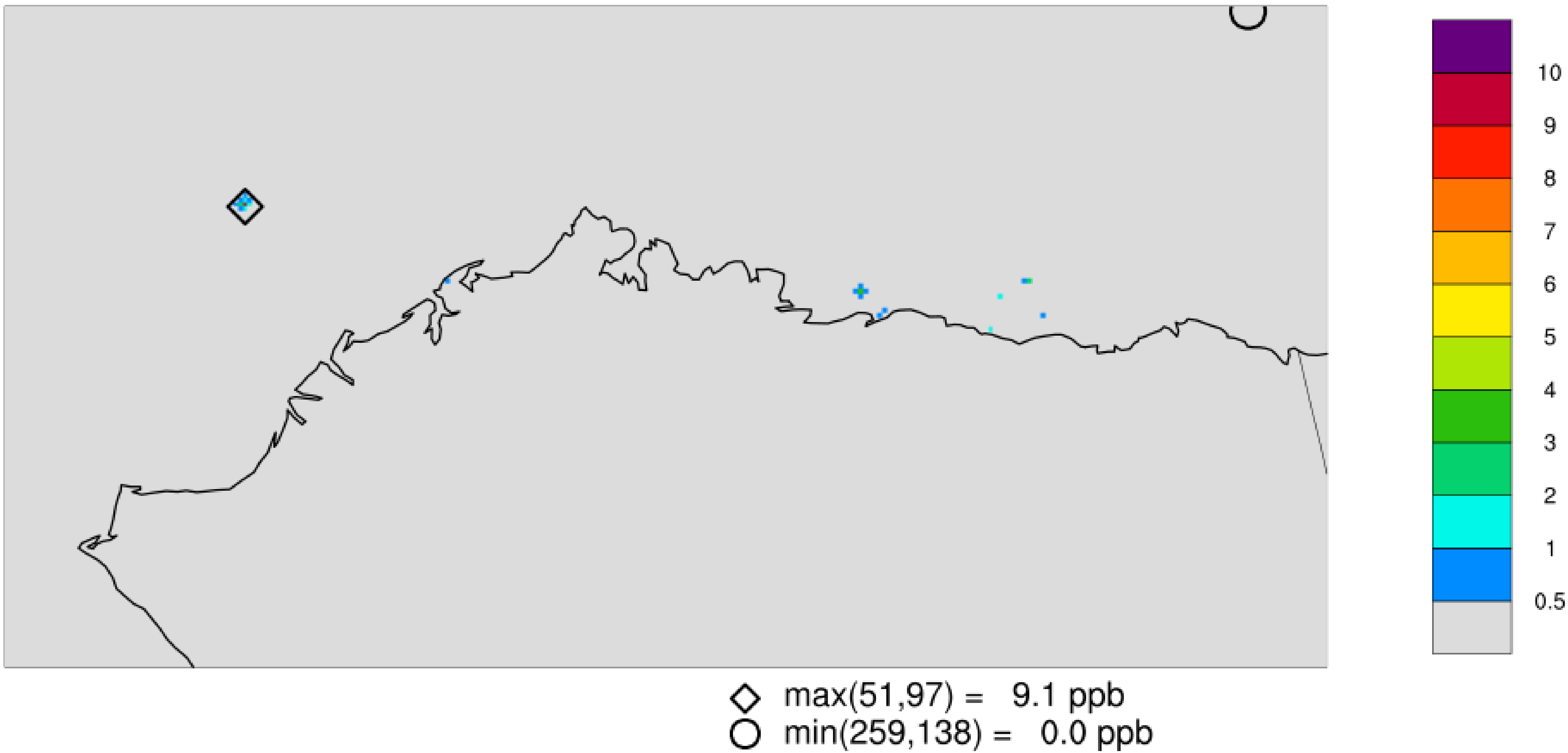

The 2nd highest daily average SO_2 concentration
Low Development Scenario-Indirect Impact
0.3
0.2
0.1
0.05
0.01
-0.01
-0.05
-0.1
-0.2
-0.3
max(229,66) = 0.116 ppb
min(178,92) = -0.028 ppb

Annual average SO_2 concentration
High Development Scenario-Cumulative

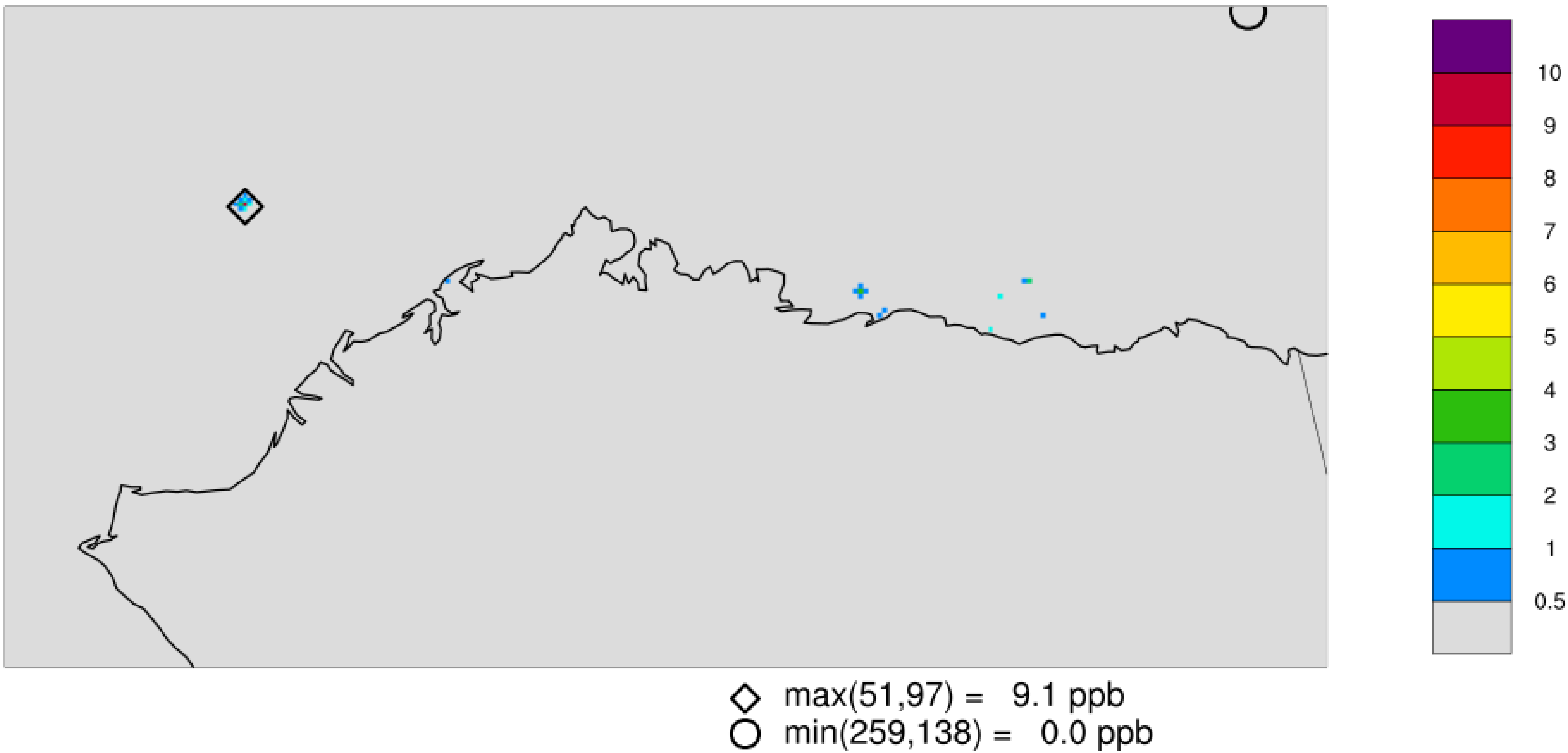


◇ max(51,97) = 9.1 ppb
○ min(259,138) = 0.0 ppb

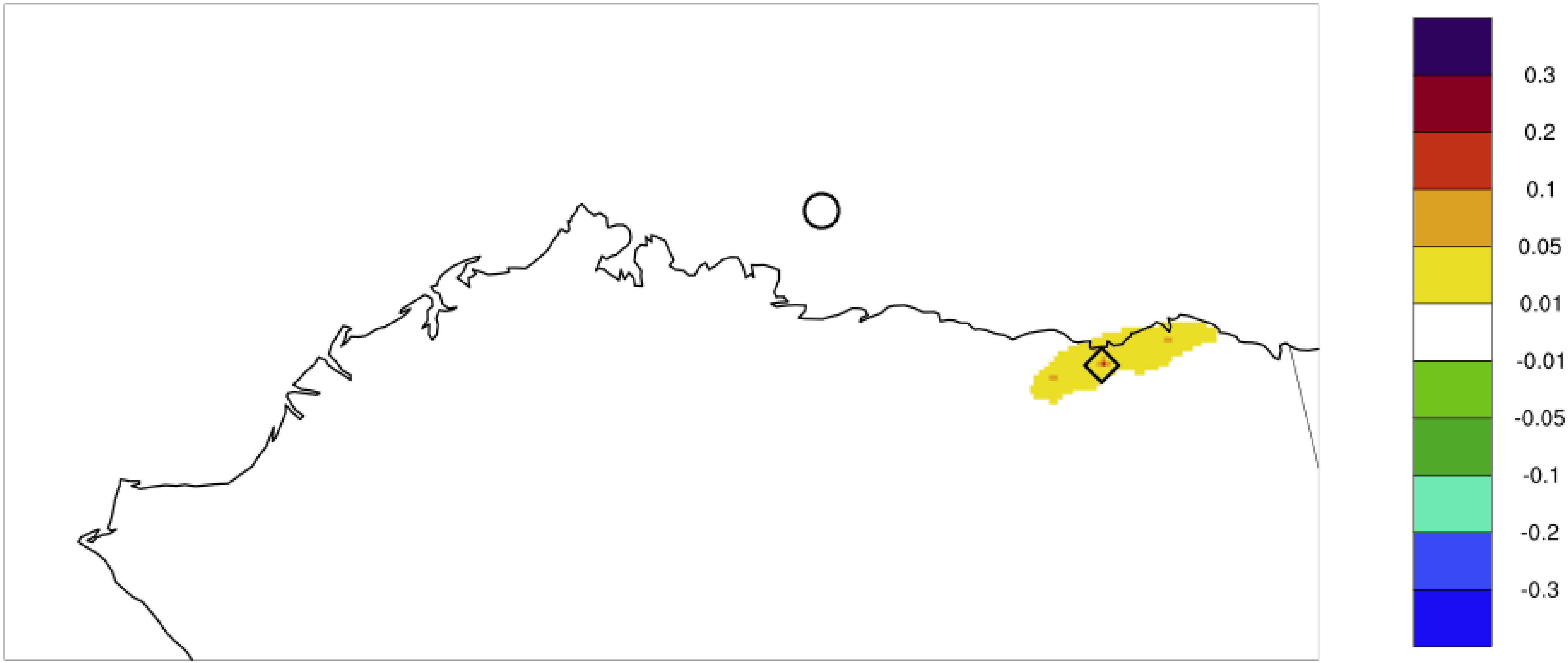
Annual average SO_2 concentration
Low Development Scenario-Cumulative



Annual average SO_2 concentration
No Action Alternative-Cumulative

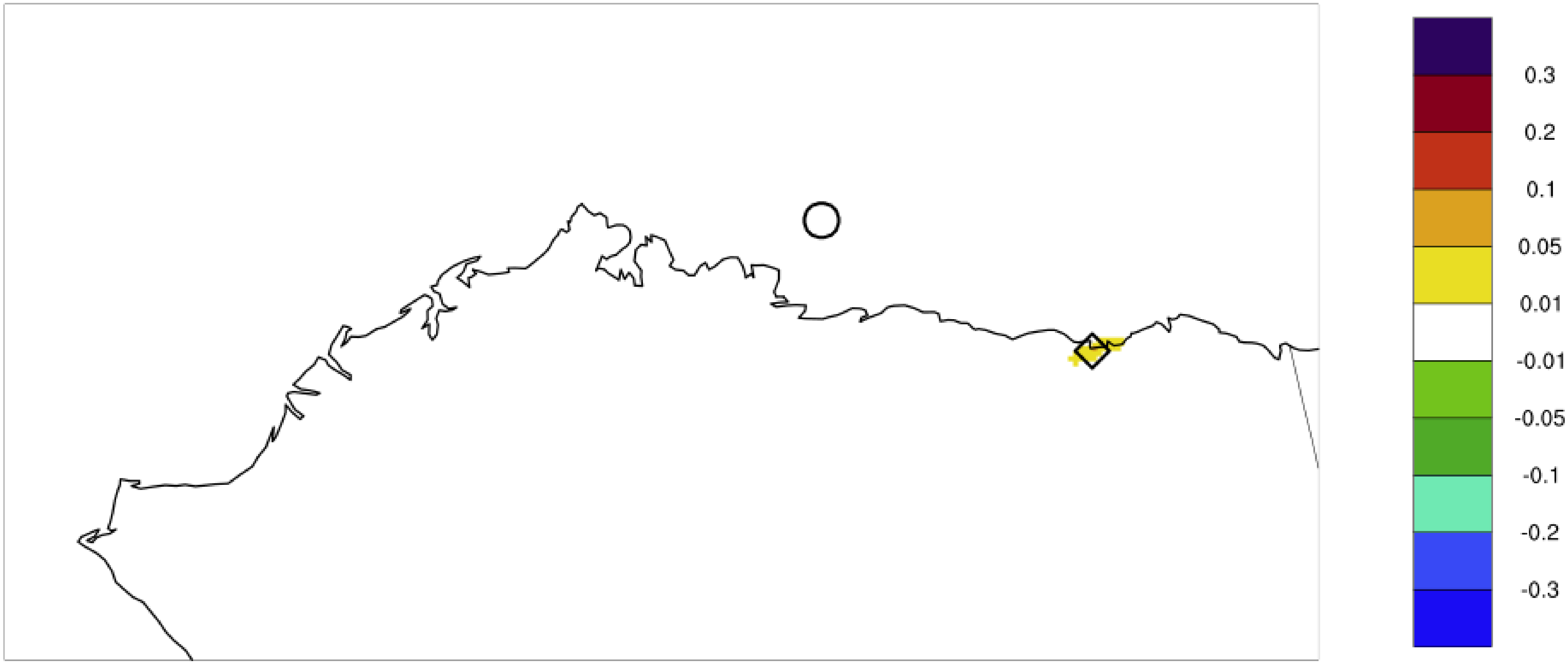


Annual average SO_2 concentration
High Development Scenario-Indirect Impact



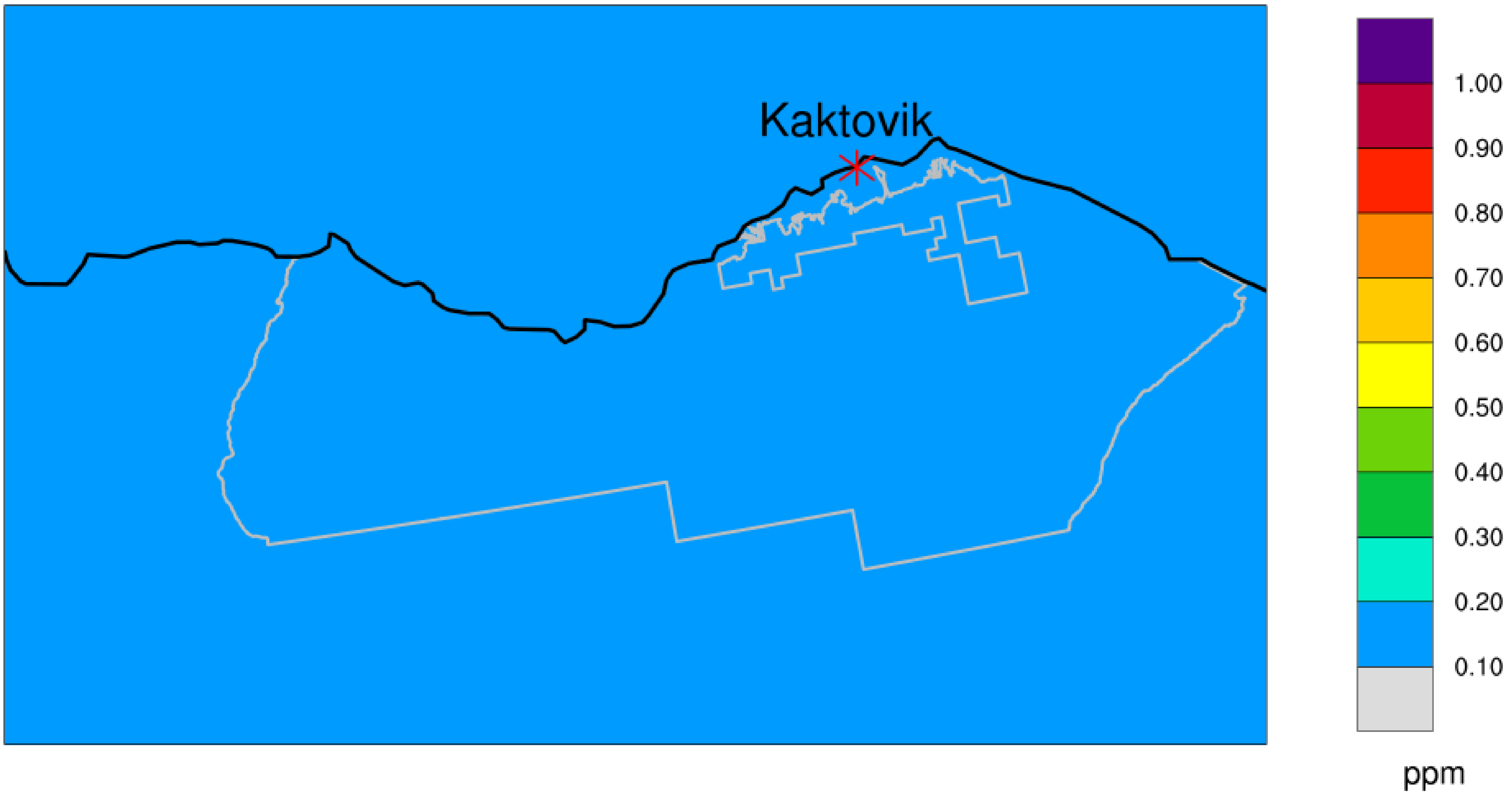
◇ max(231,63) = 0.126 ppb
○ min(172,95) = -0.000 ppb

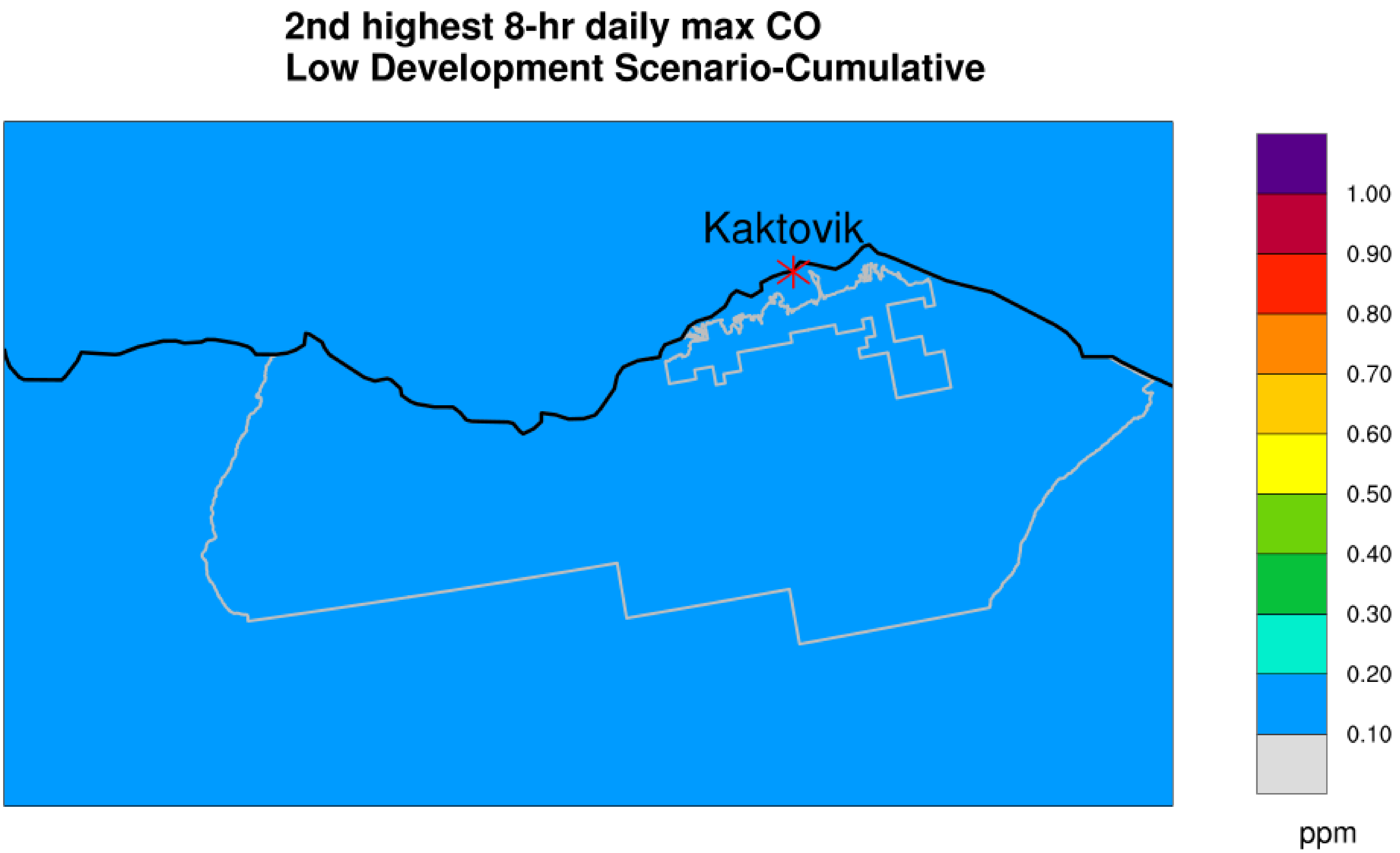
Annual average SO_2 concentration
Low Development Scenario-Indirect Impact



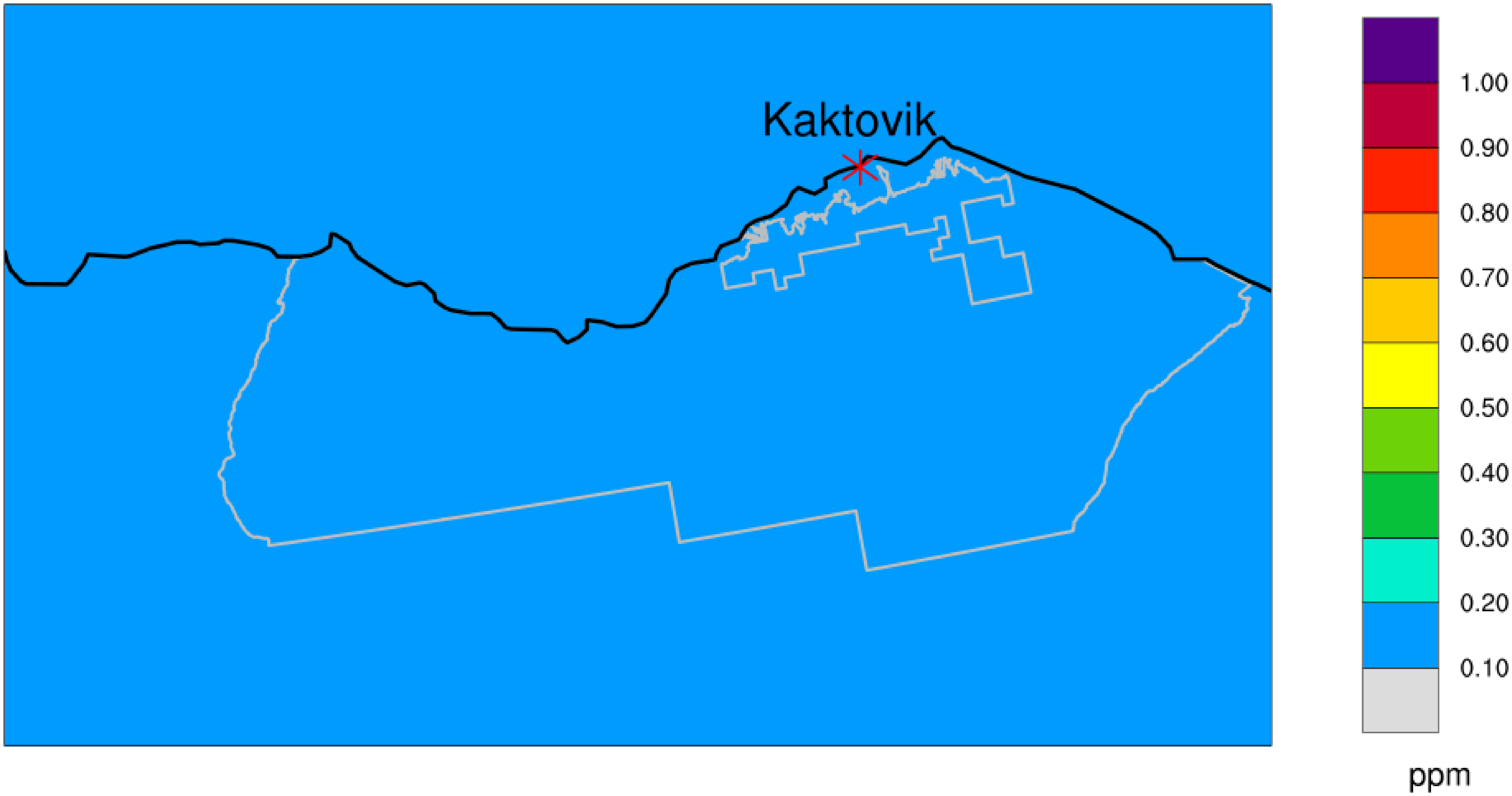
◇ max(229,66) = 0.079 ppb
○ min(172,93) = -0.000 ppb

2nd highest 8-hr daily max CO
High Development Scenario-Cumulative

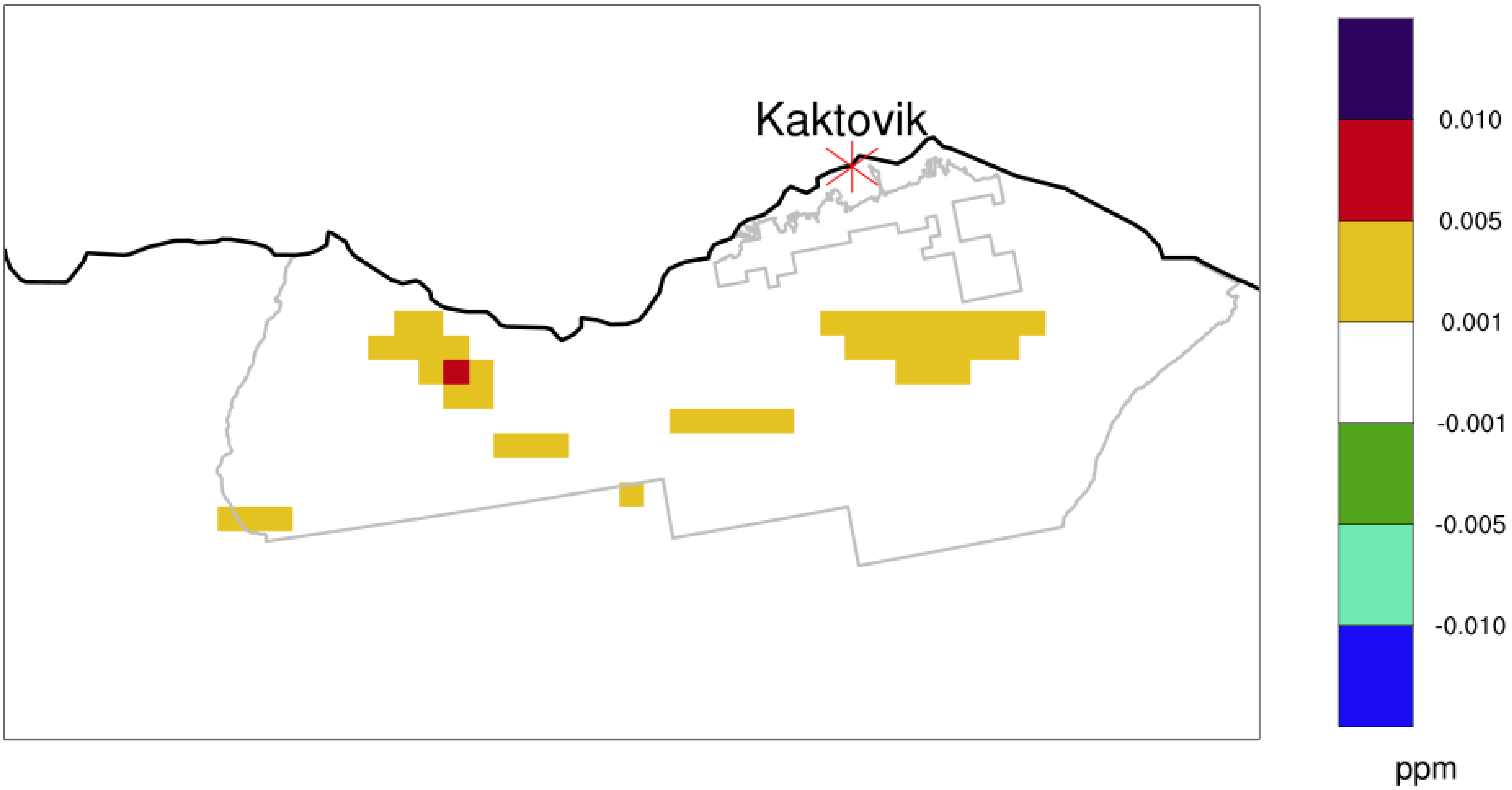



2nd highest 8-hr daily max CO
Low Development Scenario-Cumulative
Kaktovik
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
ppm

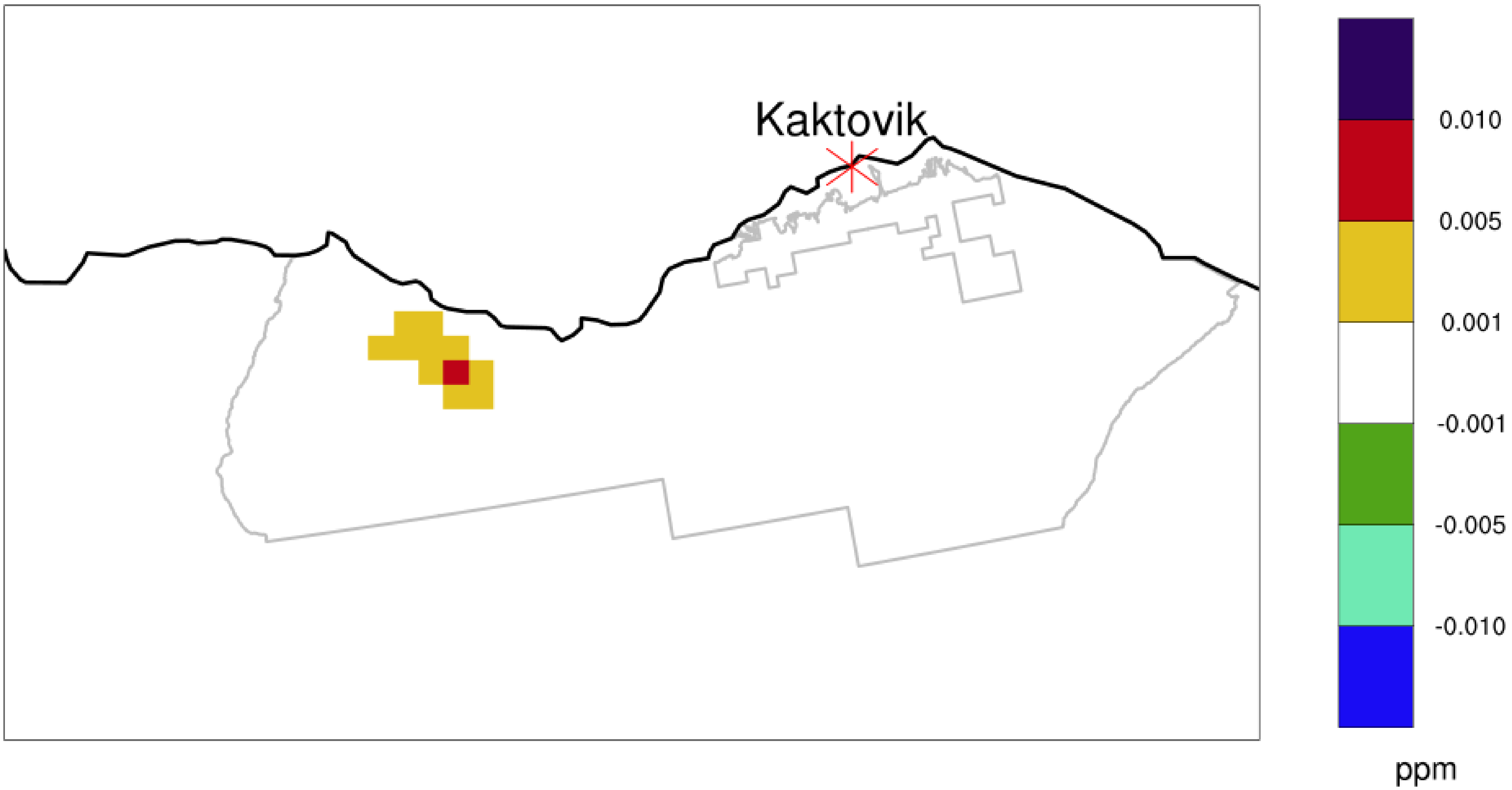
2nd highest 8-hr daily max CO
No Action Alternative-Cumulative



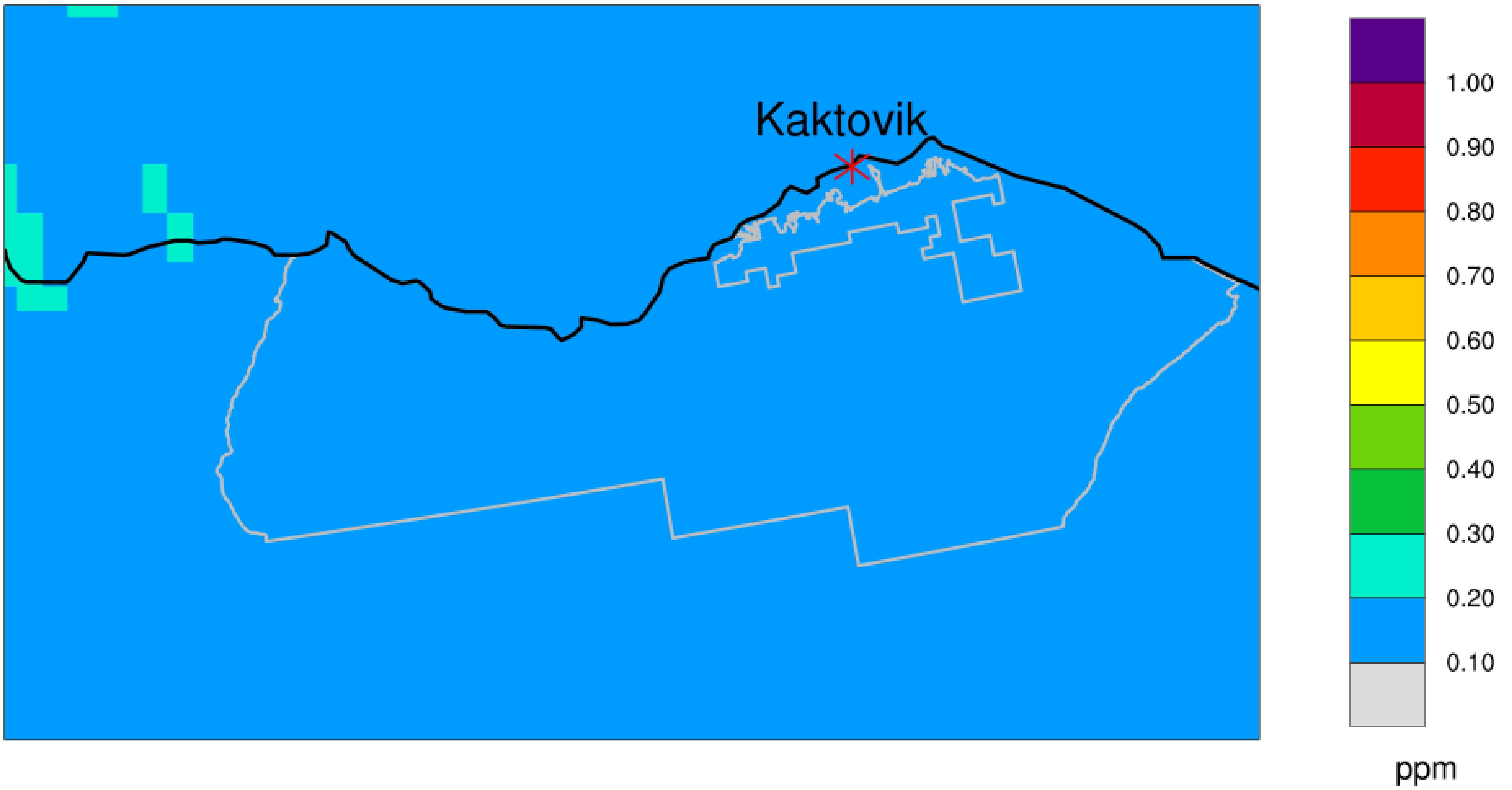
2nd highest 8-hr daily max CO
High Development Scenario-Indirect Impact

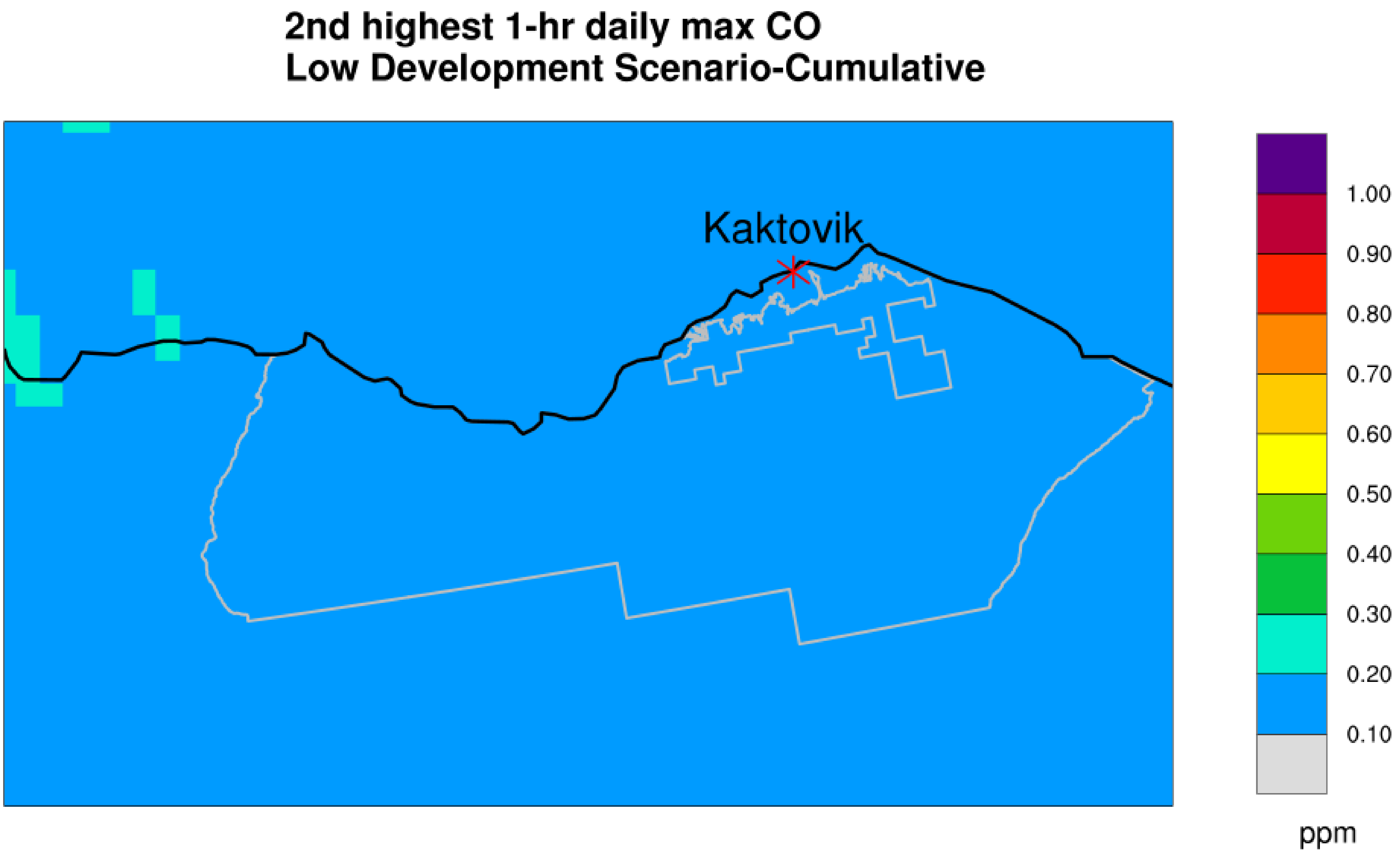


2nd highest 8-hr daily max CO
Low Development Scenario-Indirect Impact



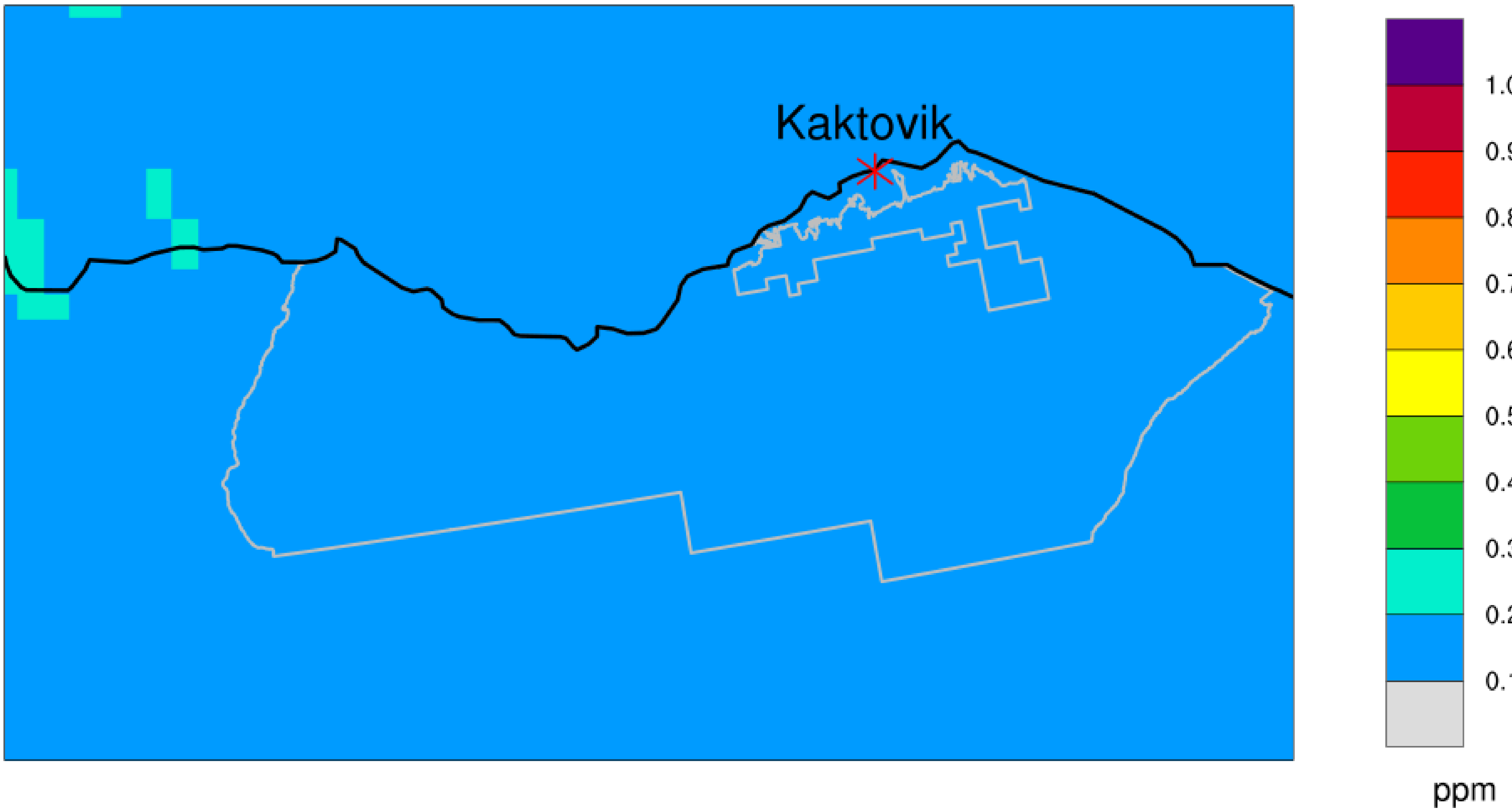
2nd highest 1-hr daily max CO
High Development Scenario-Cumulative



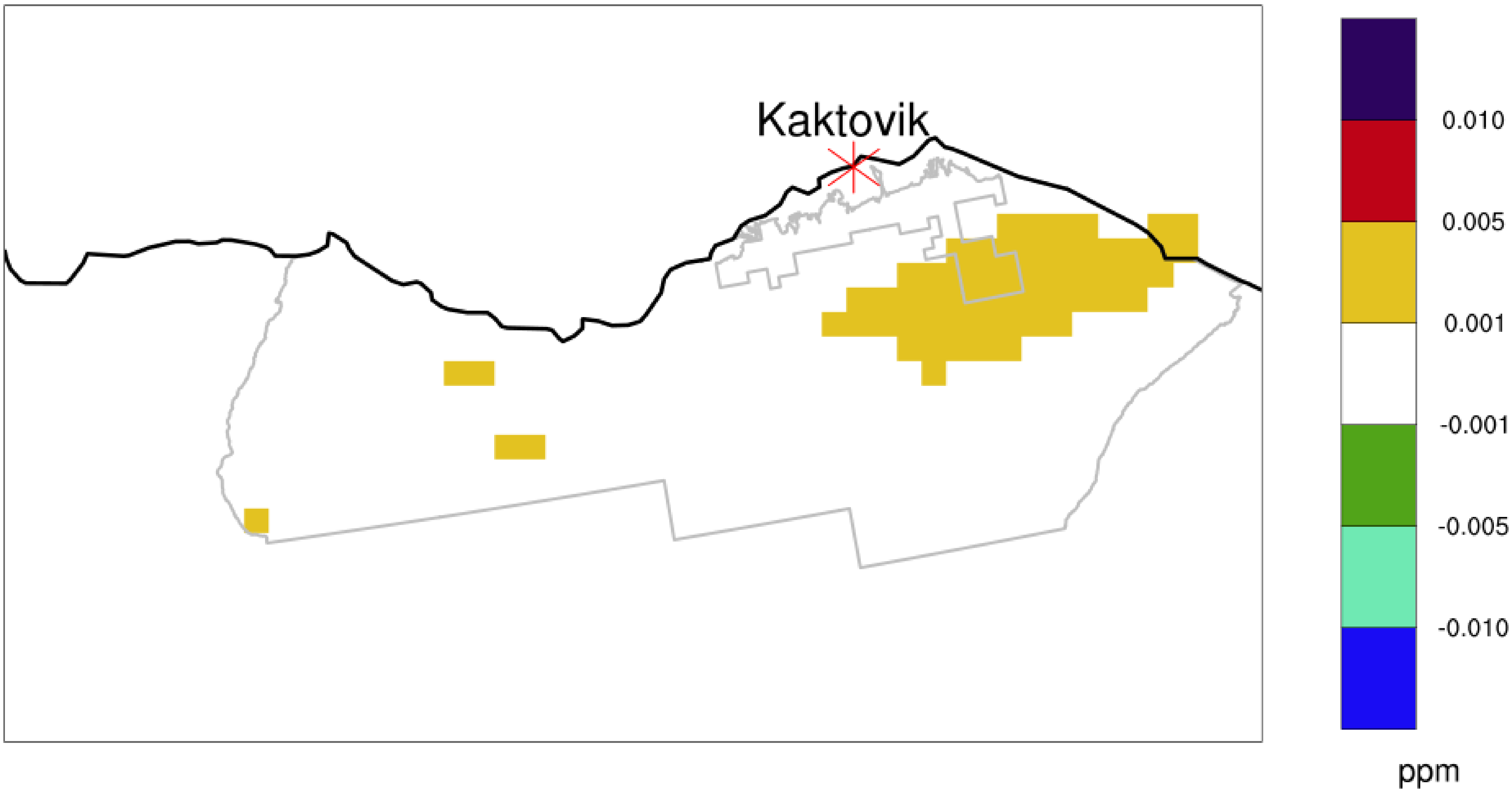


2nd highest 1-hr daily max CO
Low Development Scenario-Cumulative
Kaktovik
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
ppm

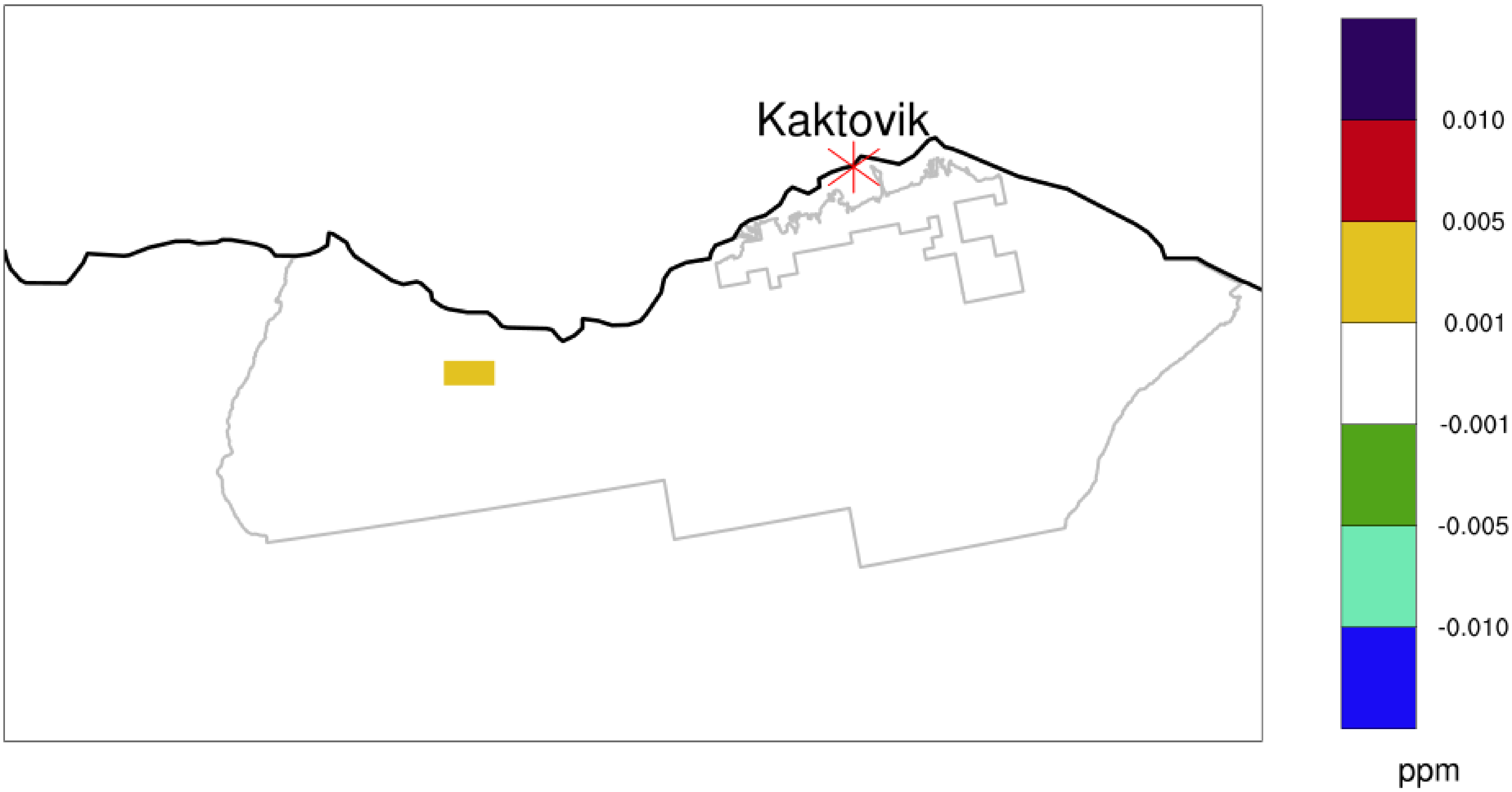
2nd highest 1-hr daily max CO
No Action Alternative-Cumulative

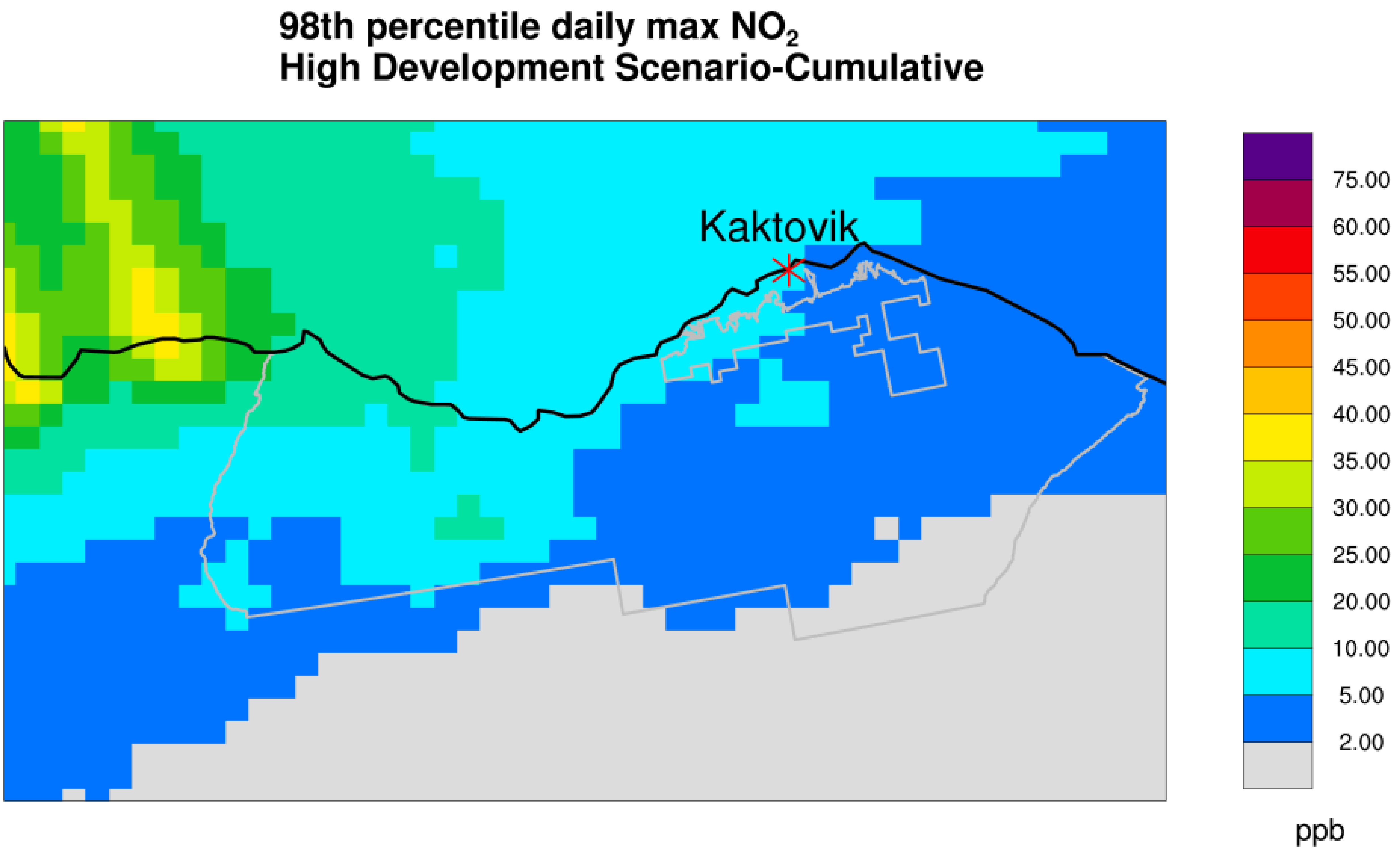


2nd highest 1-hr daily max CO
High Development Scenario-Indirect Impact



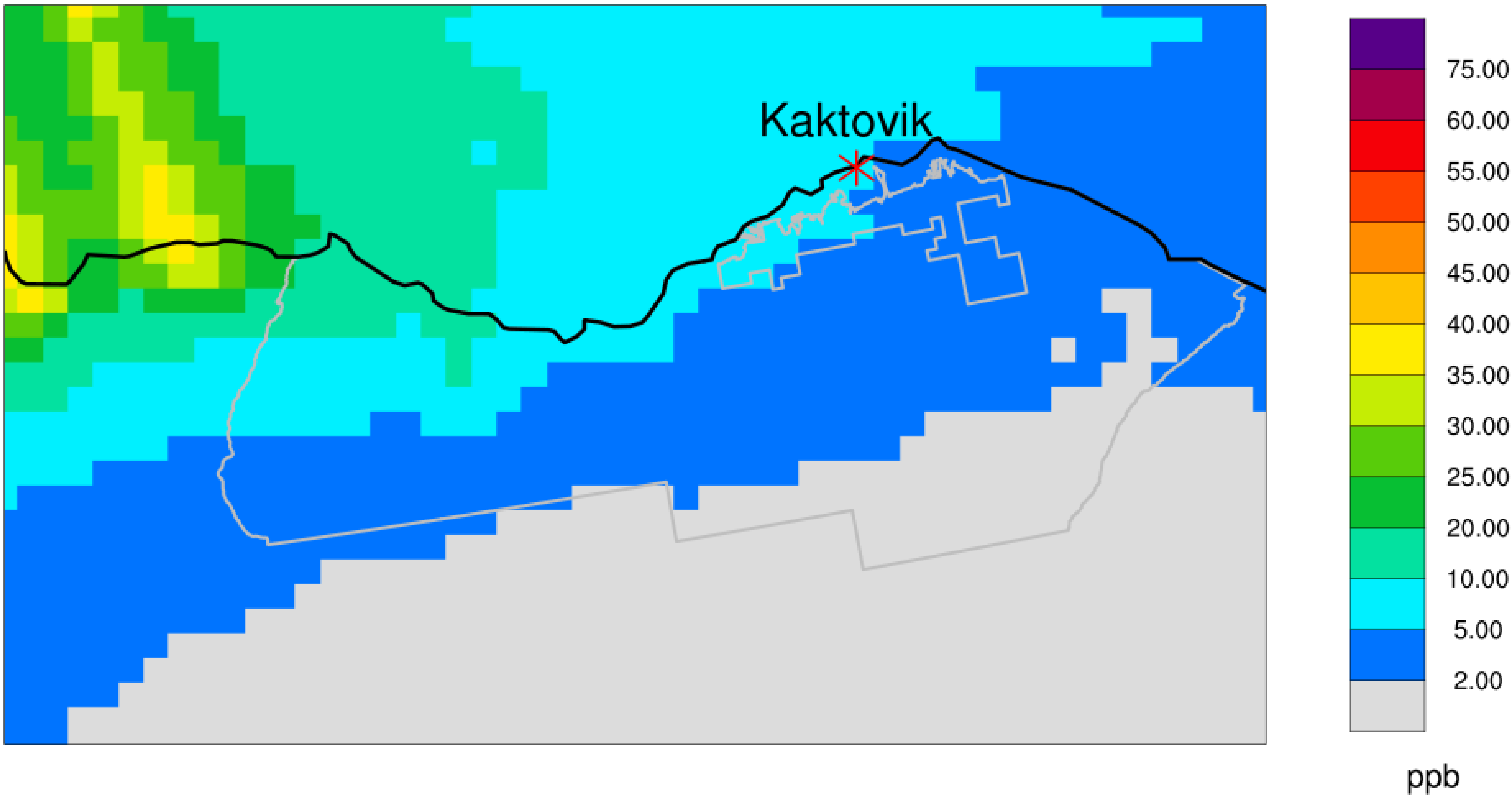
2nd highest 1-hr daily max CO
Low Development Scenario-Indirect Impact



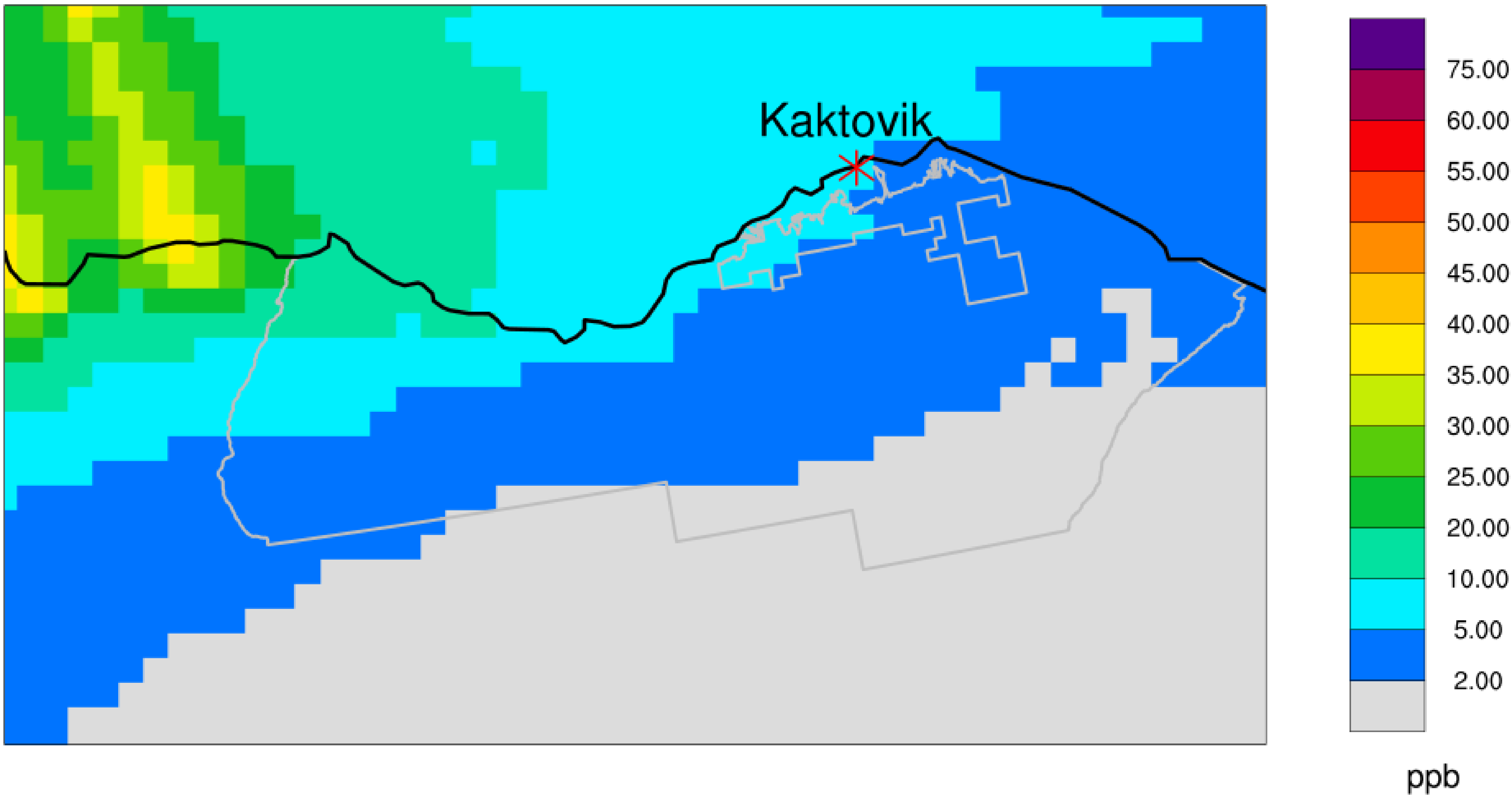


98th percentile daily max NO2
High Development Scenario-Cumulative
Kaktovik
75.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
10.00
5.00
2.00
ppb

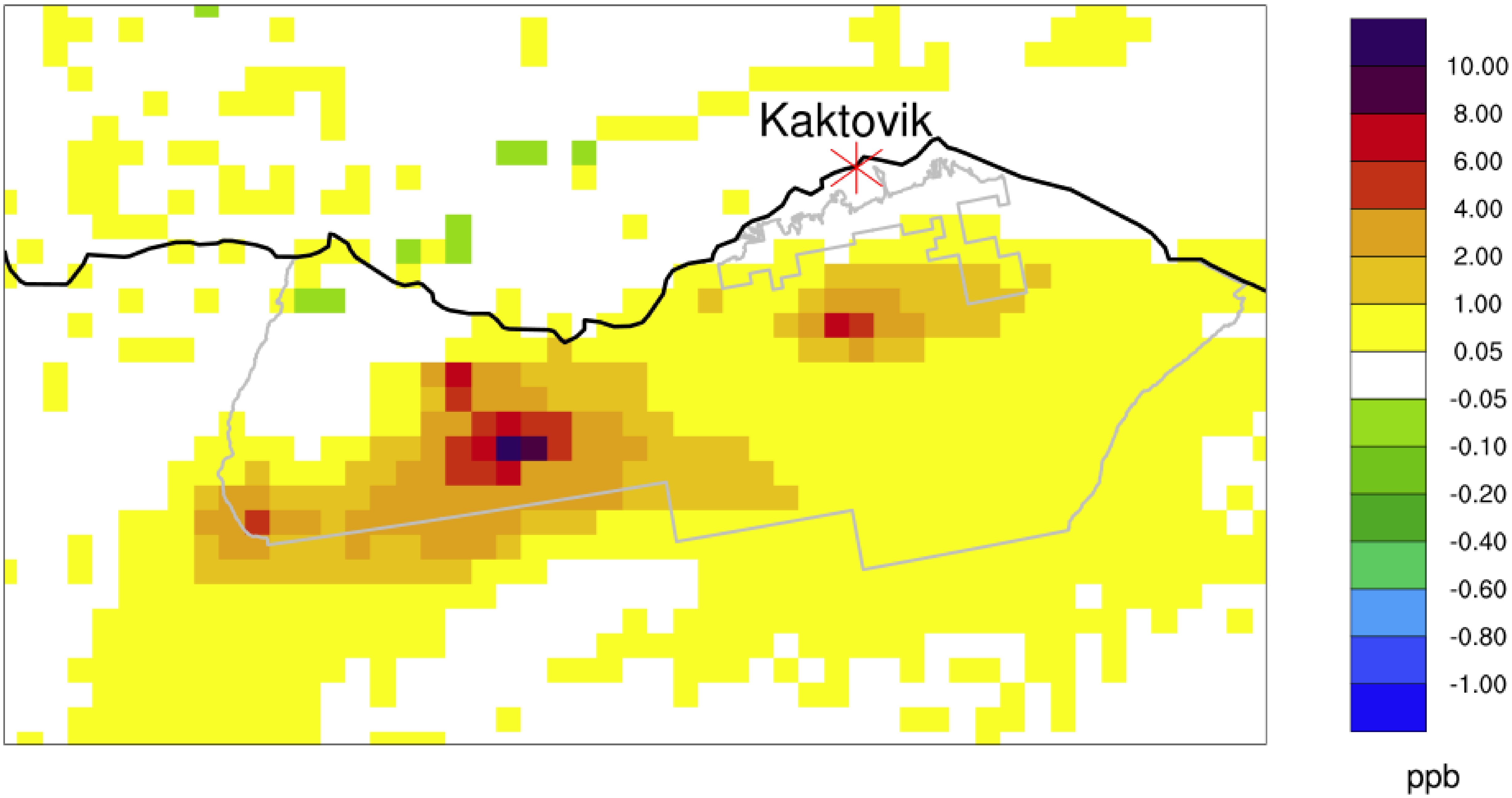
98th percentile daily max NO_2
Low Development Scenario-Cumulative

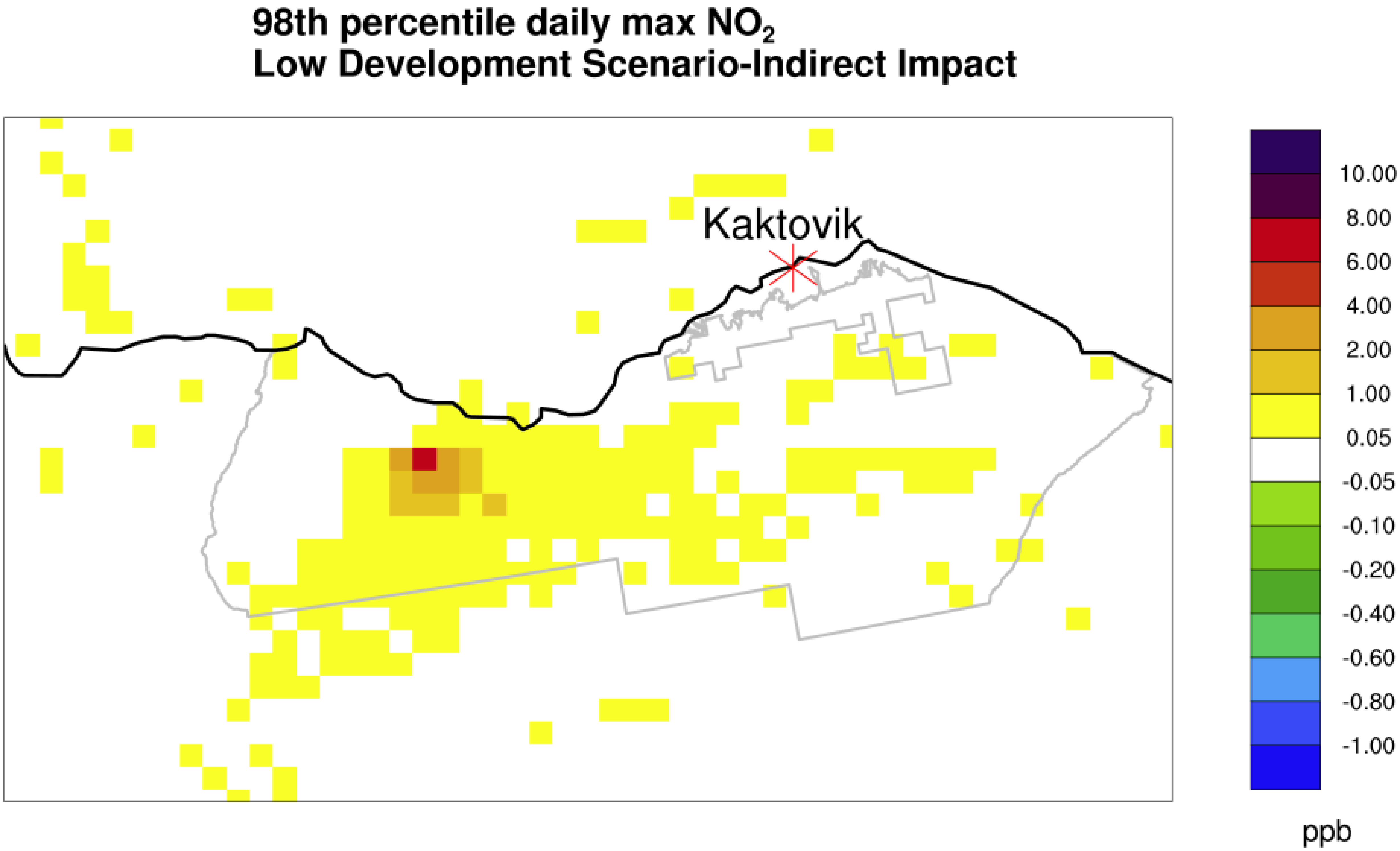


98th percentile daily max NO_2
No Action Alternative-Cumulative



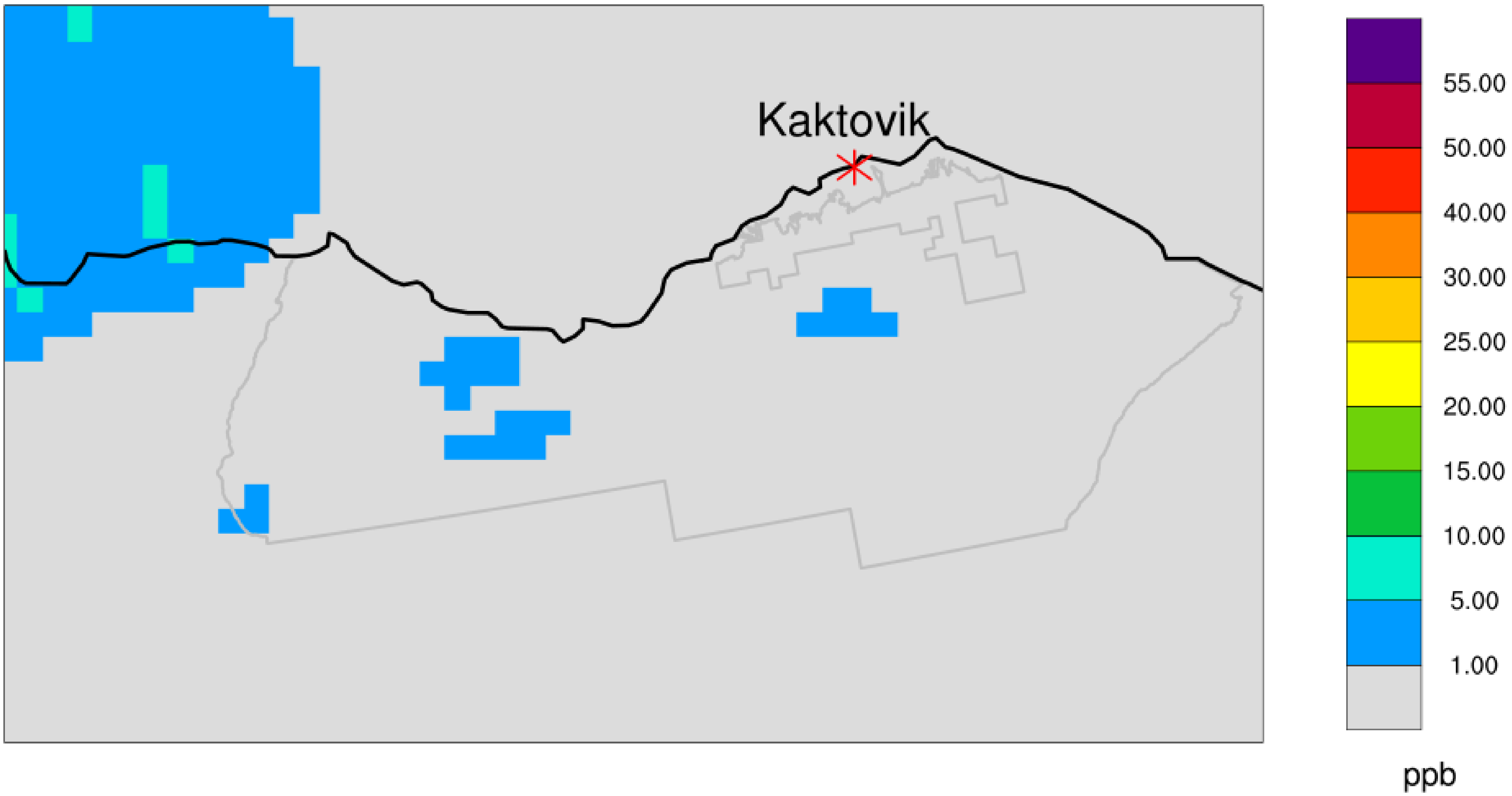
98th percentile daily max NO_2
High Development Scenario-Indirect Impact



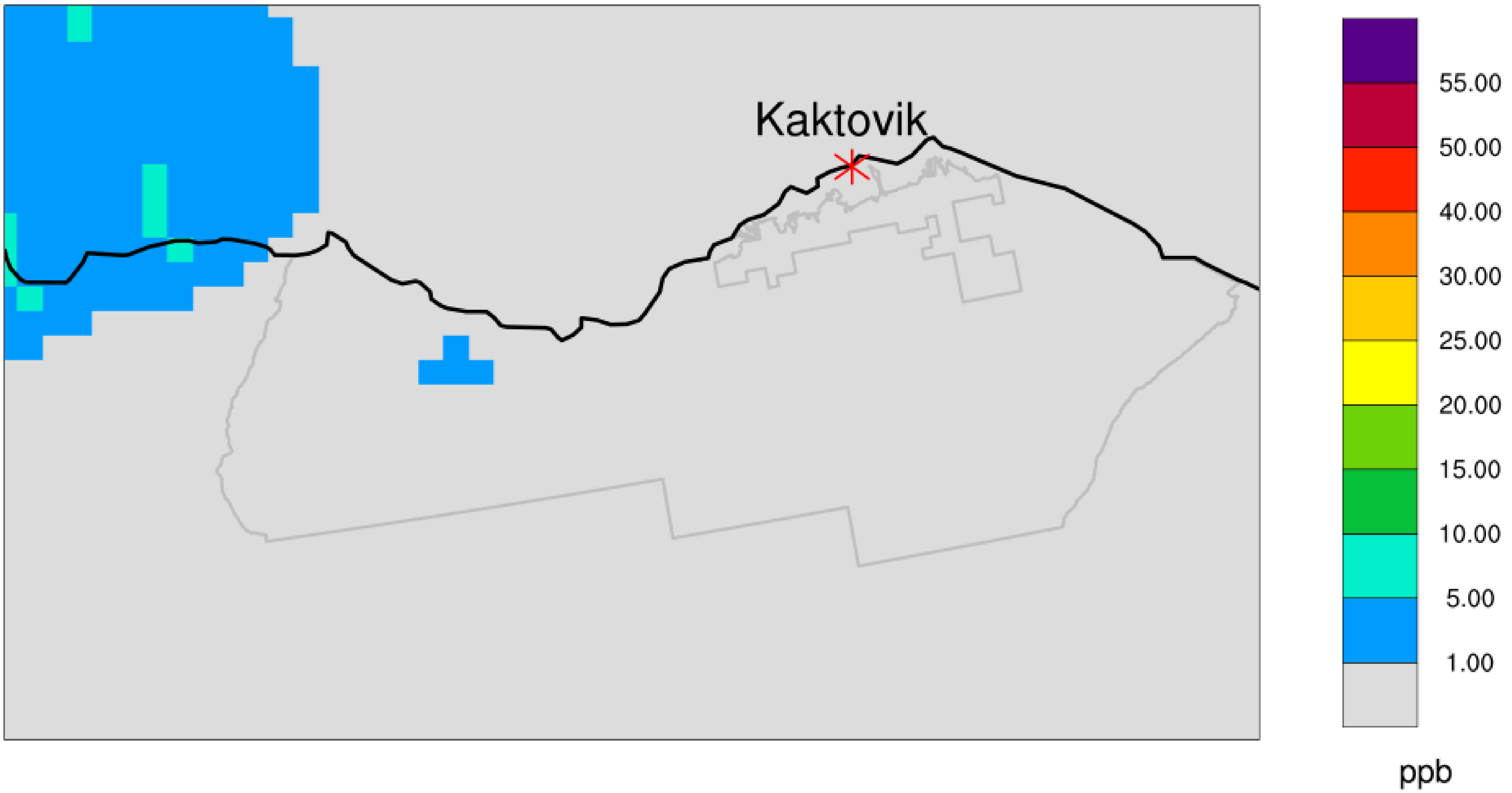


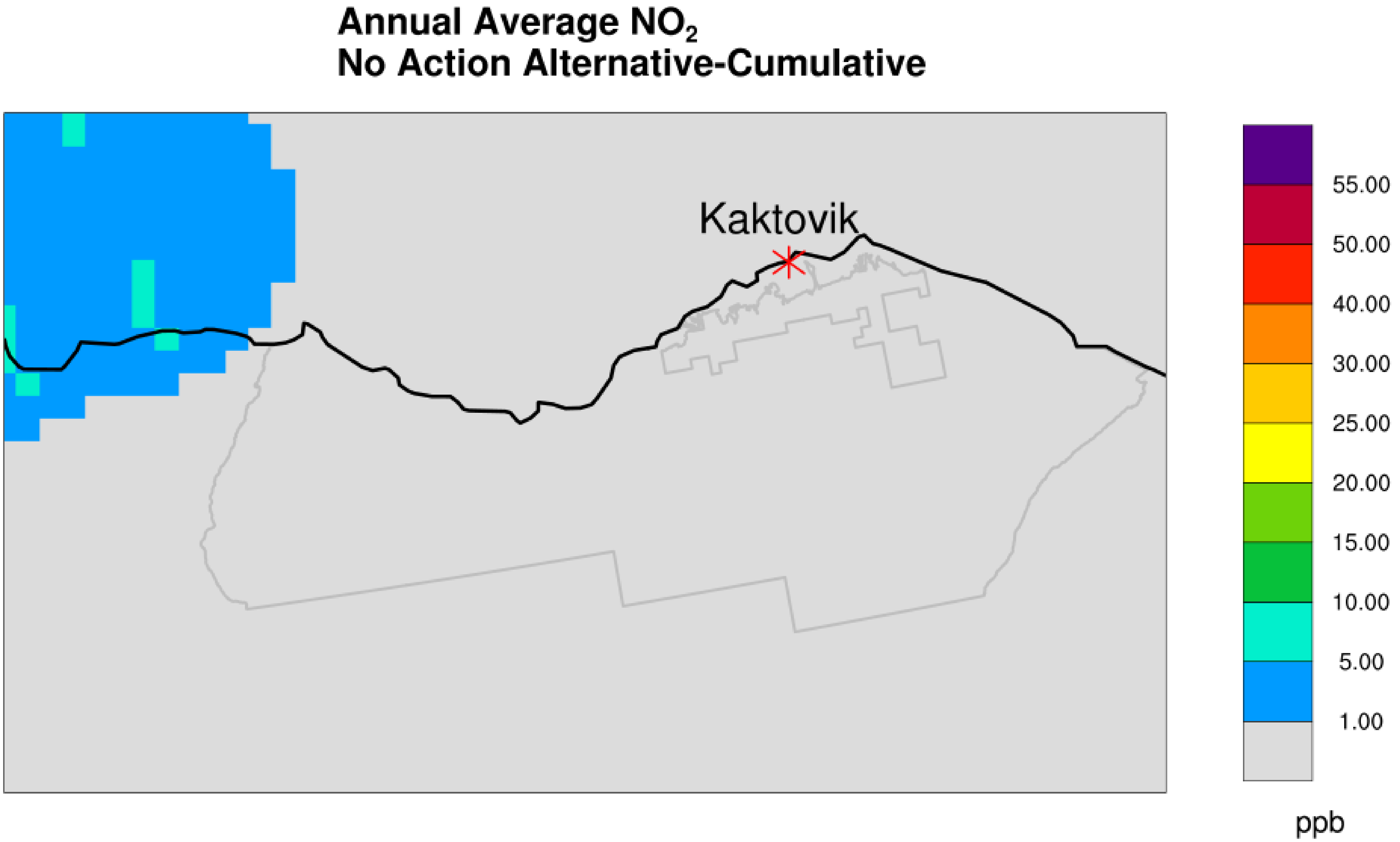
98th percentile daily max NO_2
Low Development Scenario-Indirect Impact
Kaktovik
10.00
8.00
6.00
4.00
2.00
1.00
0.05
-0.05
-0.10
-0.20
-0.40
-0.60
-0.80
-1.00
ppb

Annual Average NO_2
High Development Scenario-Cumulative

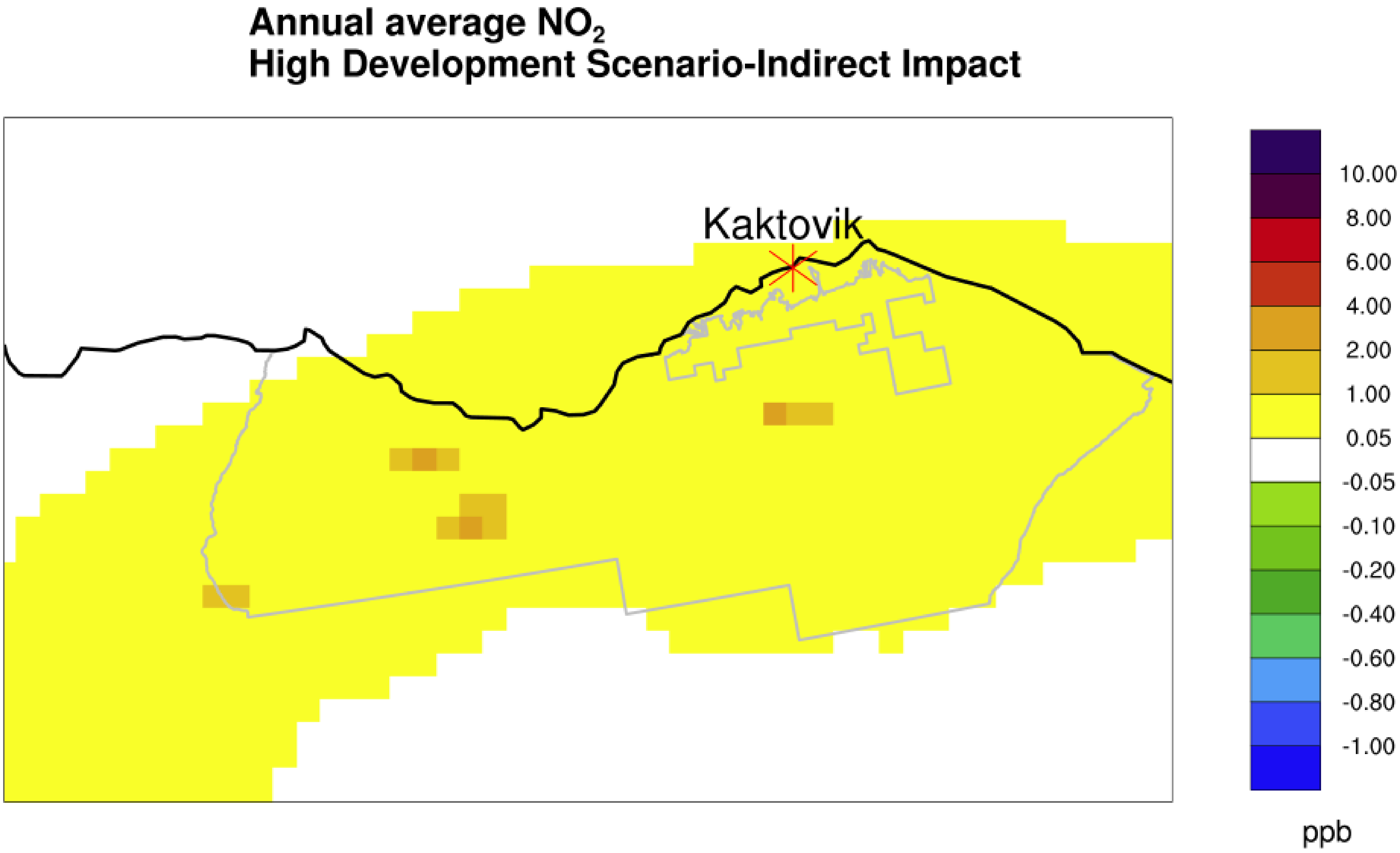


Annual Average NO_2
Low Development Scenario-Cumulative

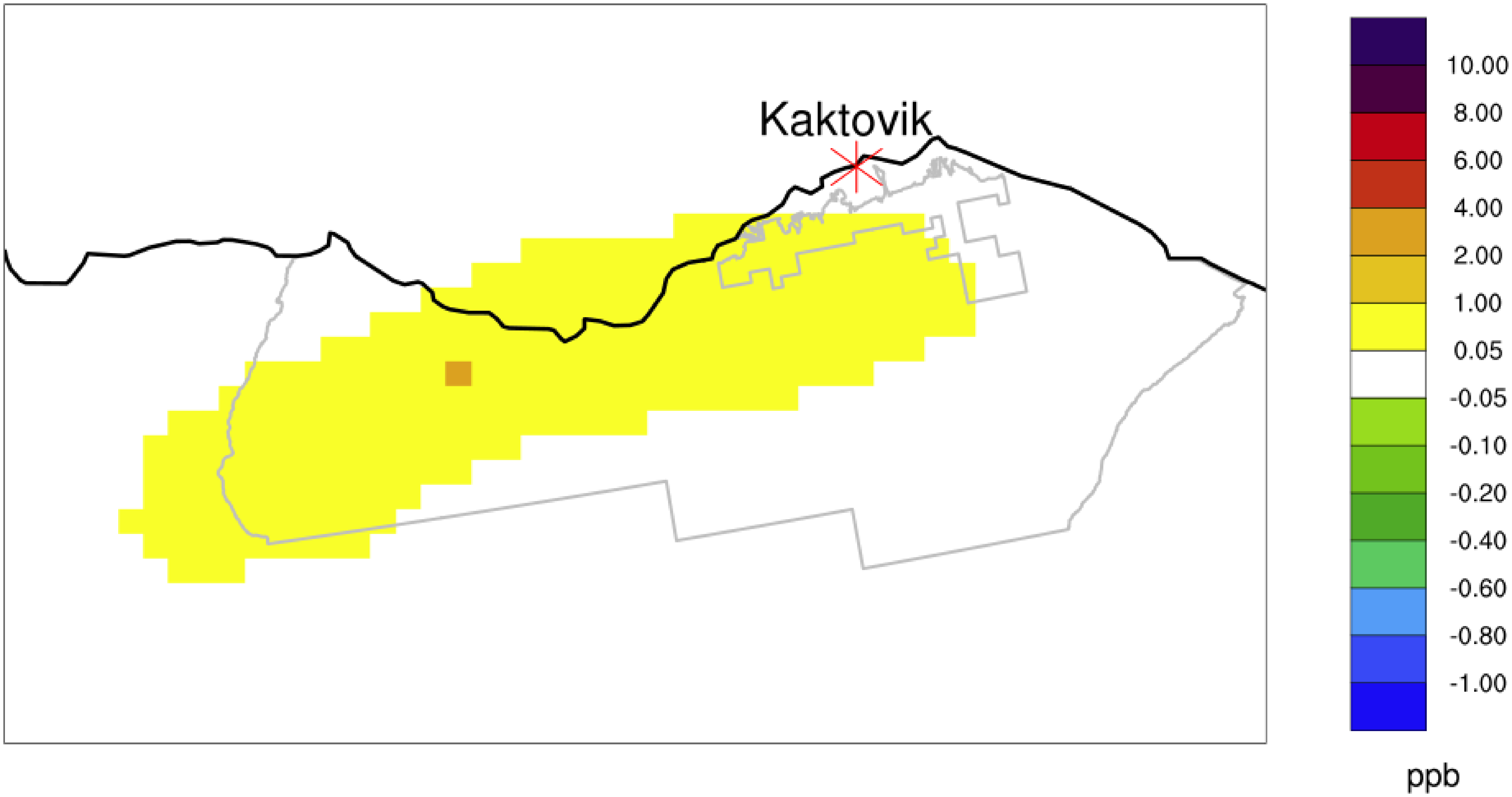




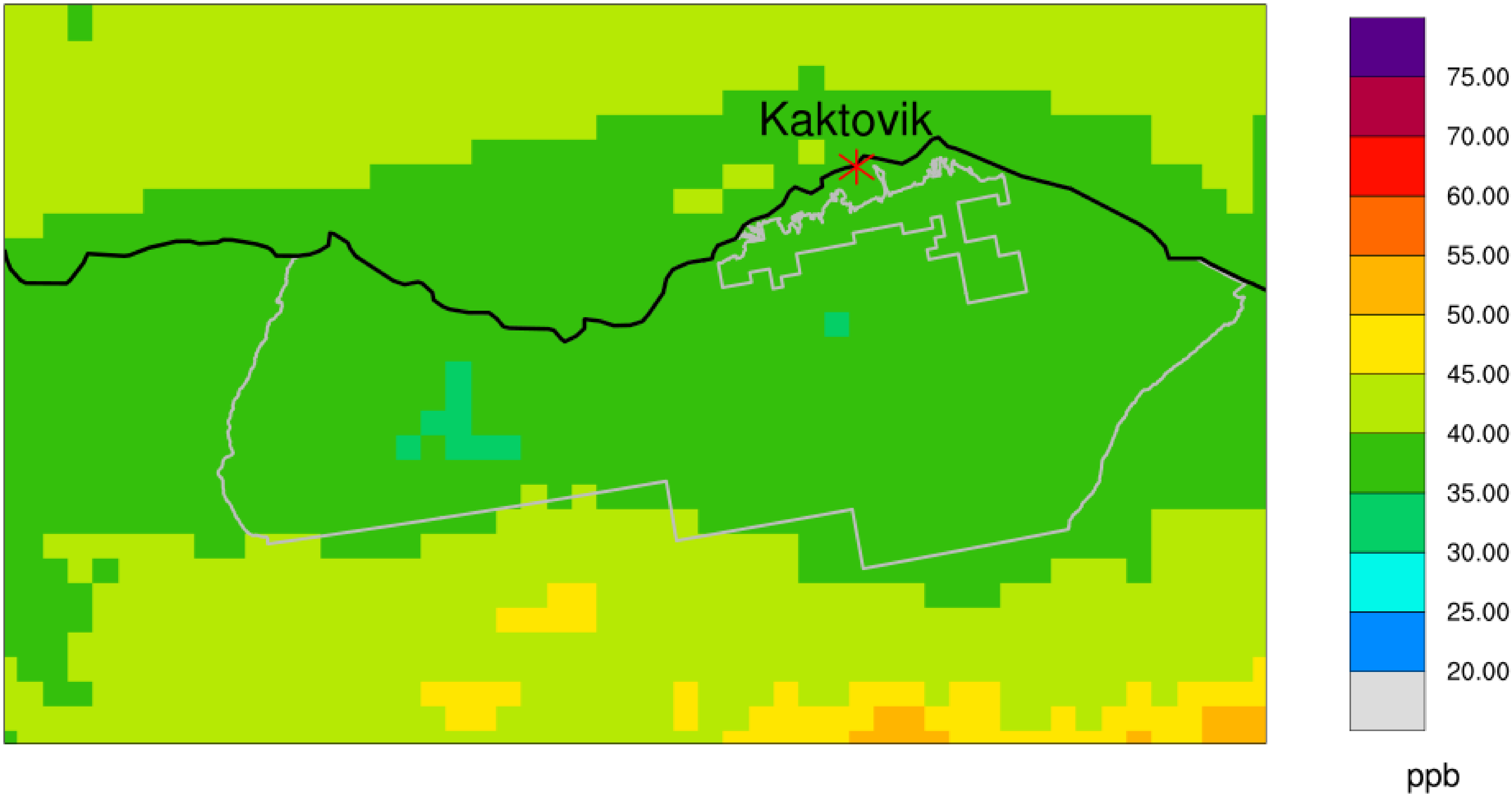
Annual Average NO_2
No Action Alternative-Cumulative
Kaktovik
55.00
50.00
40.00
30.00
25.00
20.00
15.00
10.00
5.00
1.00
ppb


Annual average NO2
High Development Scenario-Indirect Impact
Kaktovik
10.00
8.00
6.00
4.00
2.00
1.00
0.05
-0.05
-0.10
-0.20
-0.40
-0.60
-0.80
-1.00
ppb

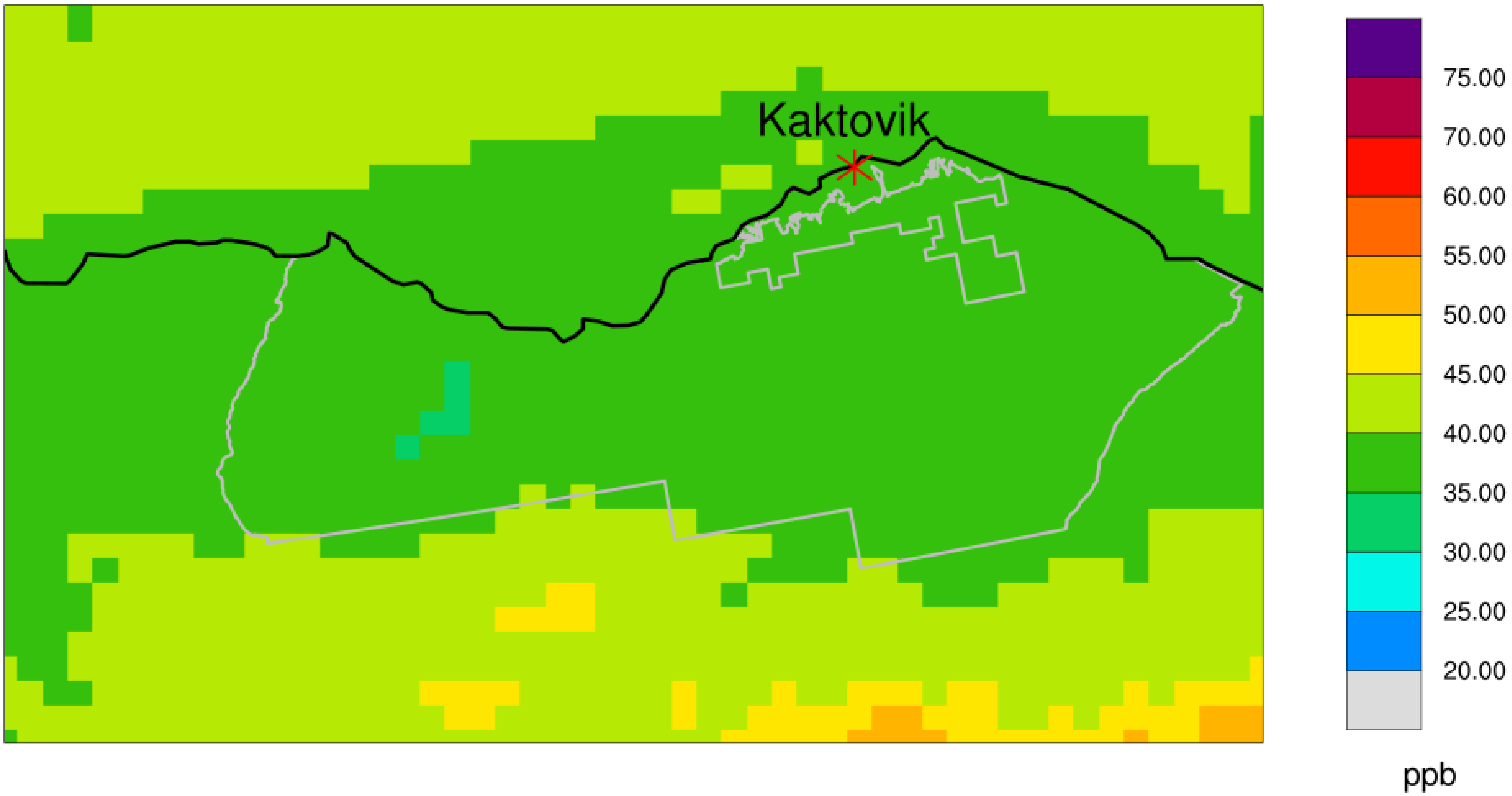
Annual average NO_2
Low Development Scenario-Indirect Impact



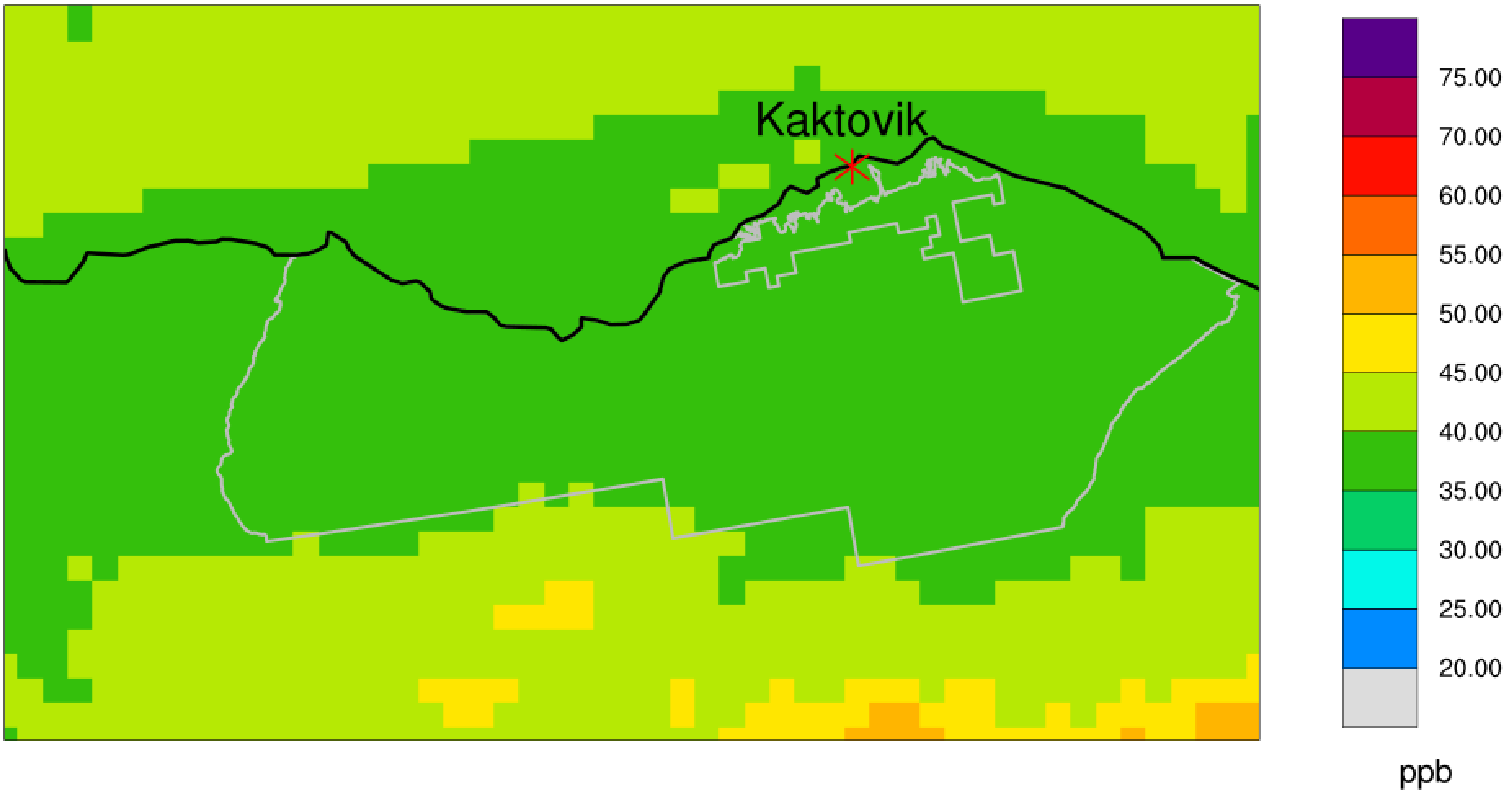
4th High Daily Max 8 Hour Avg Ozone
High Development Scenario-Cumulative



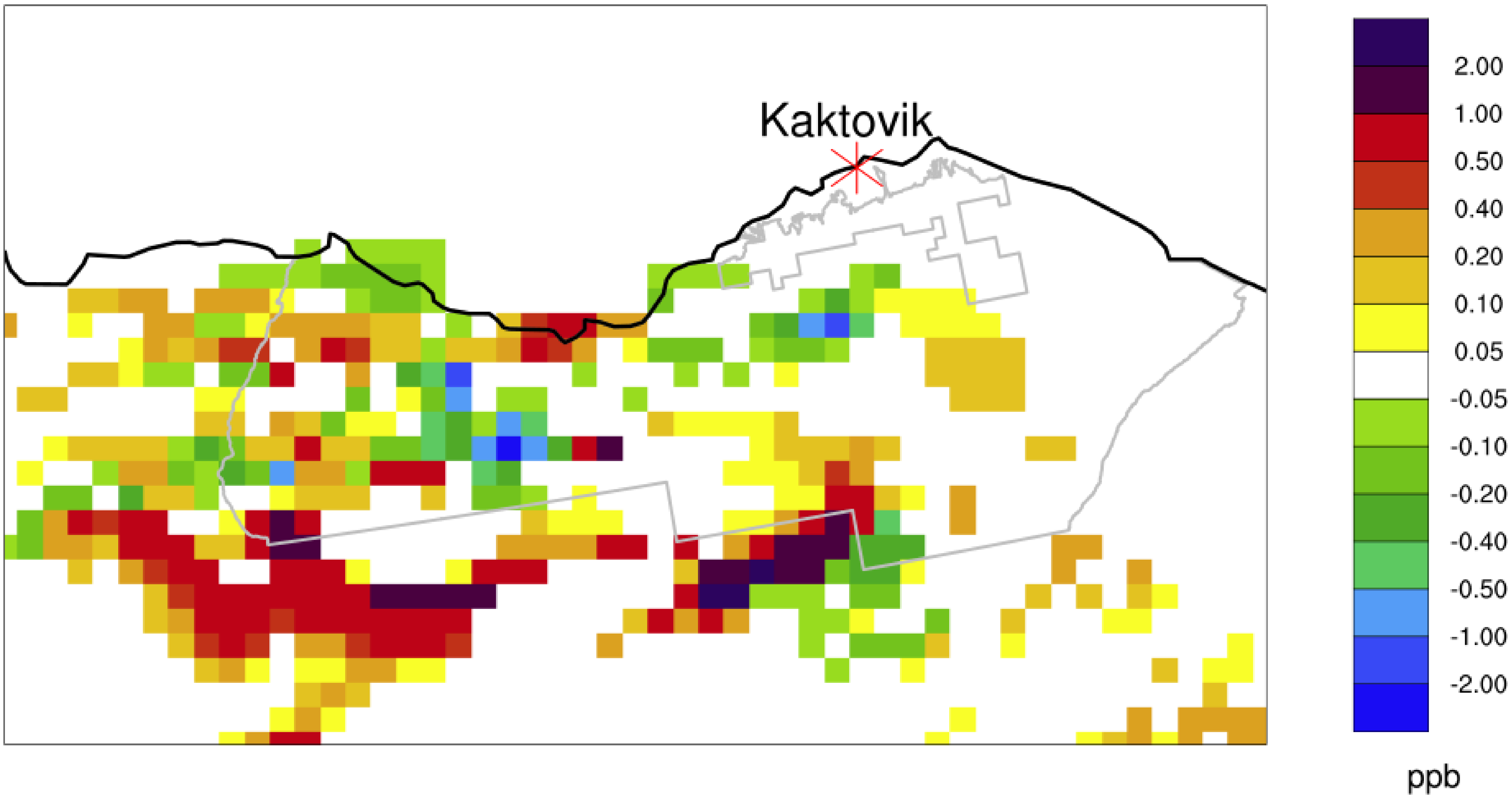
**4th High Daily Max 8 Hour Avg Ozone
Low Development Scenario-Cumulative**



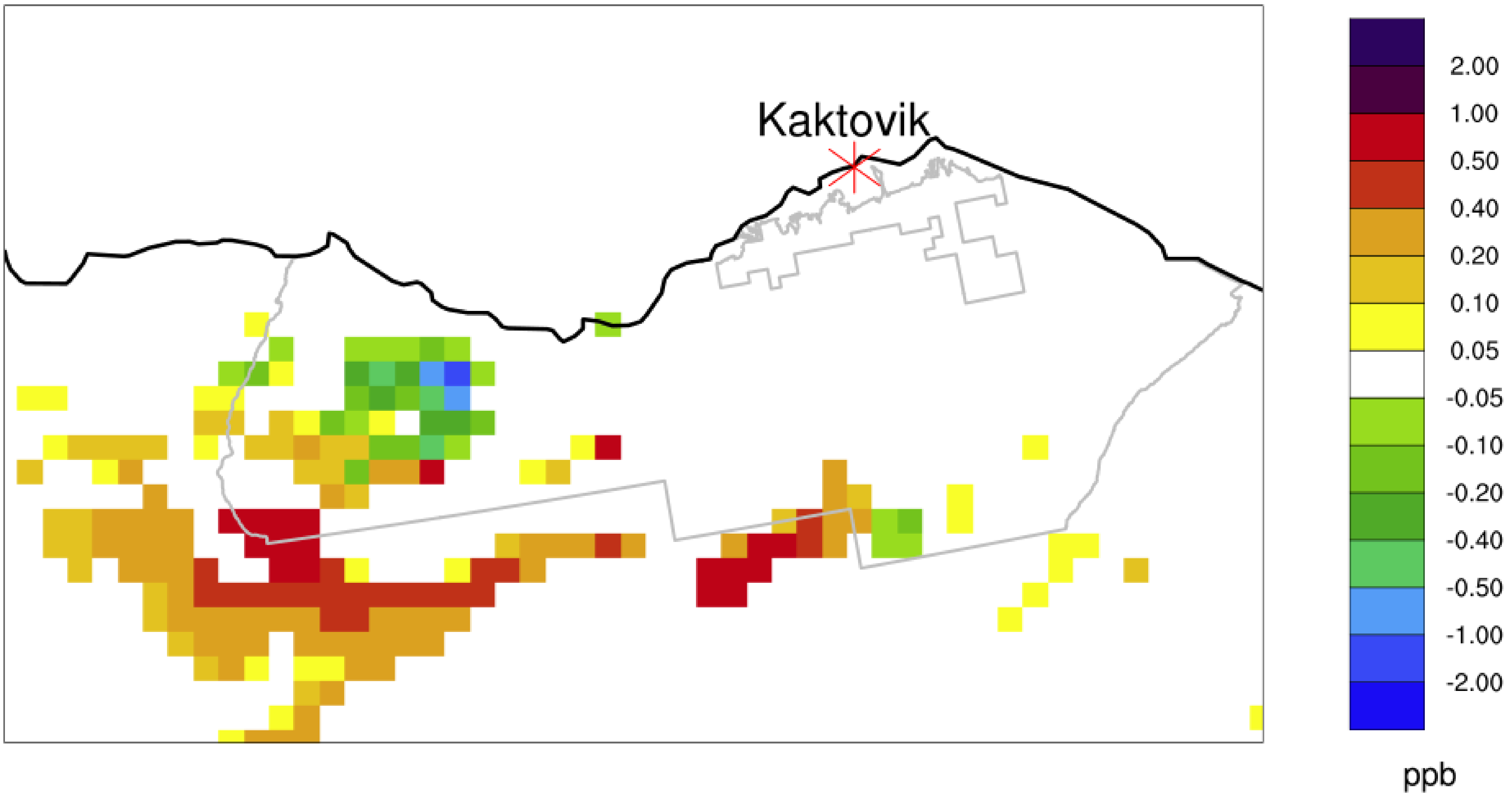
4th High Daily Max 8 Hour Avg Ozone
No Action Alternative-Cumulative



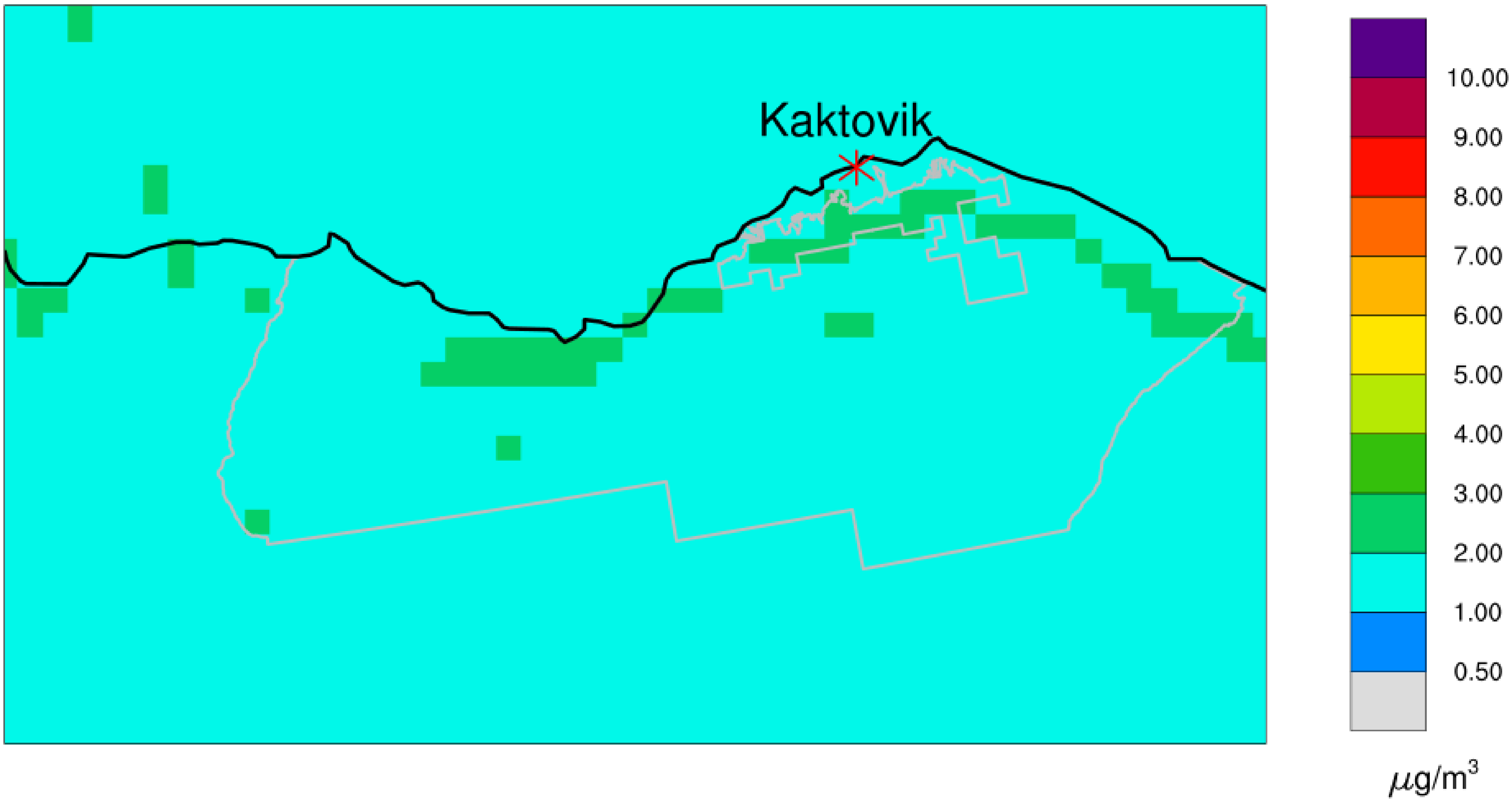
4th High Daily Max 8 Hour Avg Ozone
High Development Scenario-Indirect Impact



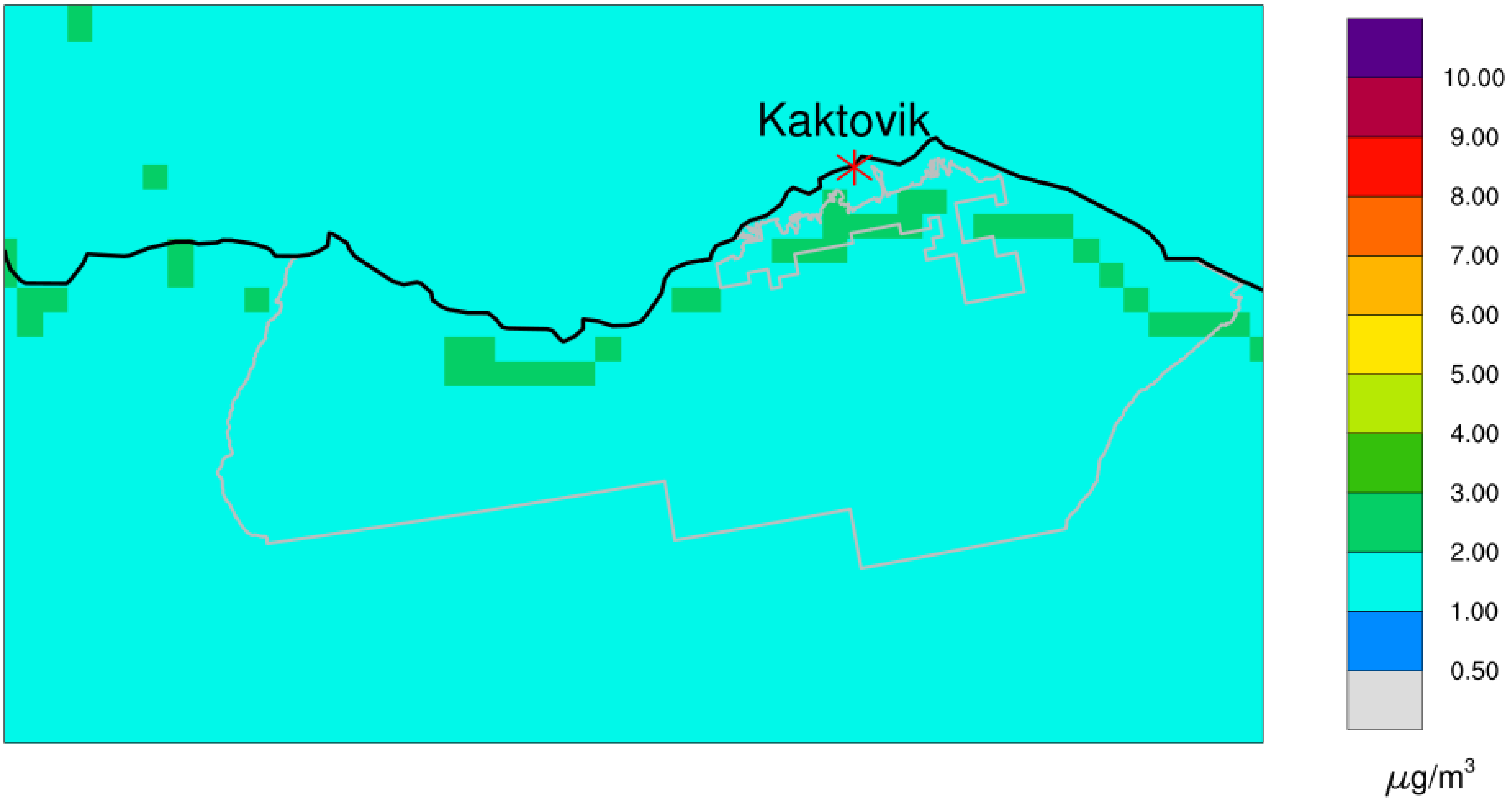
4th High Daily Max 8 Hour Avg Ozone
Low Development Scenario-Indirect Impact



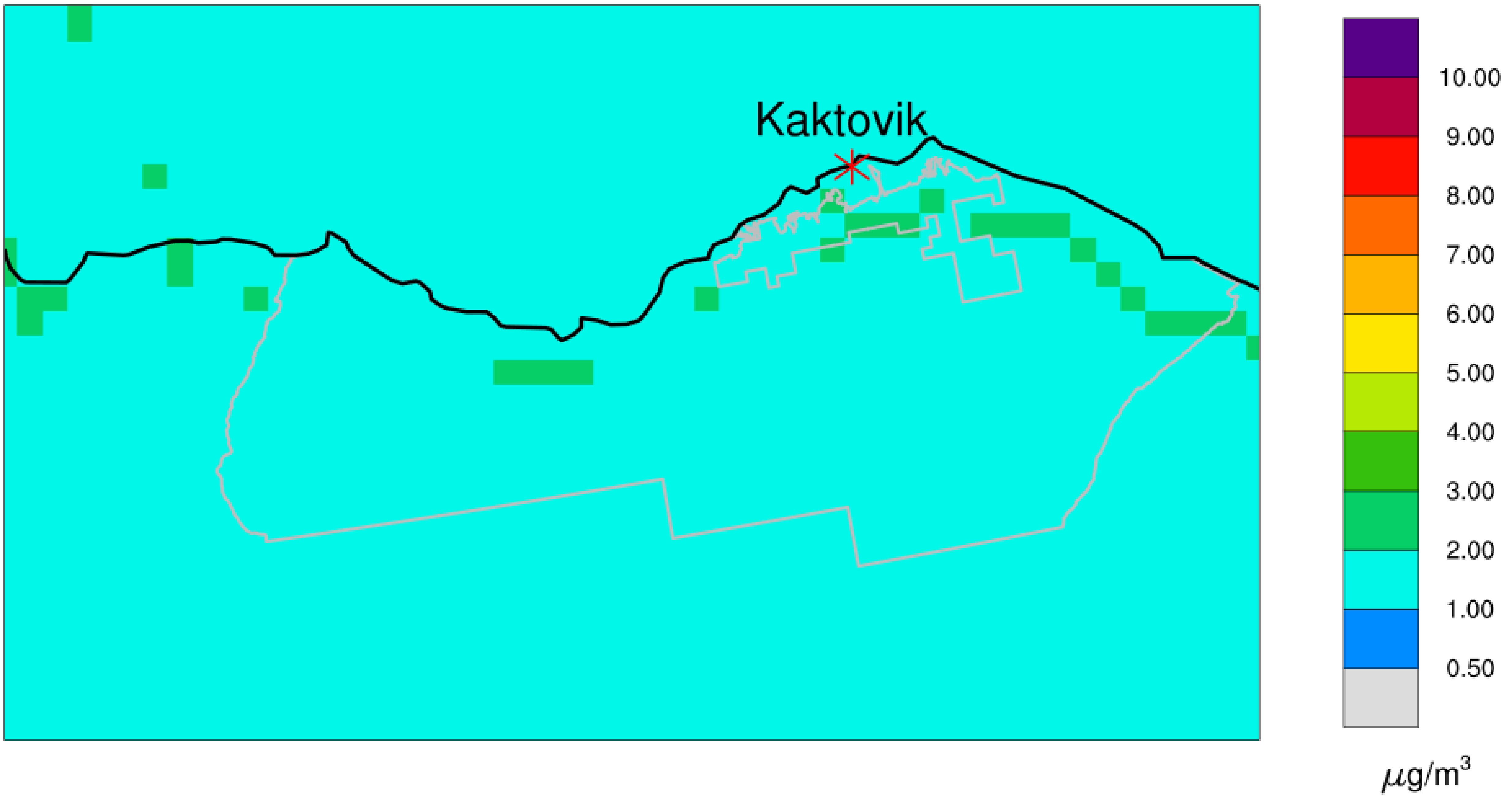
Annual average $PM_{2.5}$ concentration
High Development Scenario-Cumulative

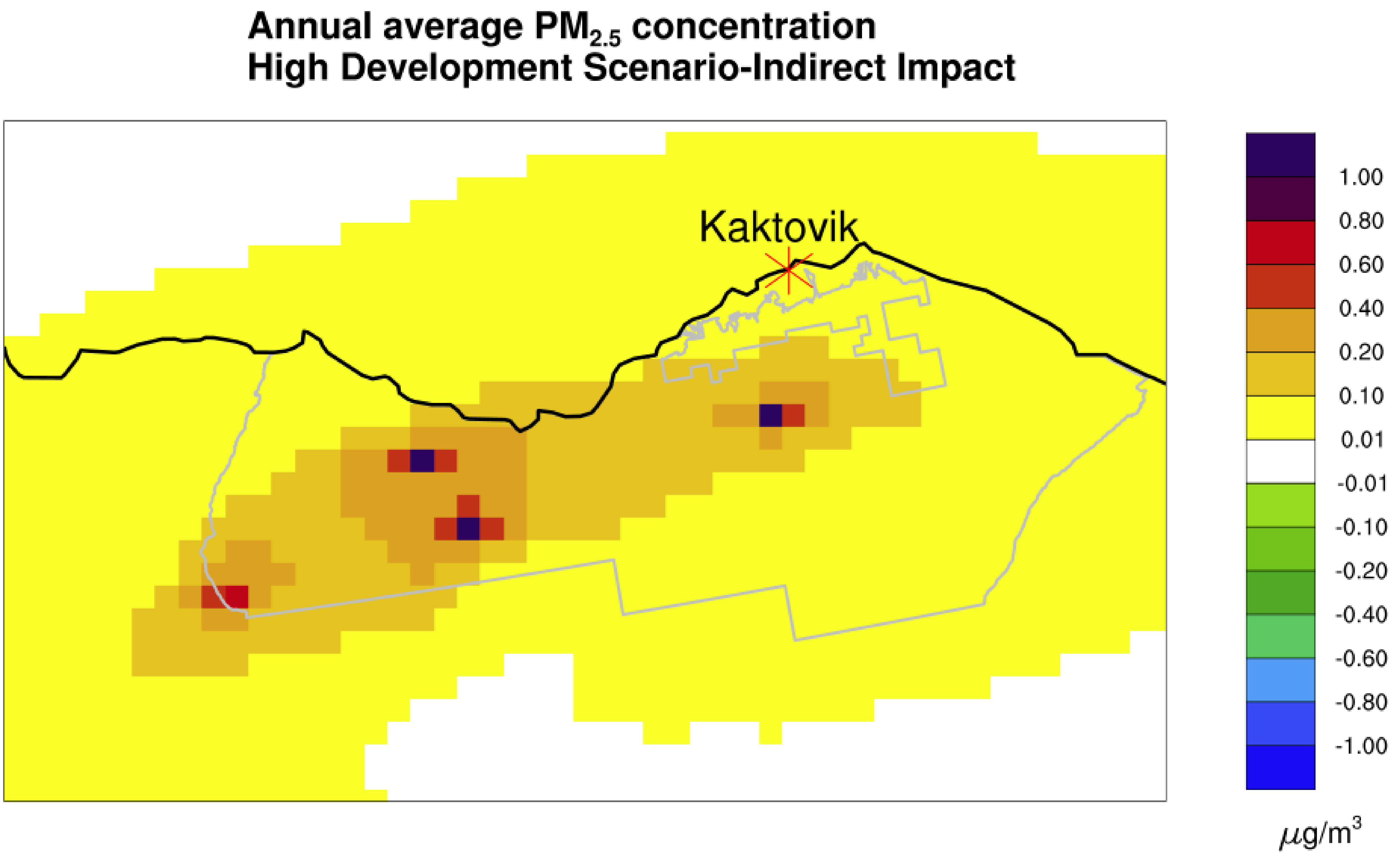


Annual average $PM_{2.5}$ concentration
Low Development Scenario-Cumulative

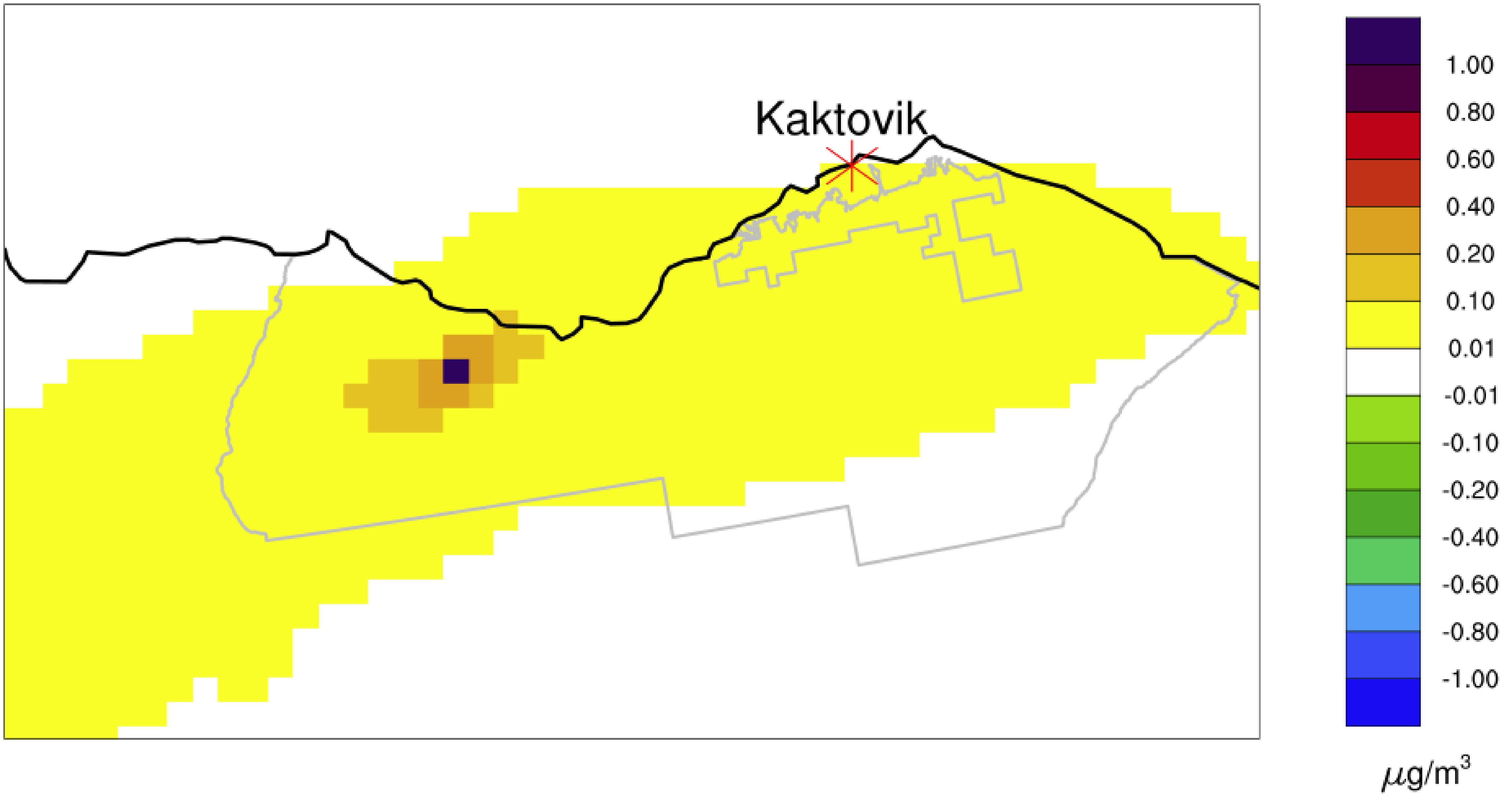


Annual average $PM_{2.5}$ concentration
No Action Alternative-Cumulative

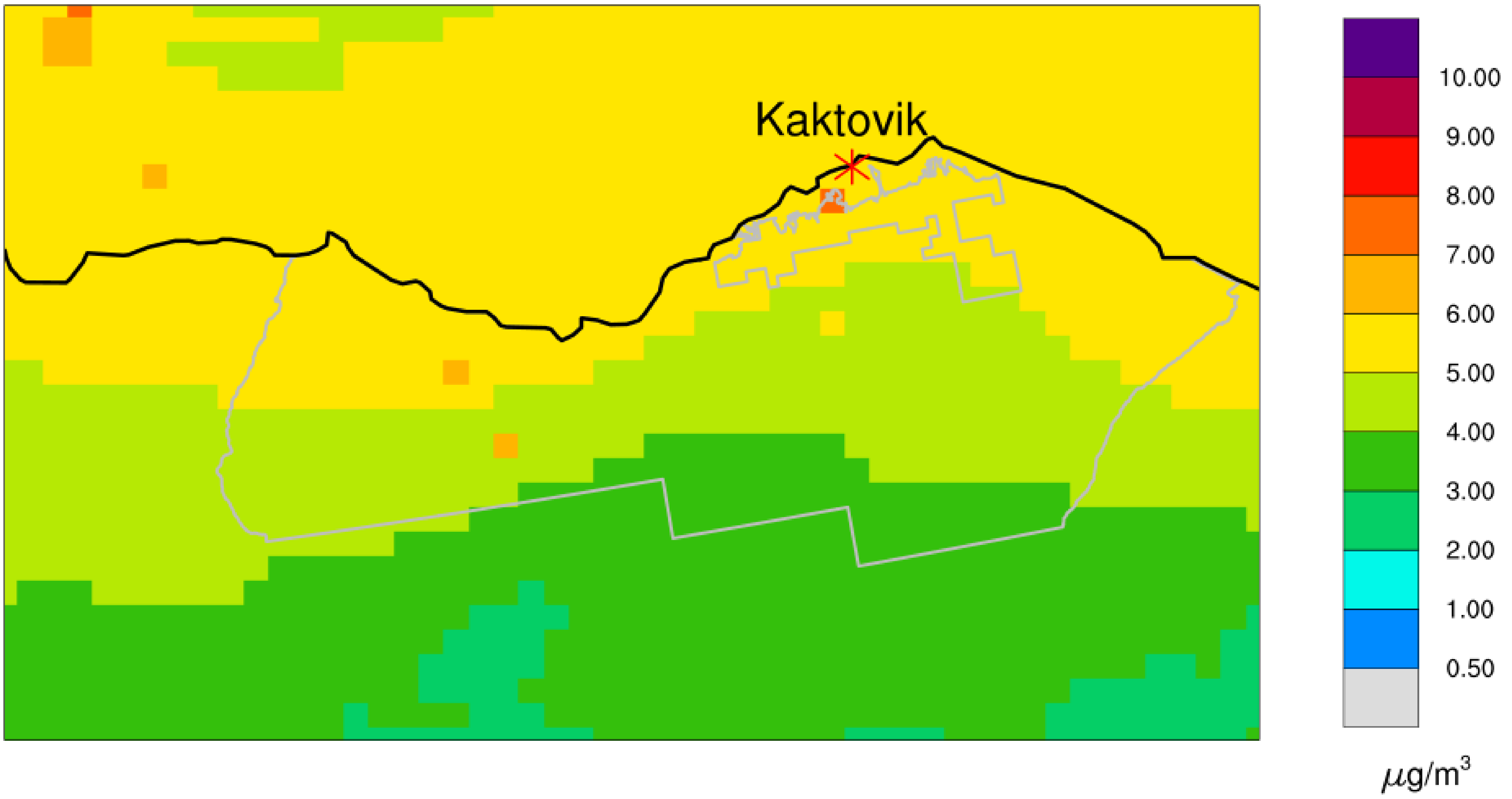



Annual average PM2.5 concentration
High Development Scenario-Indirect Impact
Kaktovik
1.00
0.80
0.60
0.40
0.20
0.10
0.01
-0.01
-0.10
-0.20
-0.40
-0.60
-0.80
-1.00
μg/m3

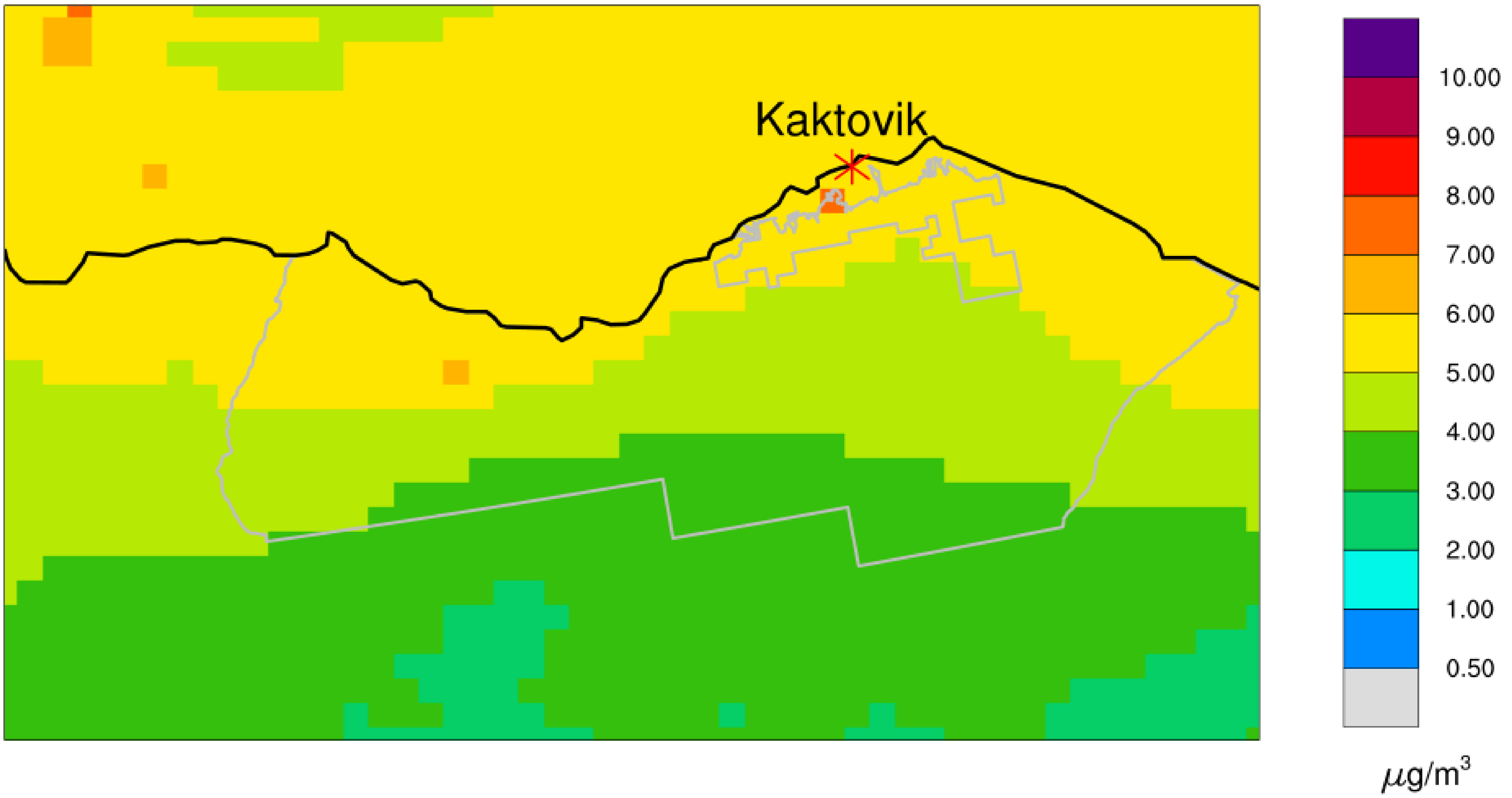
Annual average $PM_{2.5}$ concentration
Low Development Scenario-Indirect Impact

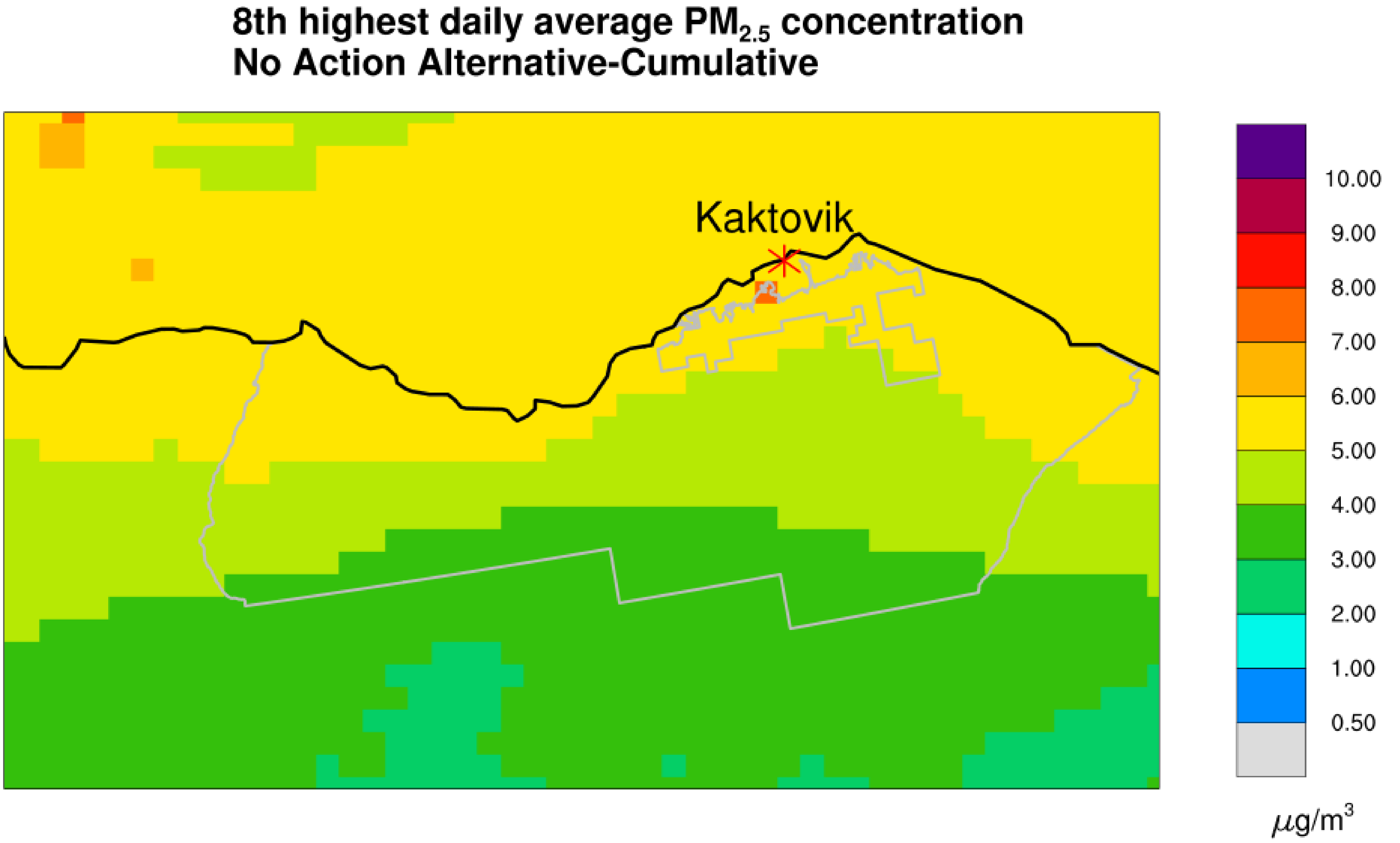


8th highest daily average $PM_{2.5}$ concentration
High Development Scenario-Cumulative

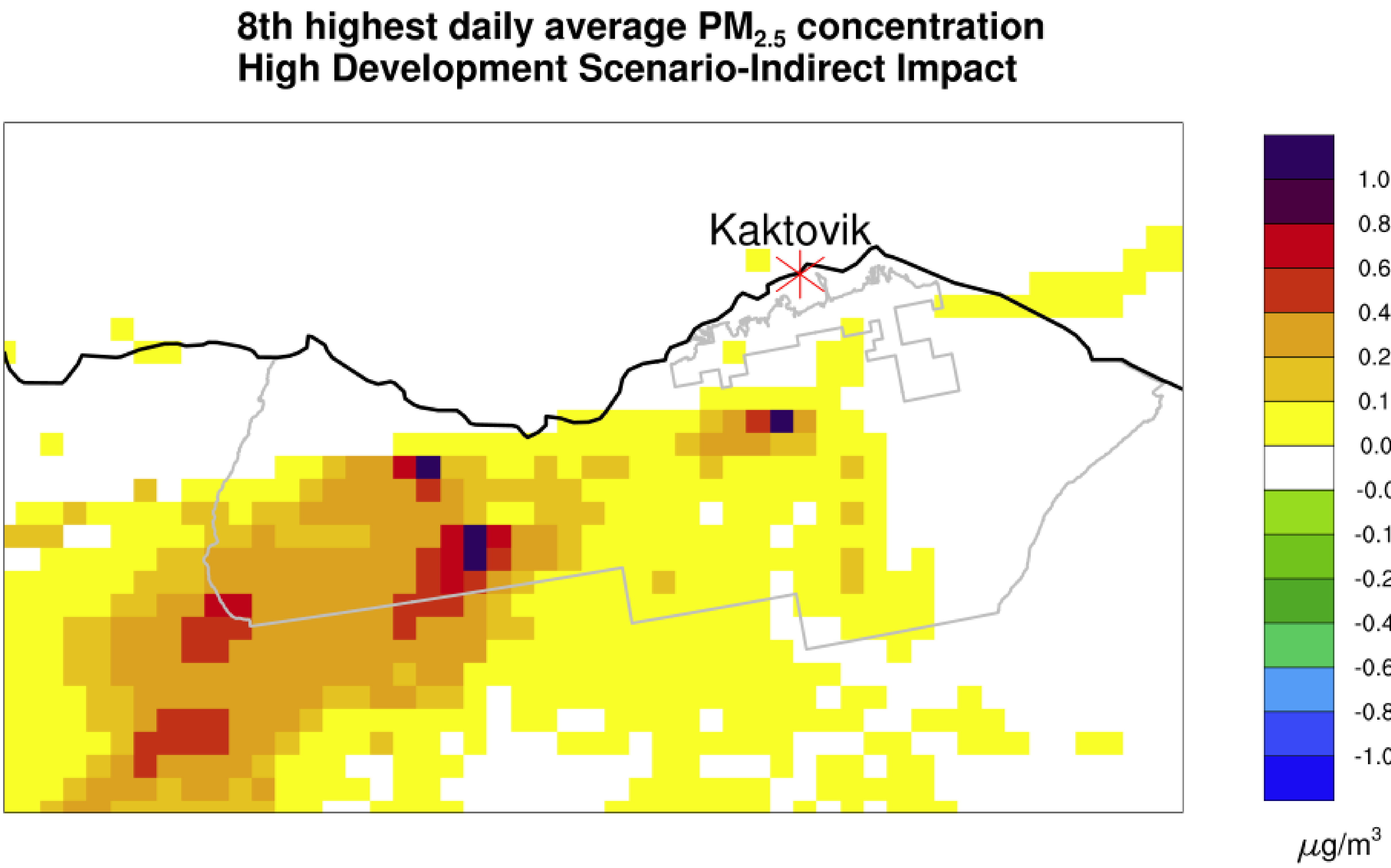


8th highest daily average $PM_{2.5}$ concentration
Low Development Scenario-Cumulative

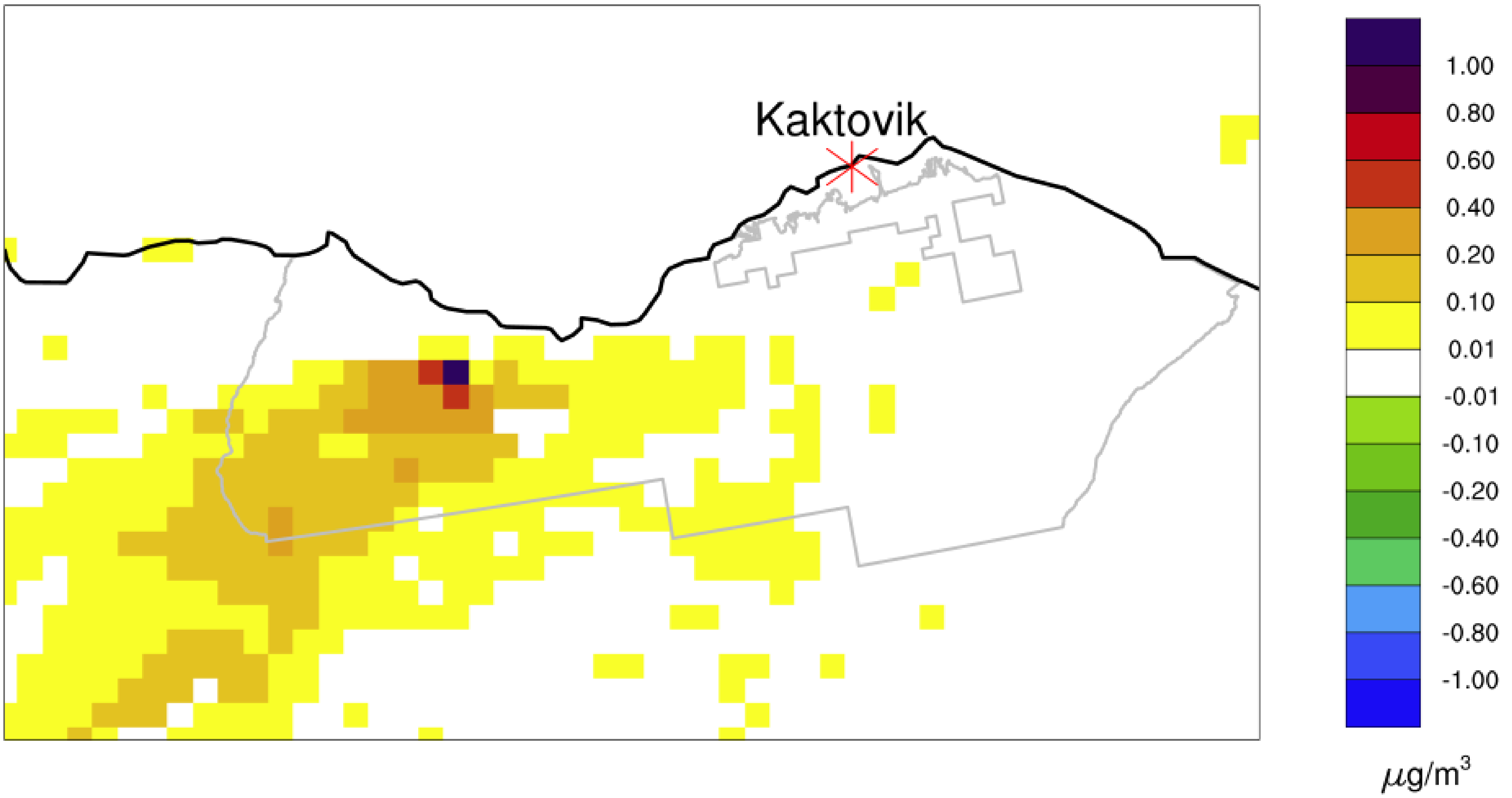




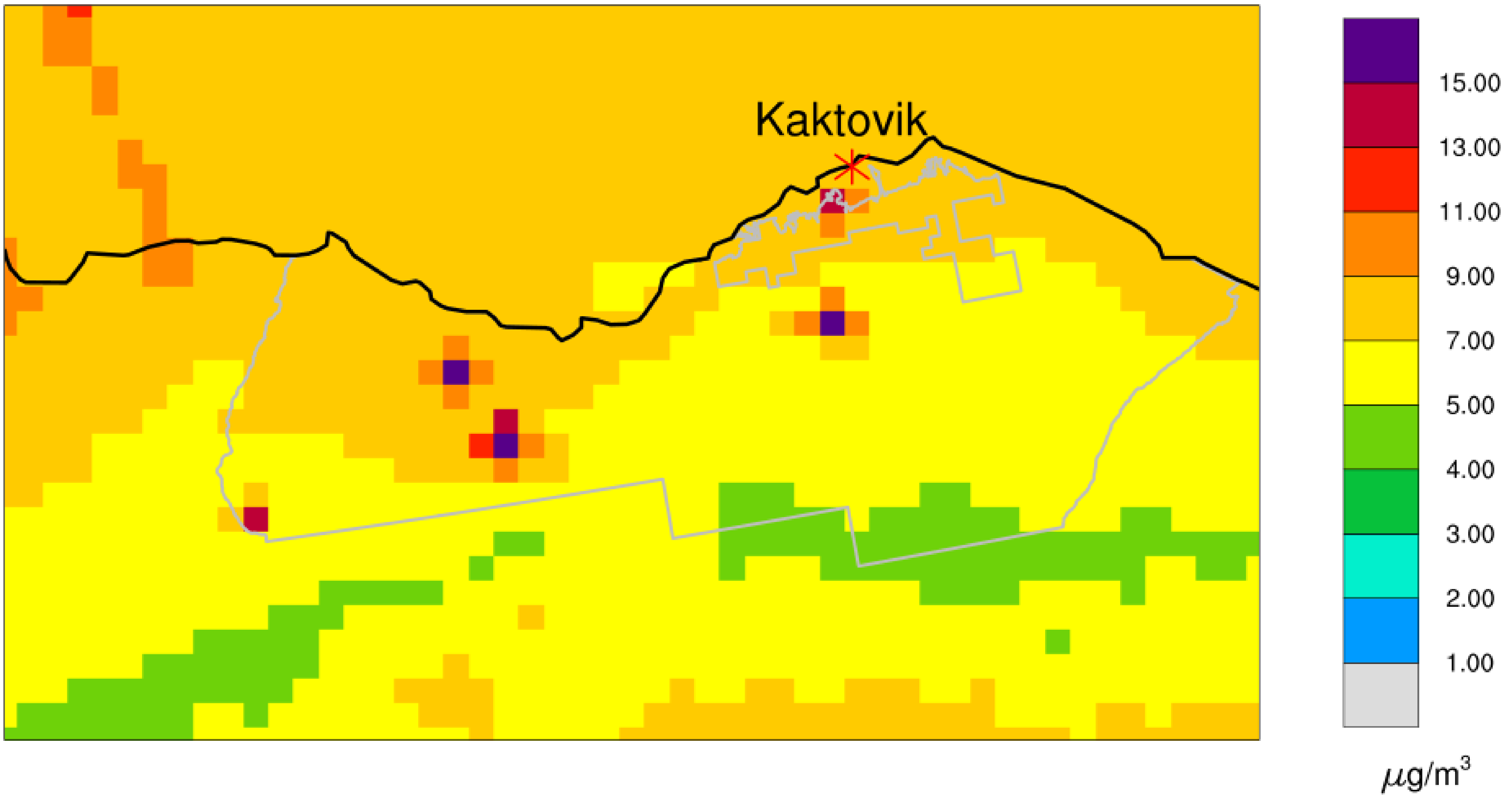
8th highest daily average $PM_{2.5}$ concentration
No Action Alternative-Cumulative
Kaktovik
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.50
$\mu g/m^3$


8th highest daily average $PM_{2.5}$ concentration
High Development Scenario-Indirect Impact
Kaktovik
1.00
0.80
0.60
0.40
0.20
0.10
0.01
-0.01
-0.10
-0.20
-0.40
-0.60
-0.80
-1.00
$\mu g/m^3$

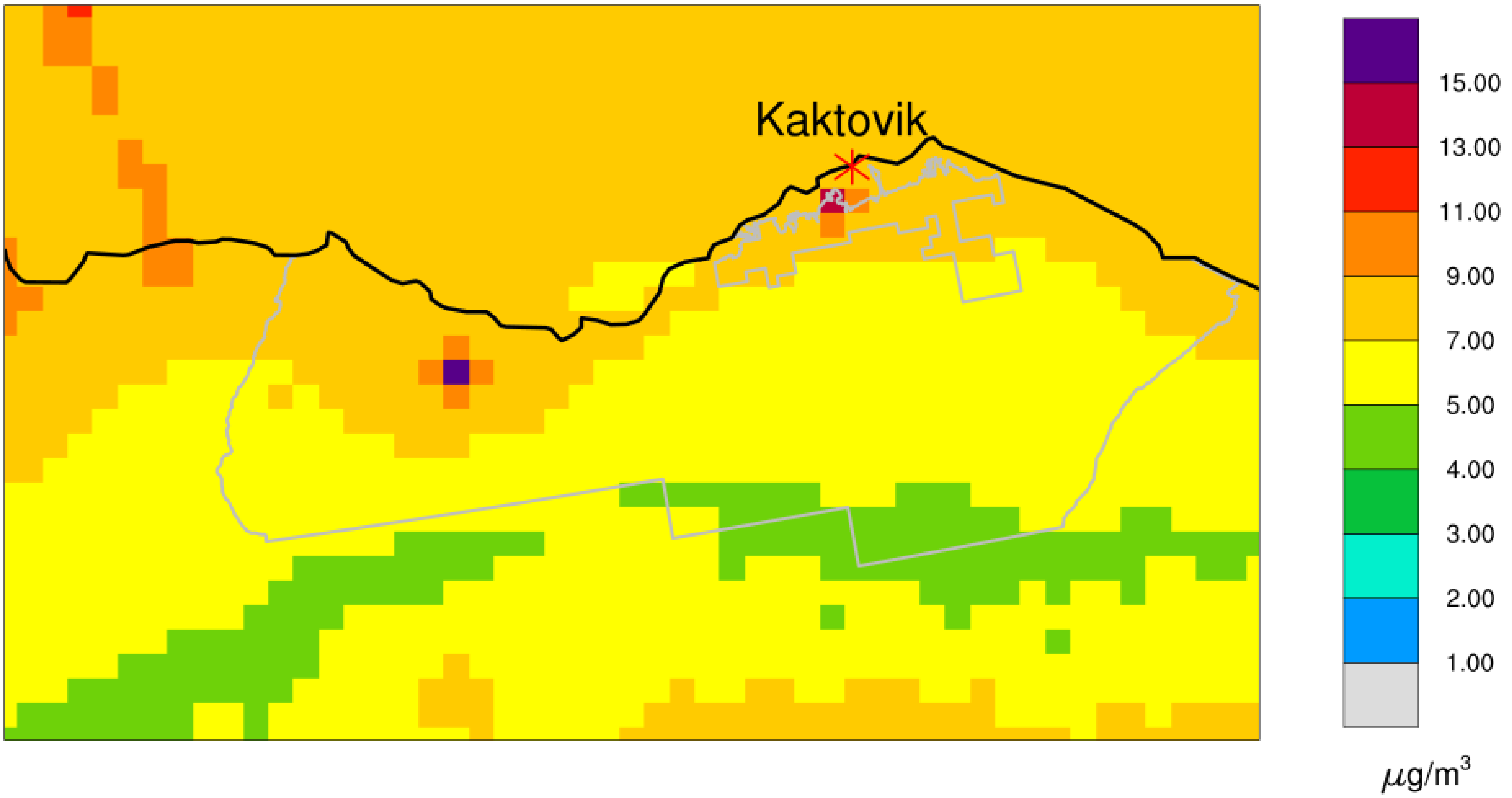
8th highest daily average $PM_{2.5}$ concentration
Low Development Scenario-Indirect Impact



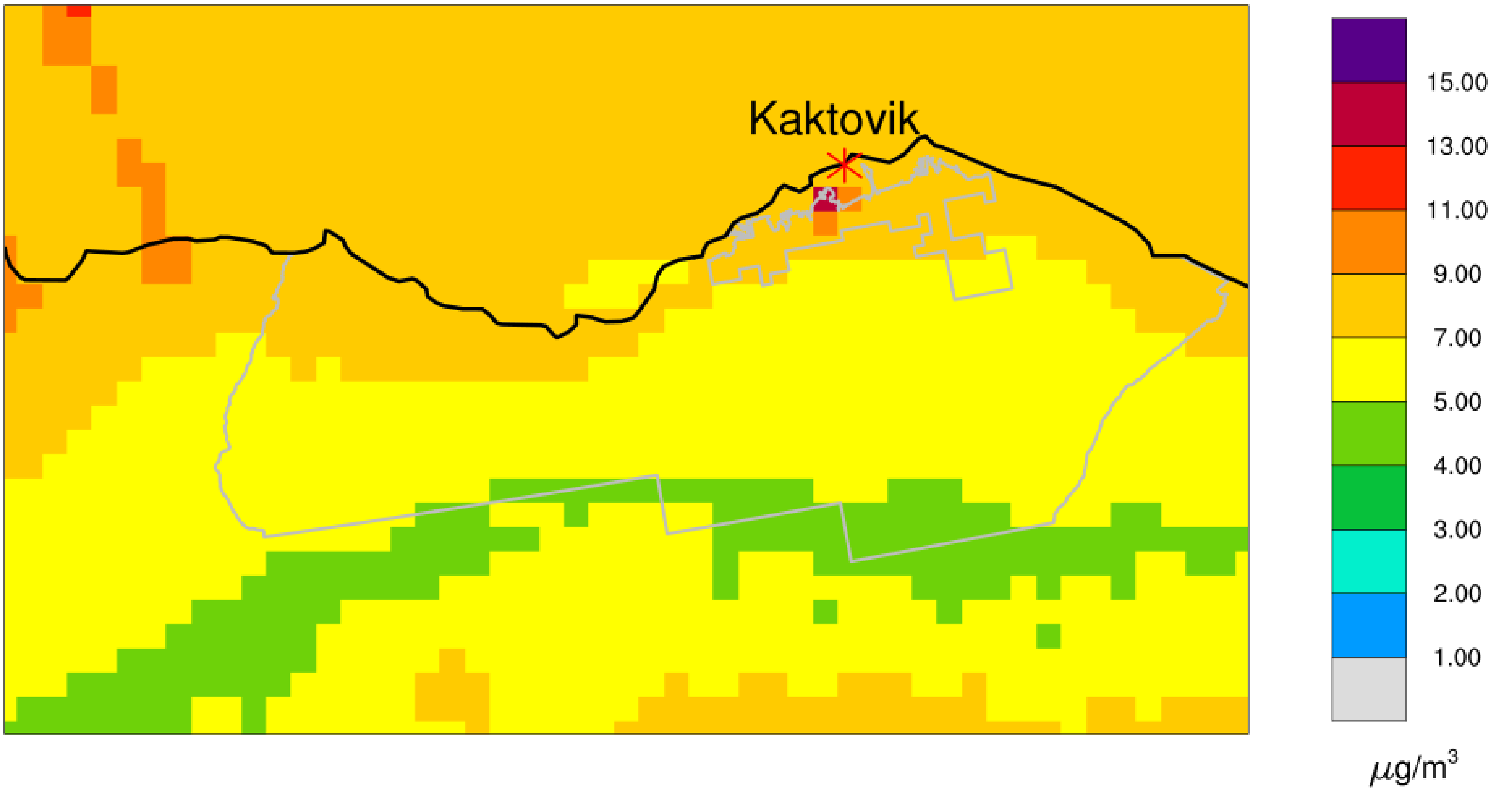
2nd highest daily average PM_{10} concentration
High Development Scenario-Cumulative



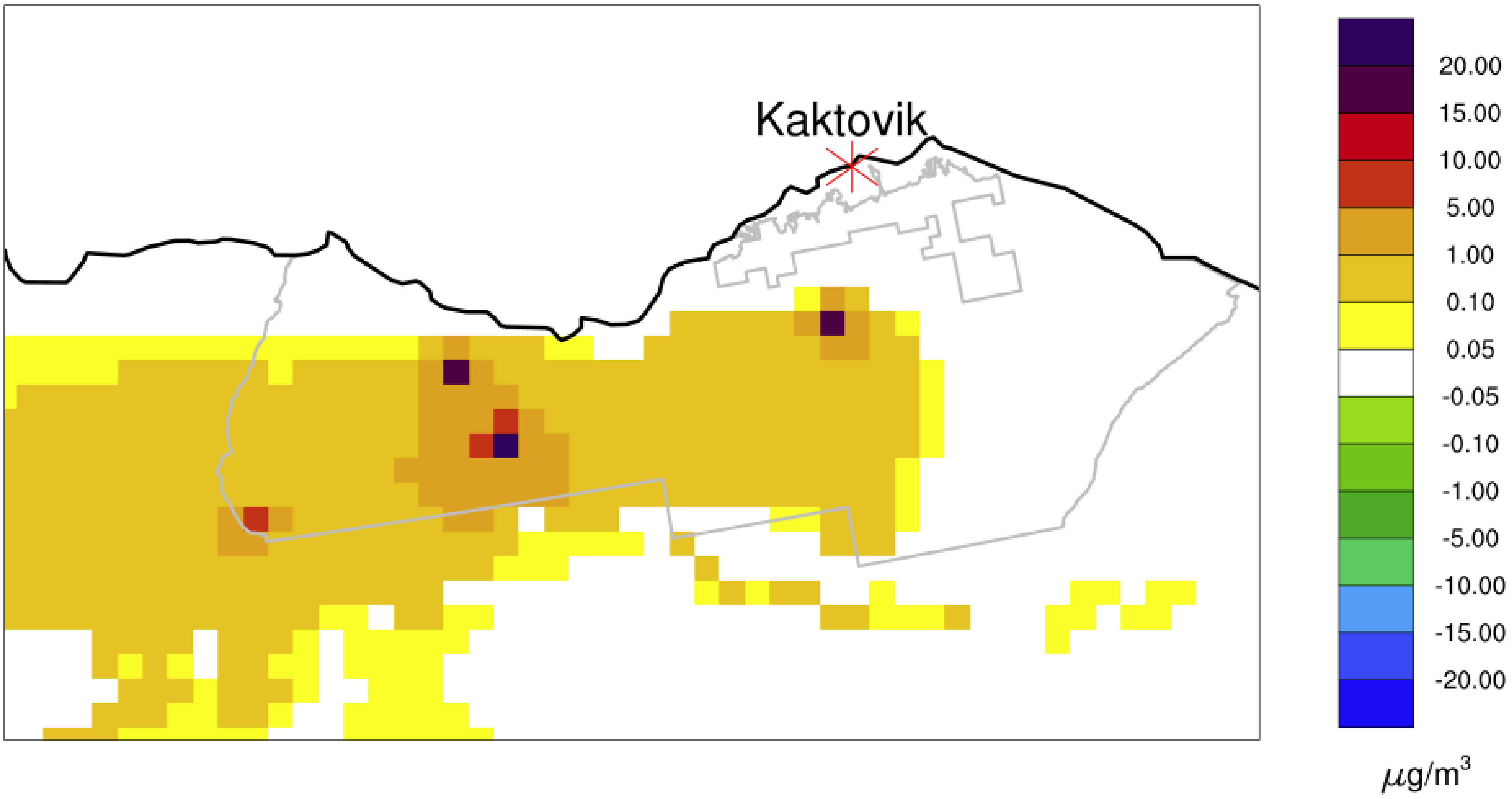
2nd highest daily average PM_{10} concentration
Low Development Scenario-Cumulative



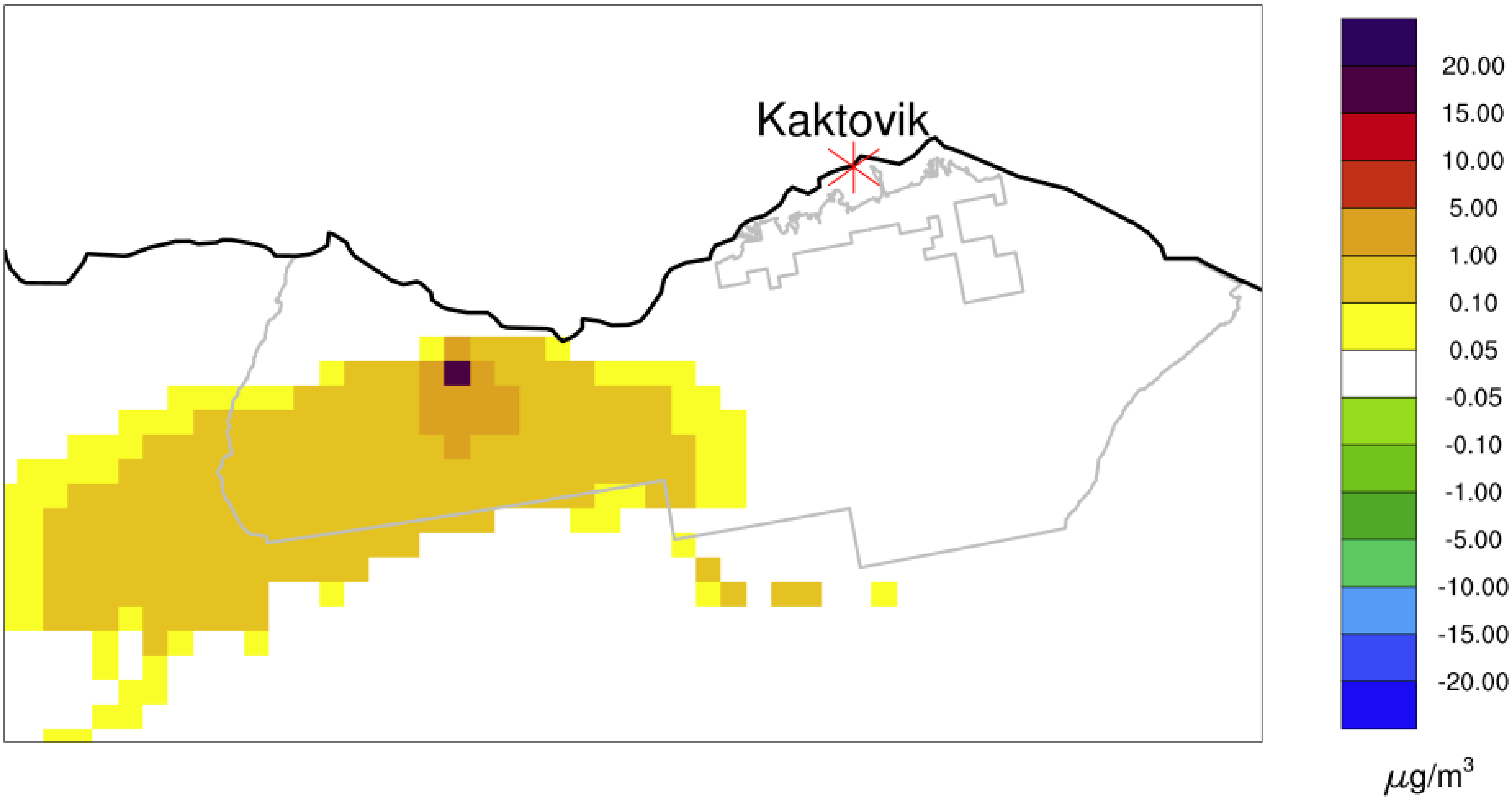
2nd highest daily average PM_{10} concentration
No Action Alternative-Cumulative



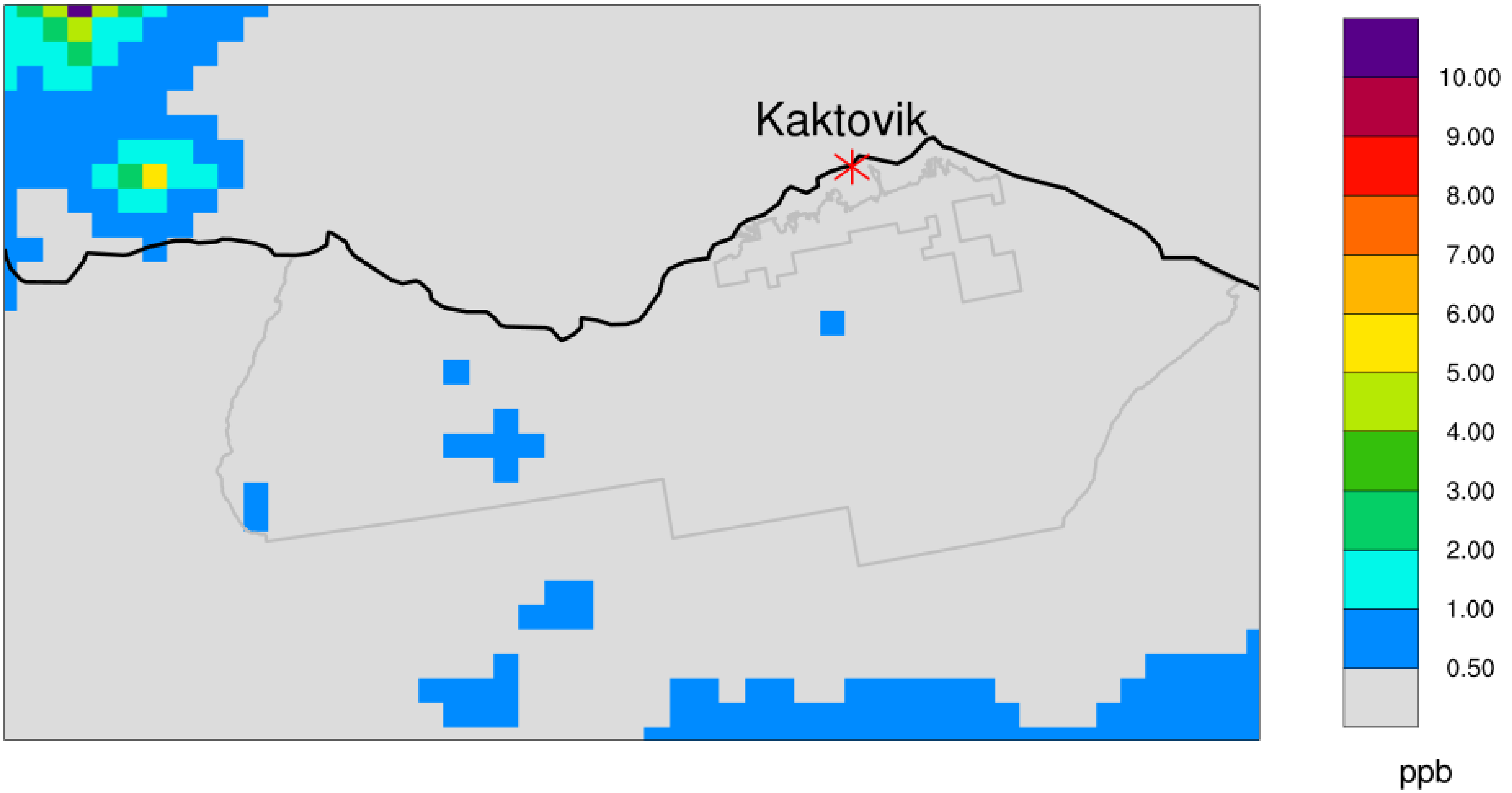
2nd highest daily average PM_{10} concentration
High Development Scenario-Indirect Impact



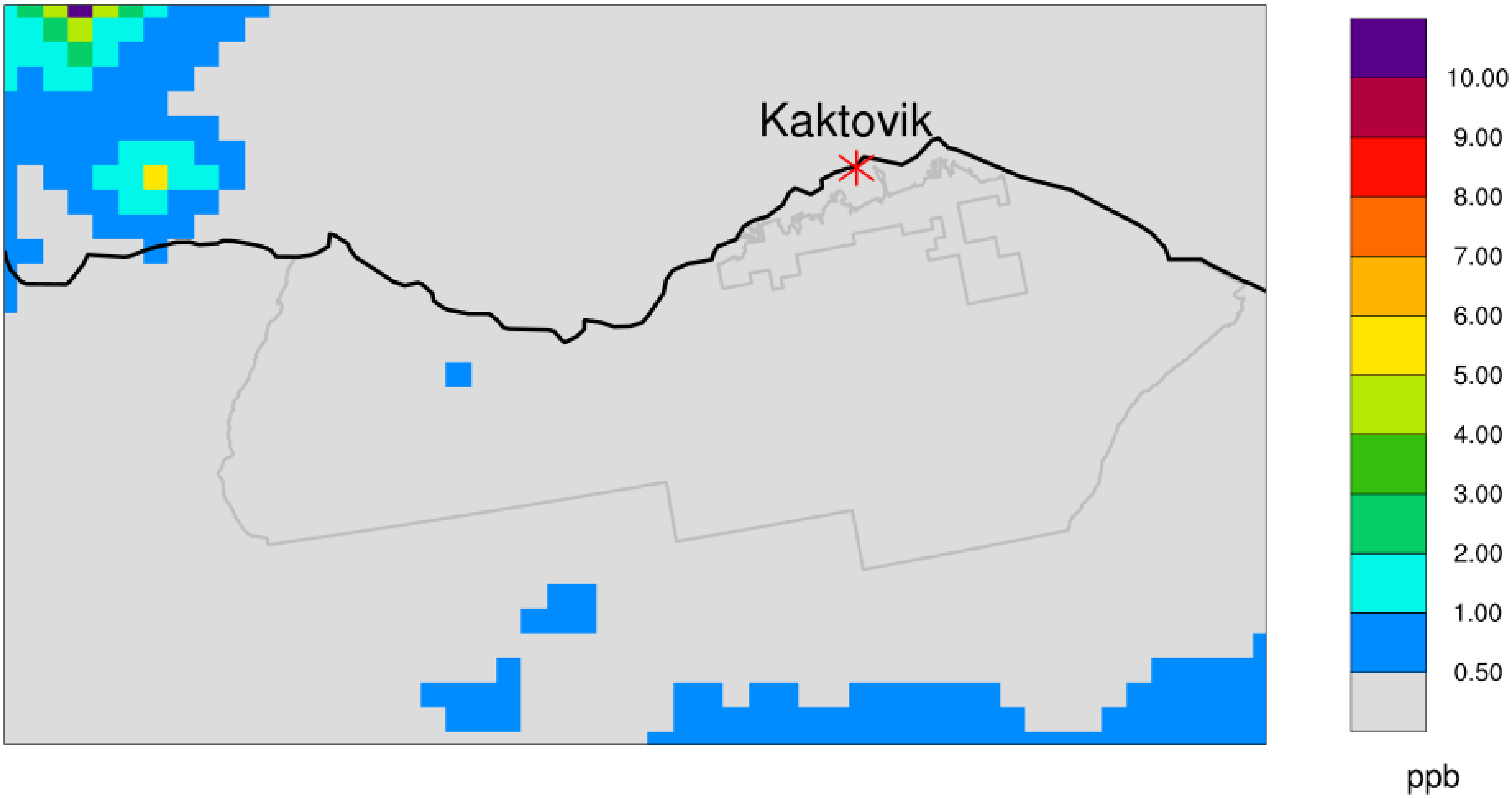
2nd highest daily average PM_{10} concentration
Low Development Scenario-Indirect Impact



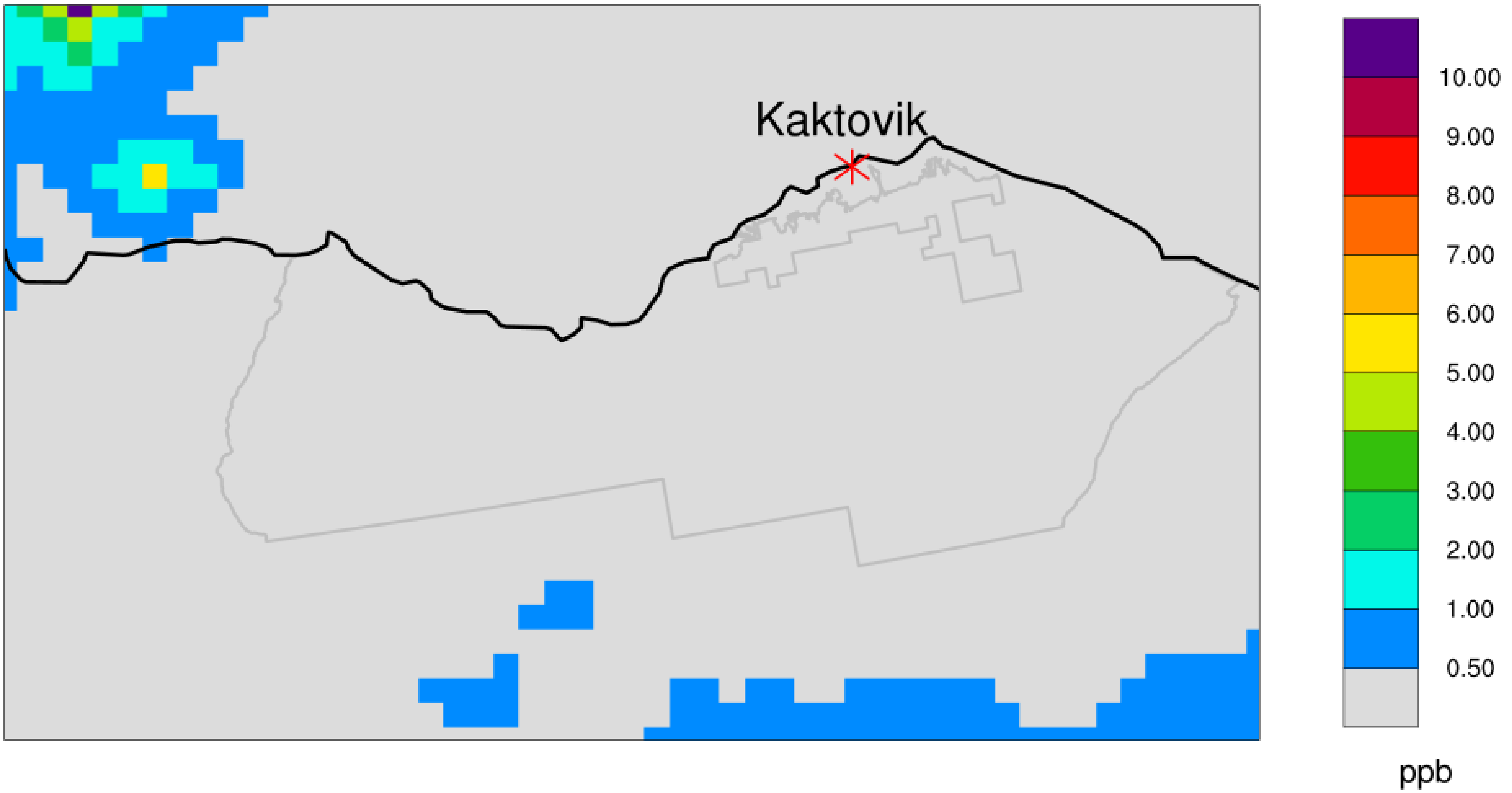
The 4th highest 1 hour daily max SO_2 concentration
High Development Scenario-Cumulative



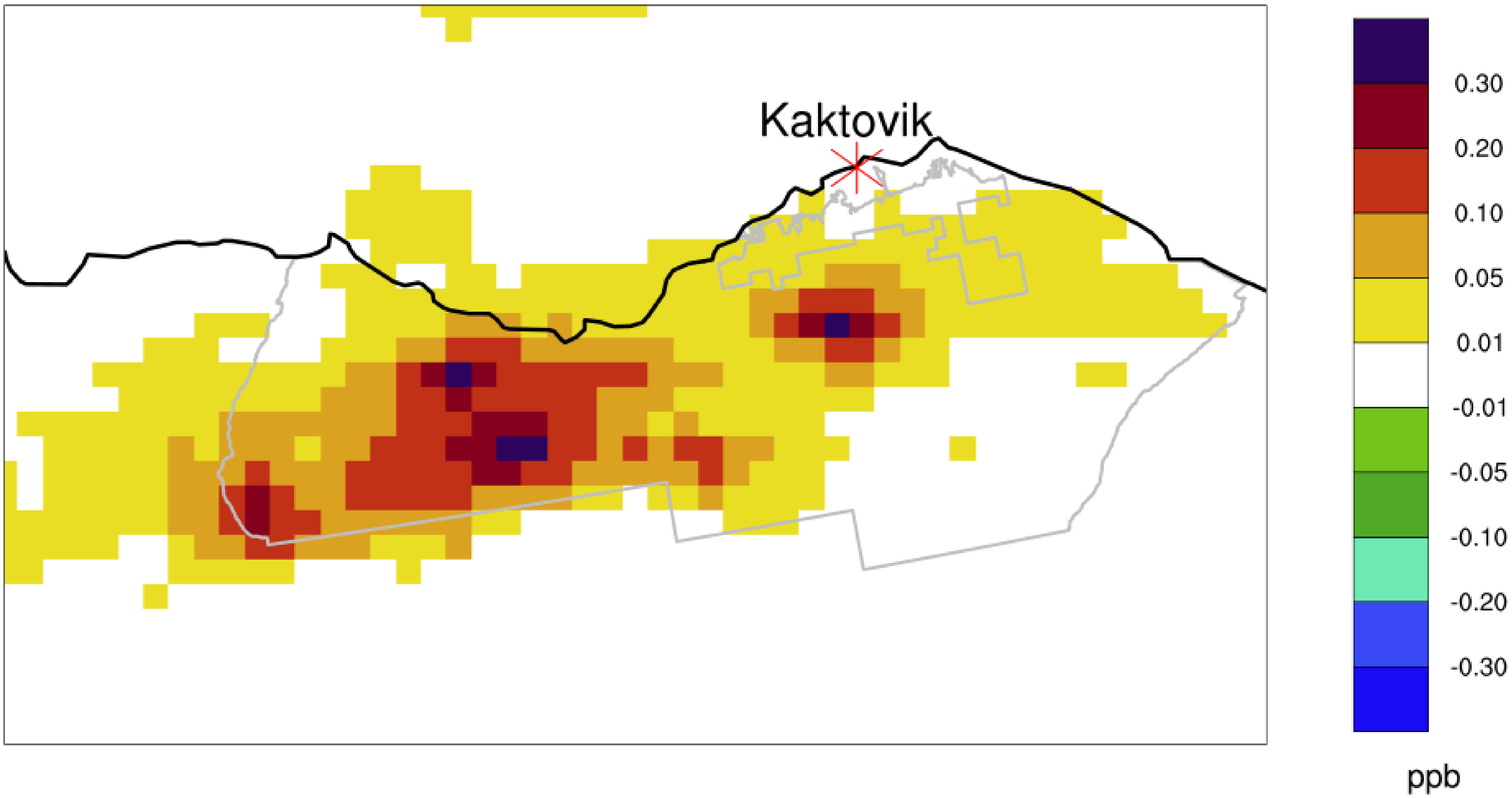
The 4th highest 1 hour daily max SO_2 concentration
Low Development Scenario-Cumulative

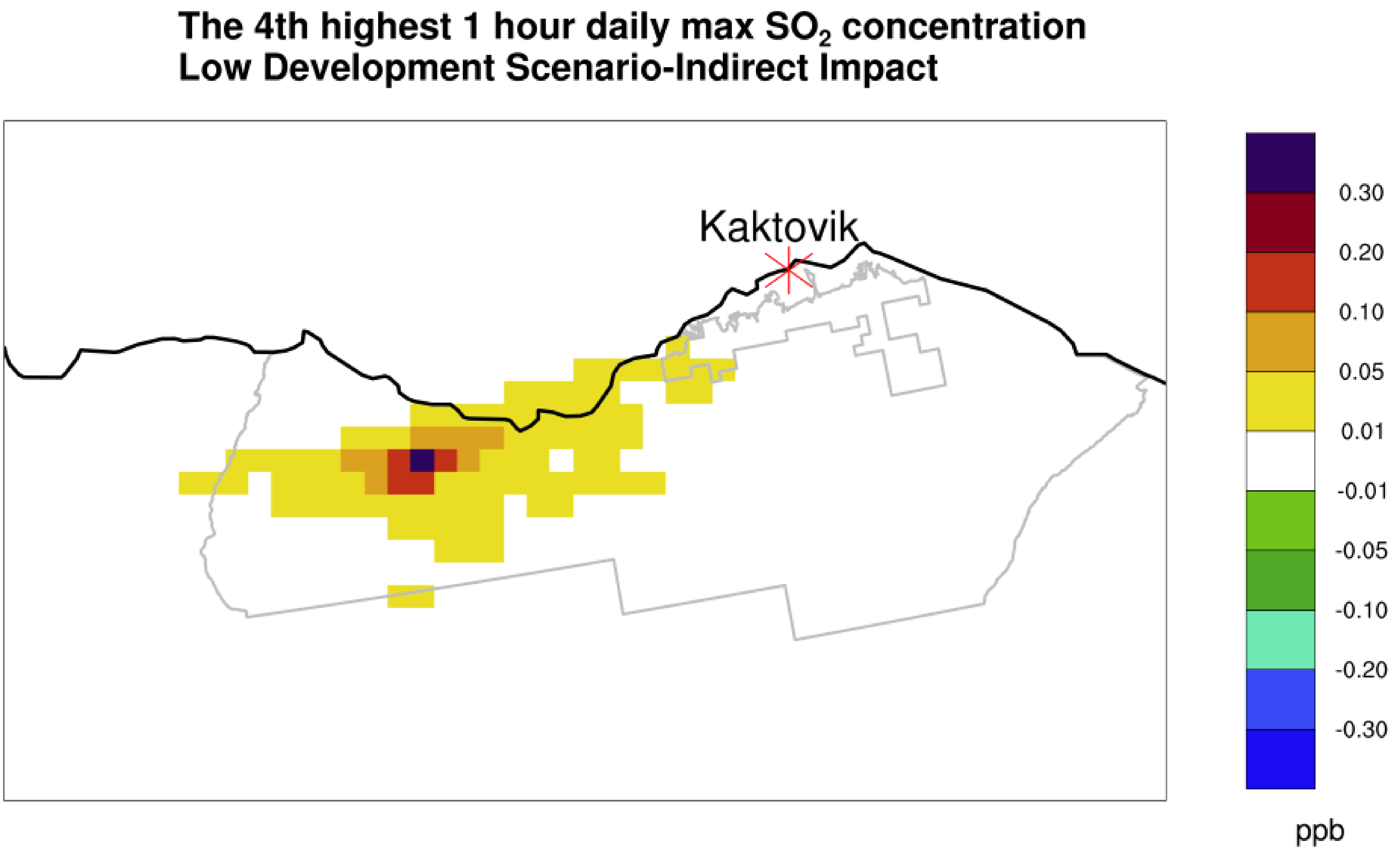


The 4th highest 1 hour daily max SO_2 concentration
No Action Alternative-Cumulative

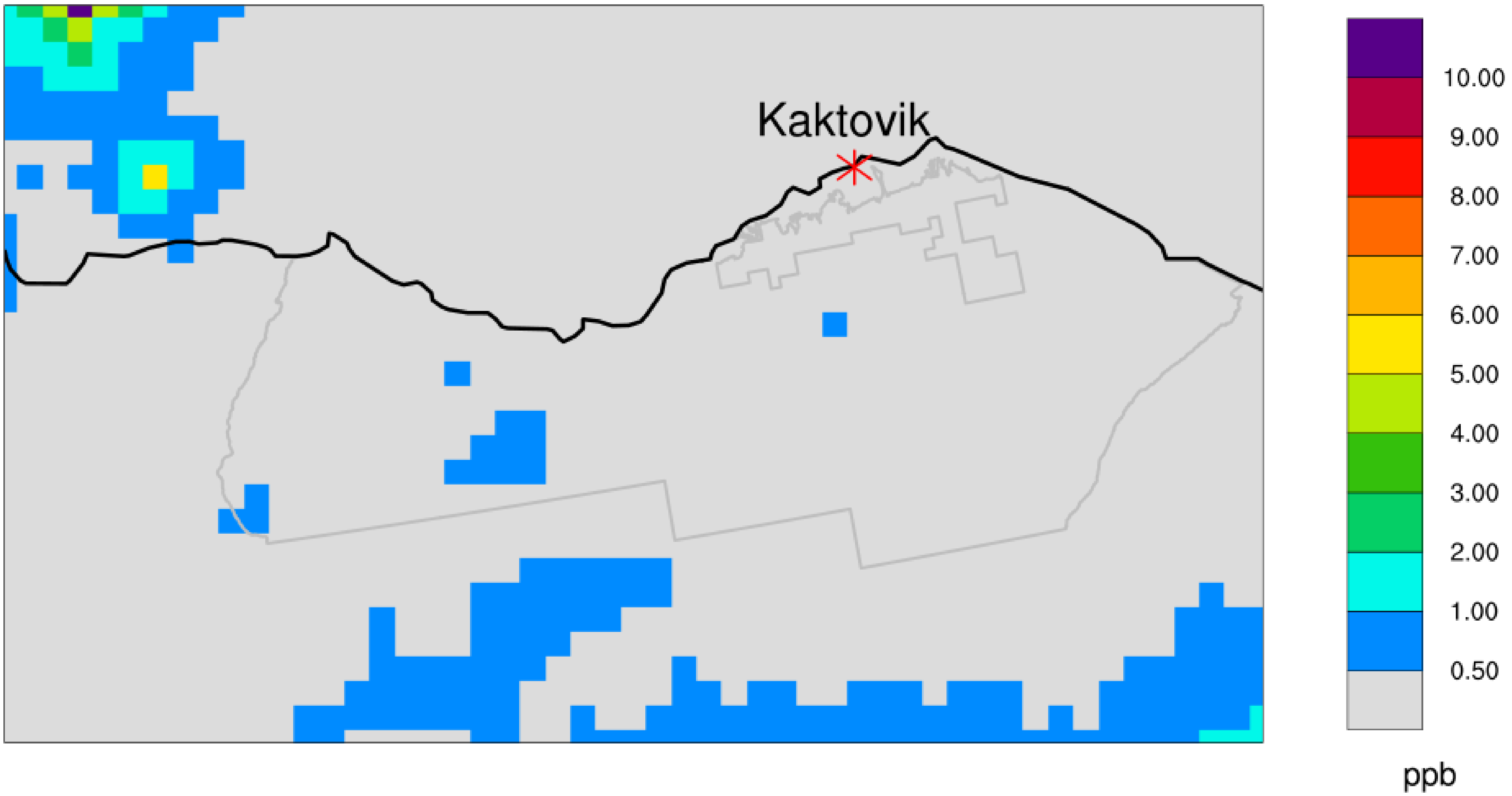


The 4th highest 1 hour daily max SO_2 concentration
High Development Scenario-Indirect Impact

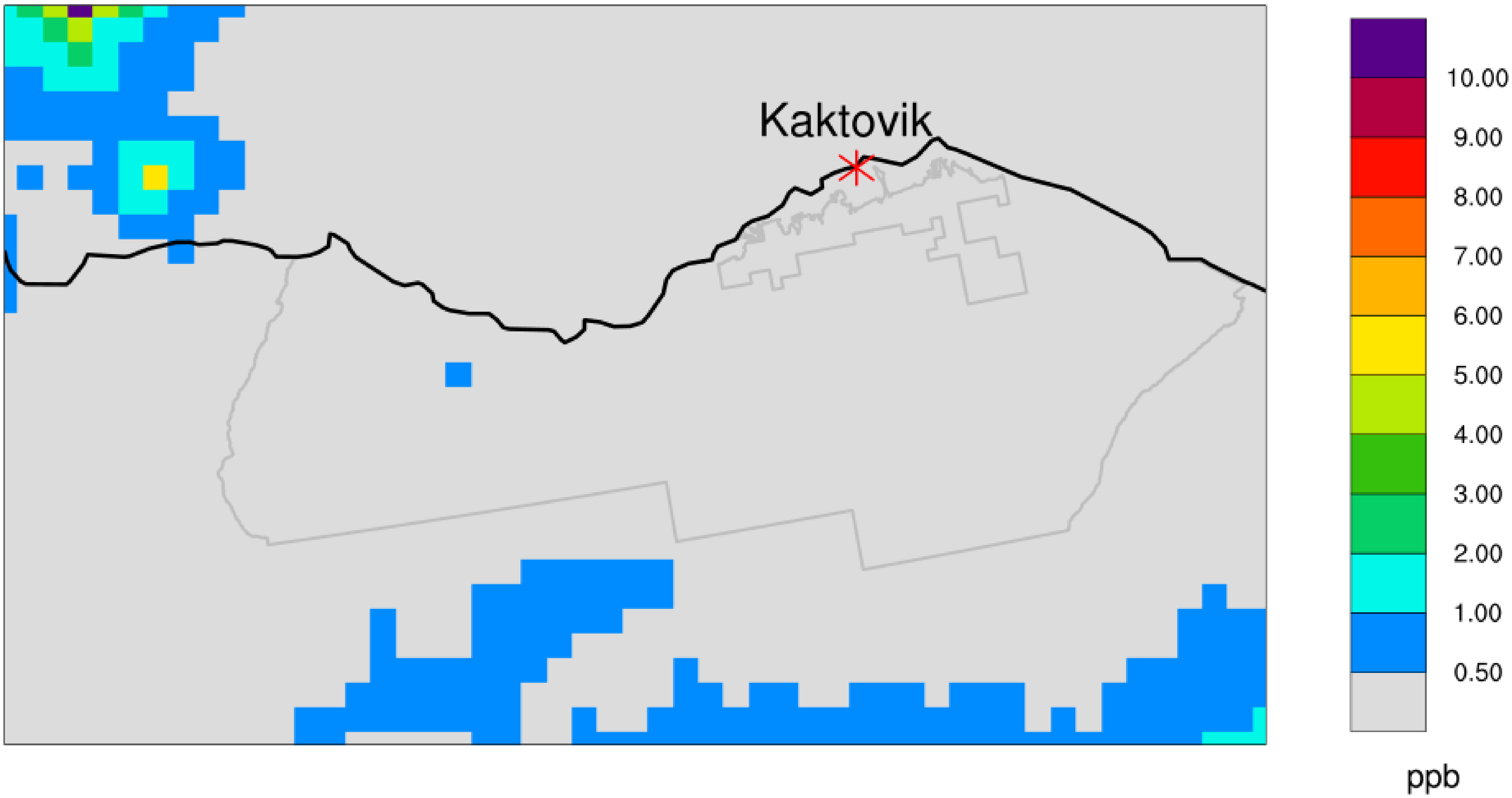



The 4th highest 1 hour daily max SO_2 concentration
Low Development Scenario-Indirect Impact
Kaktovik
0.30
0.20
0.10
0.05
0.01
-0.01
-0.05
-0.10
-0.20
-0.30
ppb

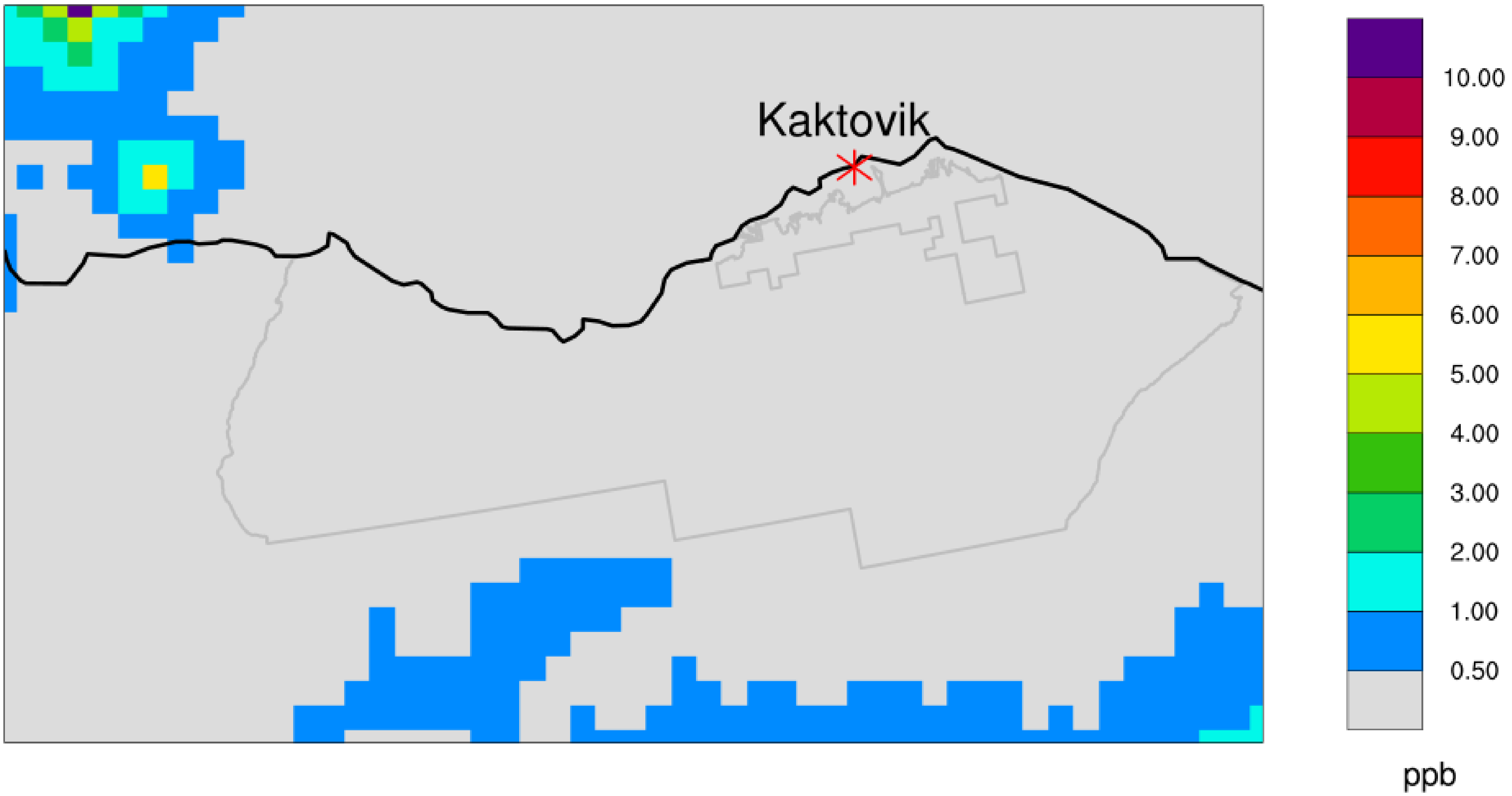
The 2nd highest 3hr average SO_2 concentration
High Development Scenario-Cumulative



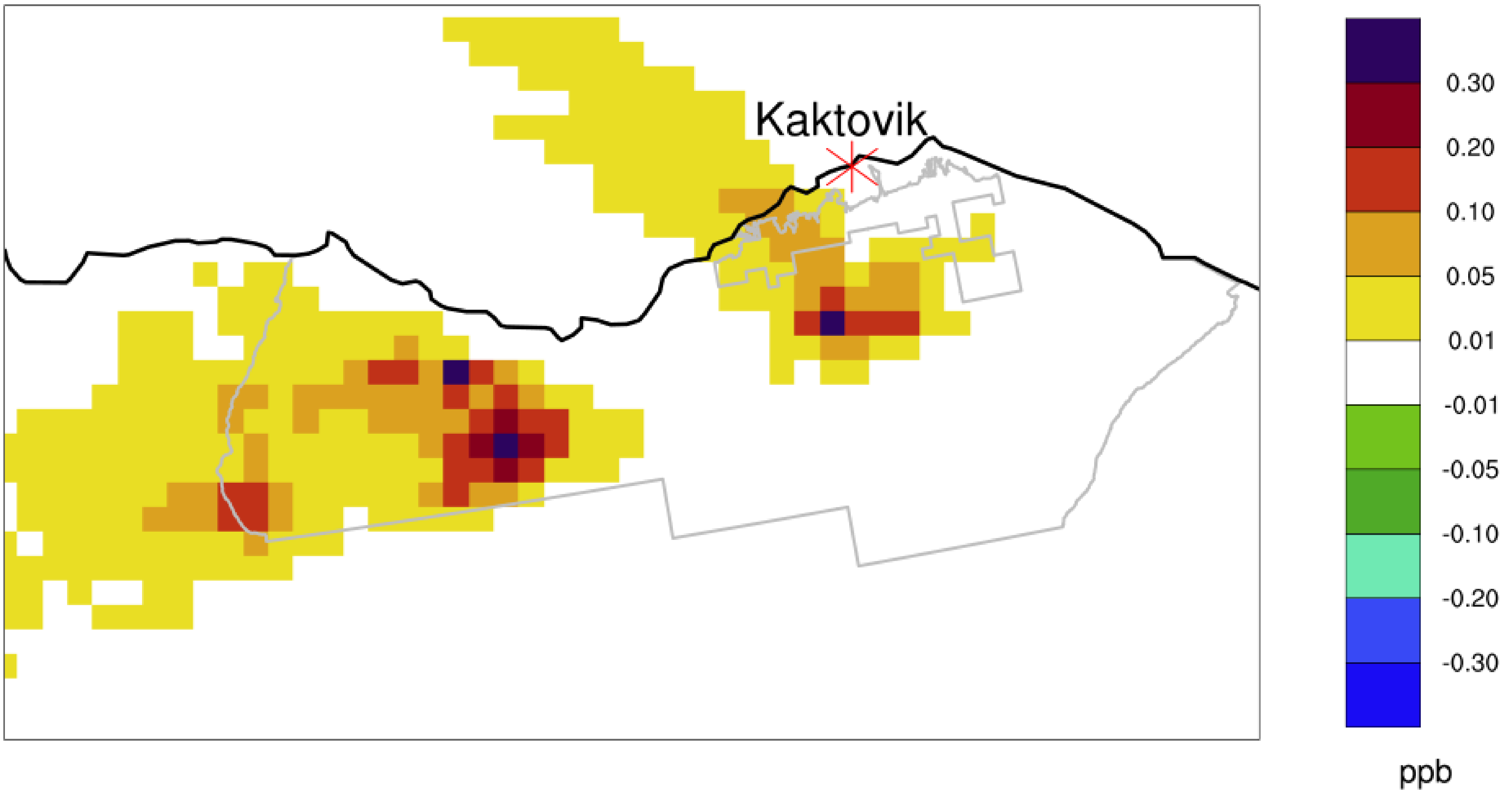
The 2nd highest 3hr average SO_2 concentration
Low Development Scenario-Cumulative



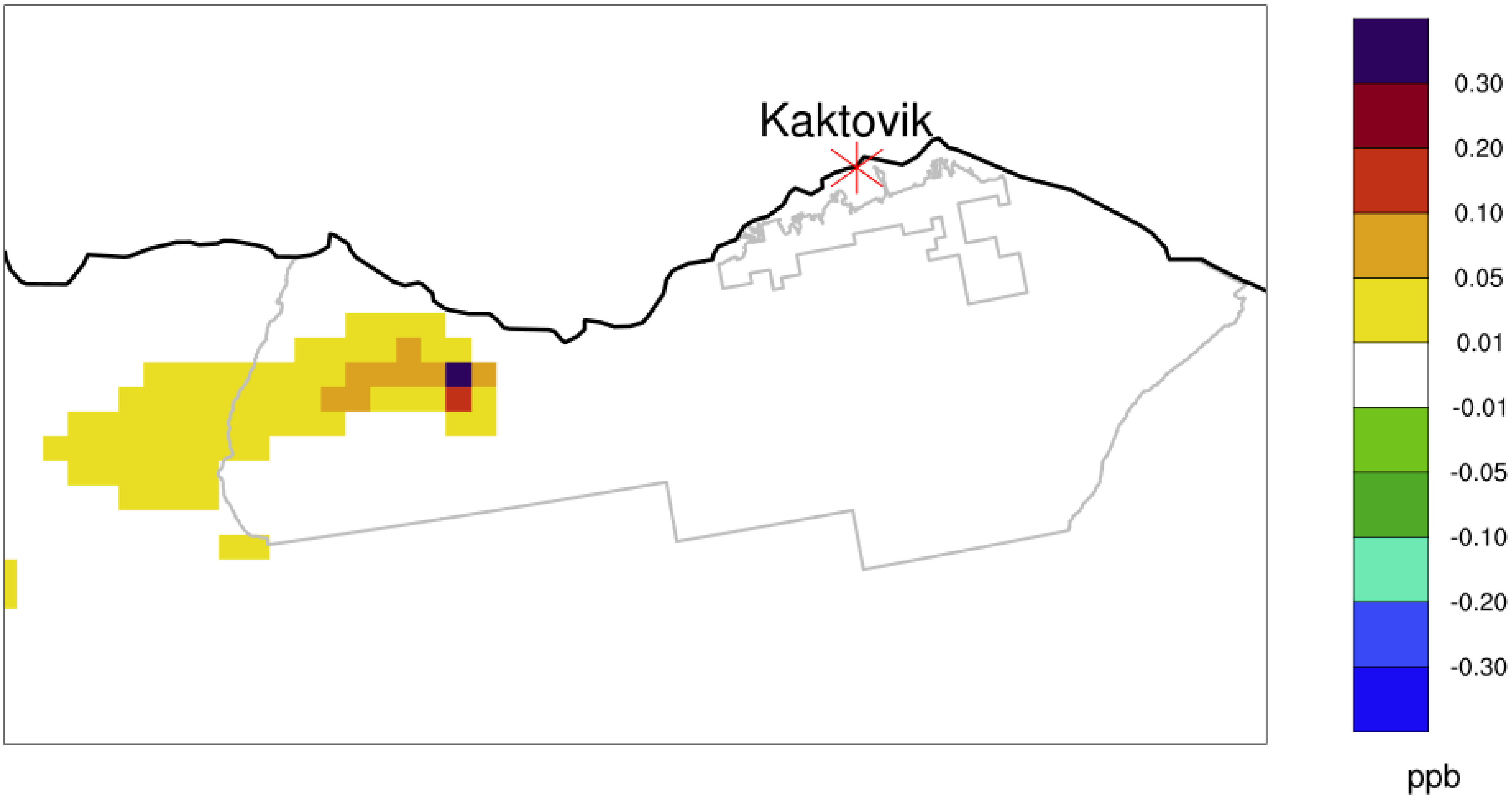
The 2nd highest 3hr average SO_2 concentration
No Action Alternative-Cumulative



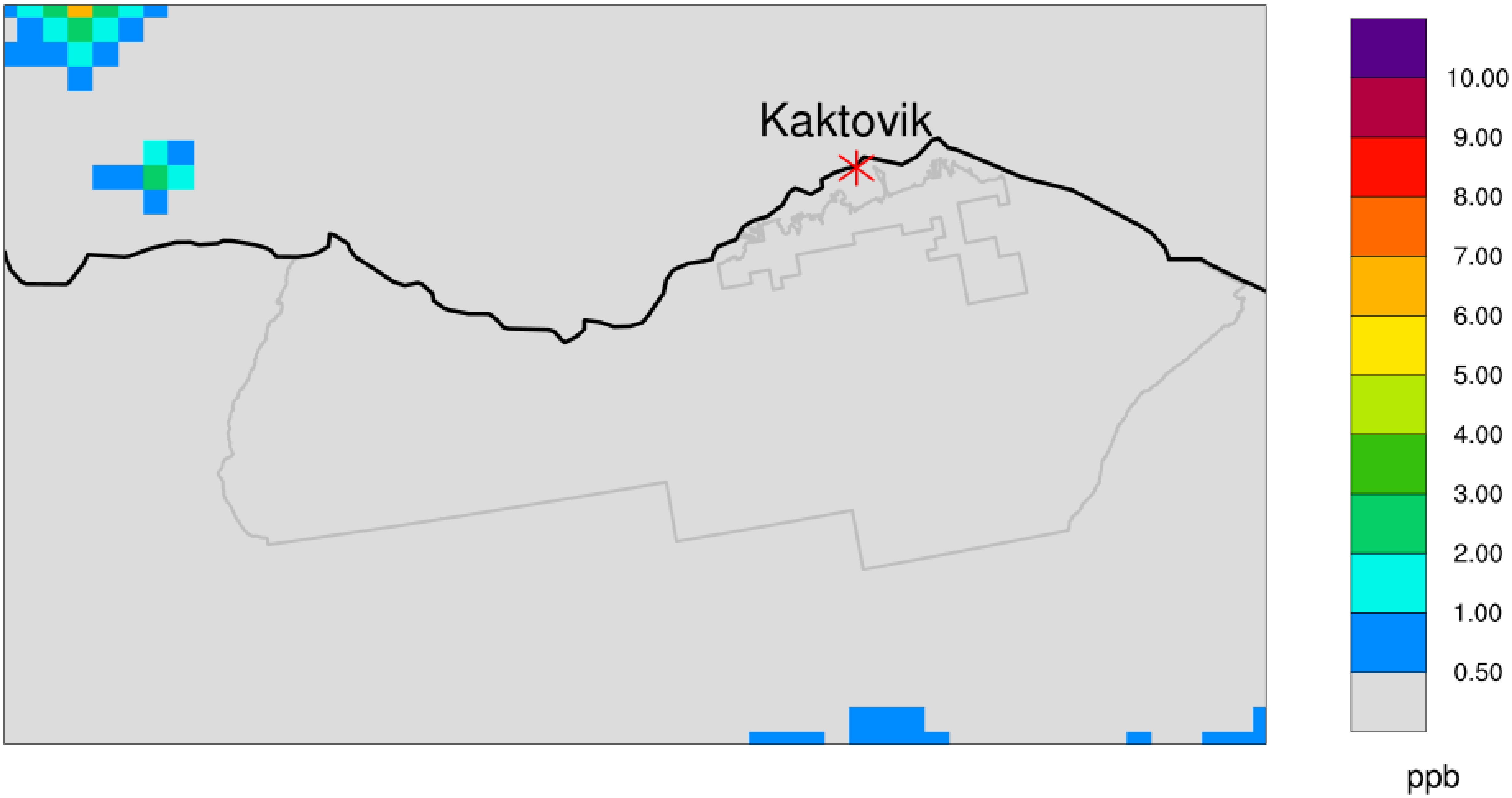
The 2nd highest 3hr average SO_2 concentration
High Development Scenario-Indirect Impact



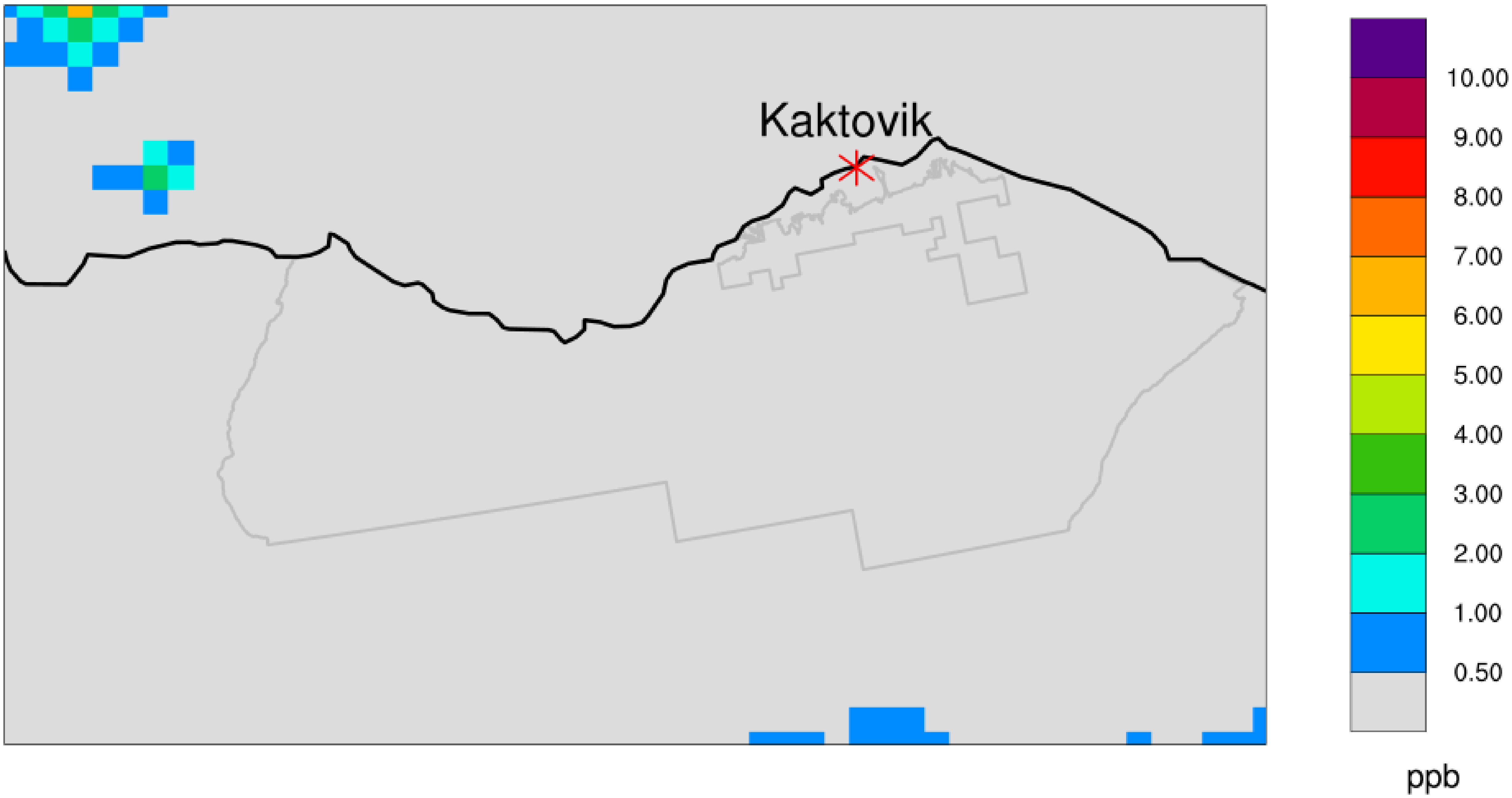
The 2nd highest 3hr average SO_2 concentration
Low Development Scenario-Indirect Impact



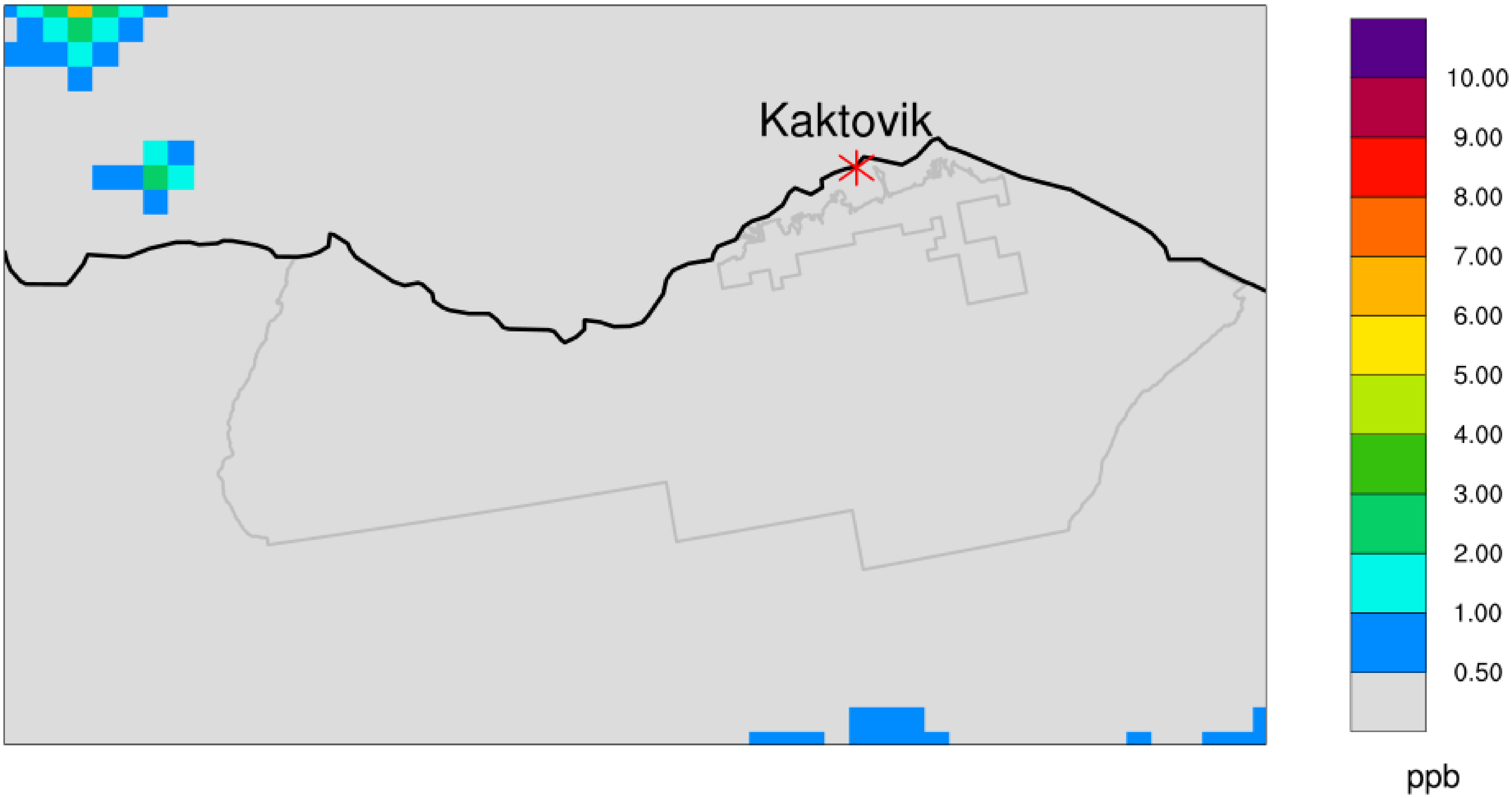
The 2nd highest daily average SO_2 concentration
High Development Scenario-Cumulative



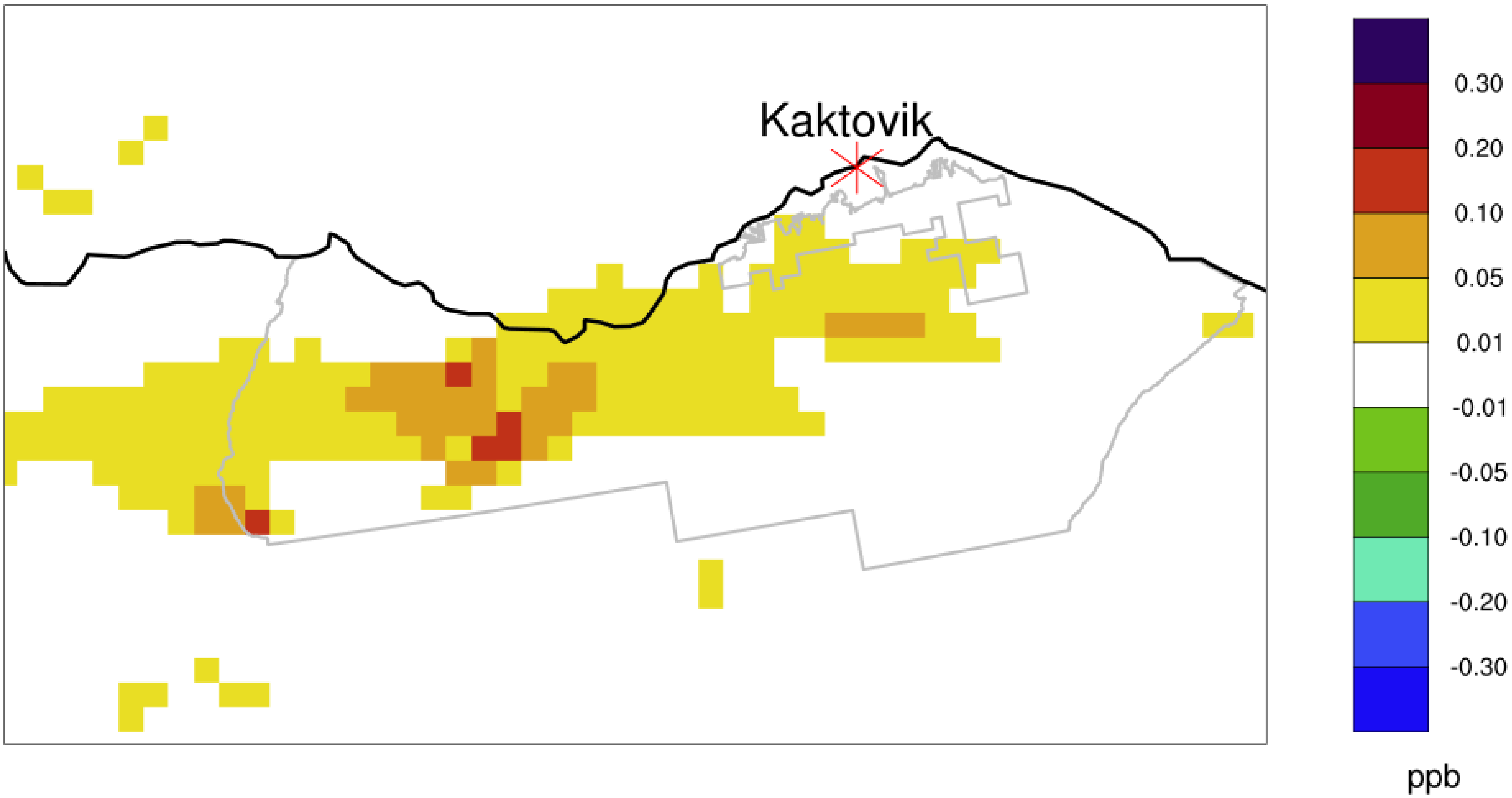
The 2nd highest daily average SO_2 concentration
Low Development Scenario-Cumulative



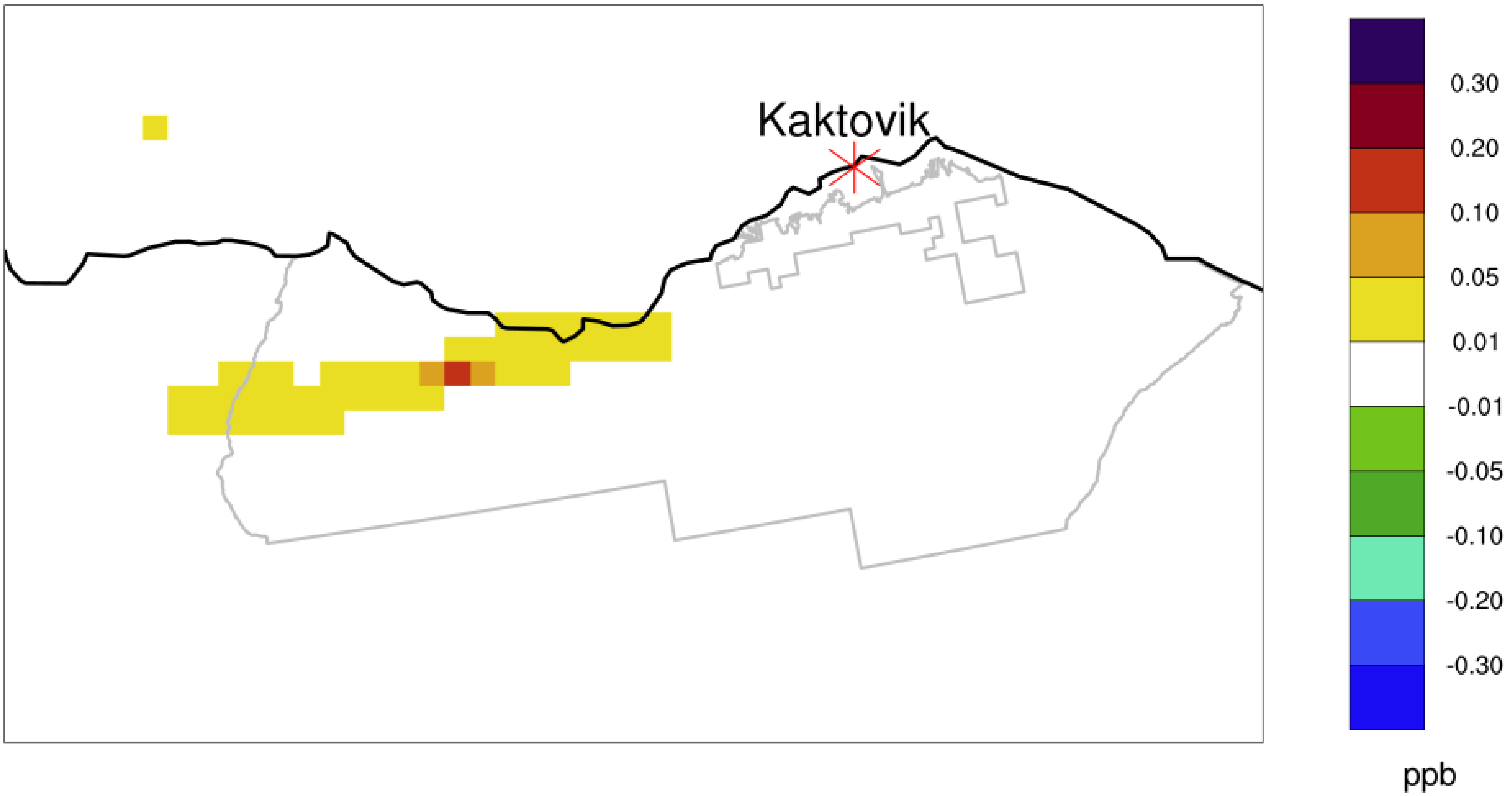
The 2nd highest daily average SO_2 concentration
No Action Alternative-Cumulative



The 2nd highest daily average SO_2 concentration
High Development Scenario-Indirect Impact



The 2nd highest daily average SO_2 concentration
Low Development Scenario-Indirect Impact

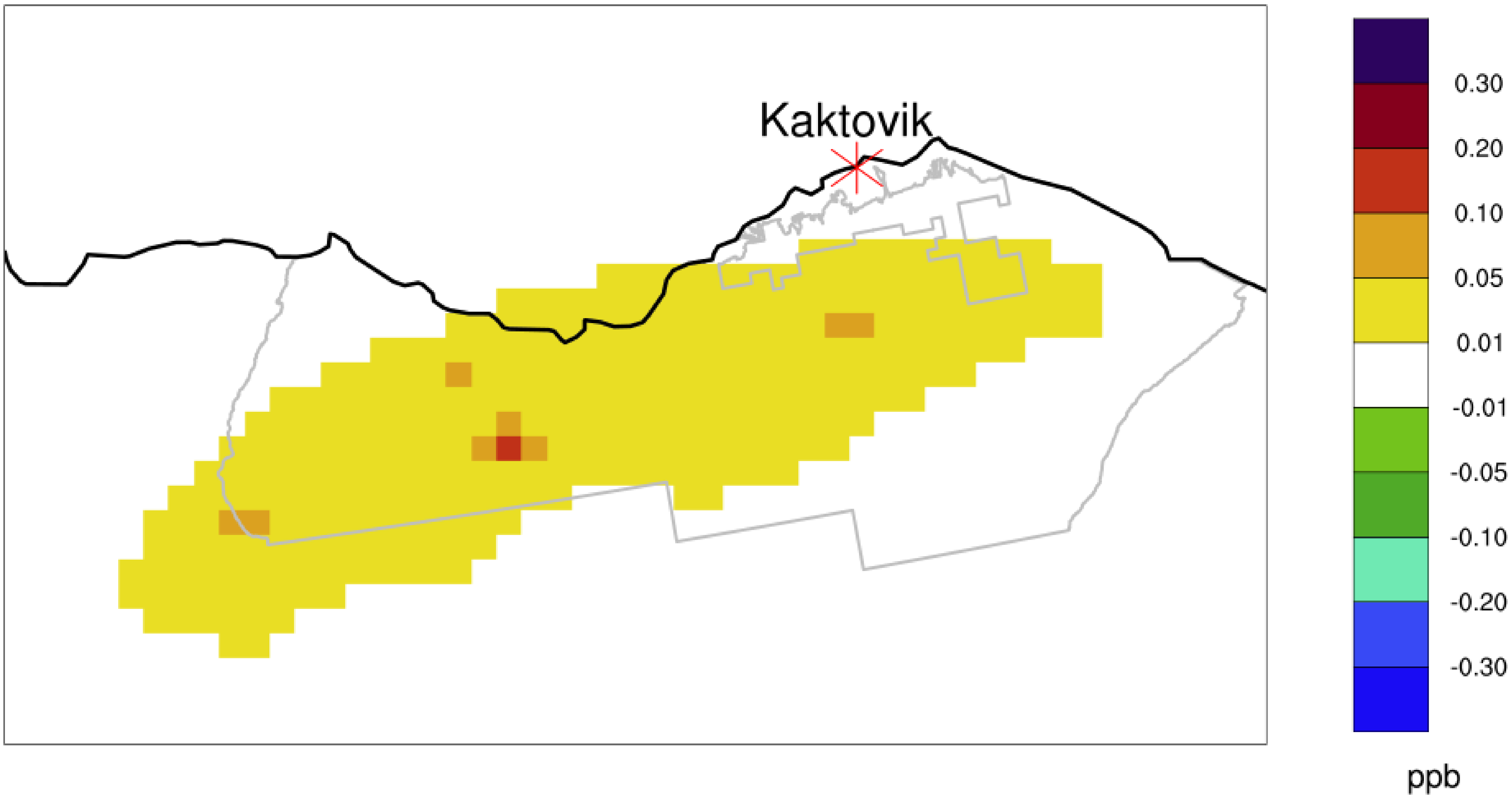


Annual average SO_2 concentration
High Development Scenario-Cumulative

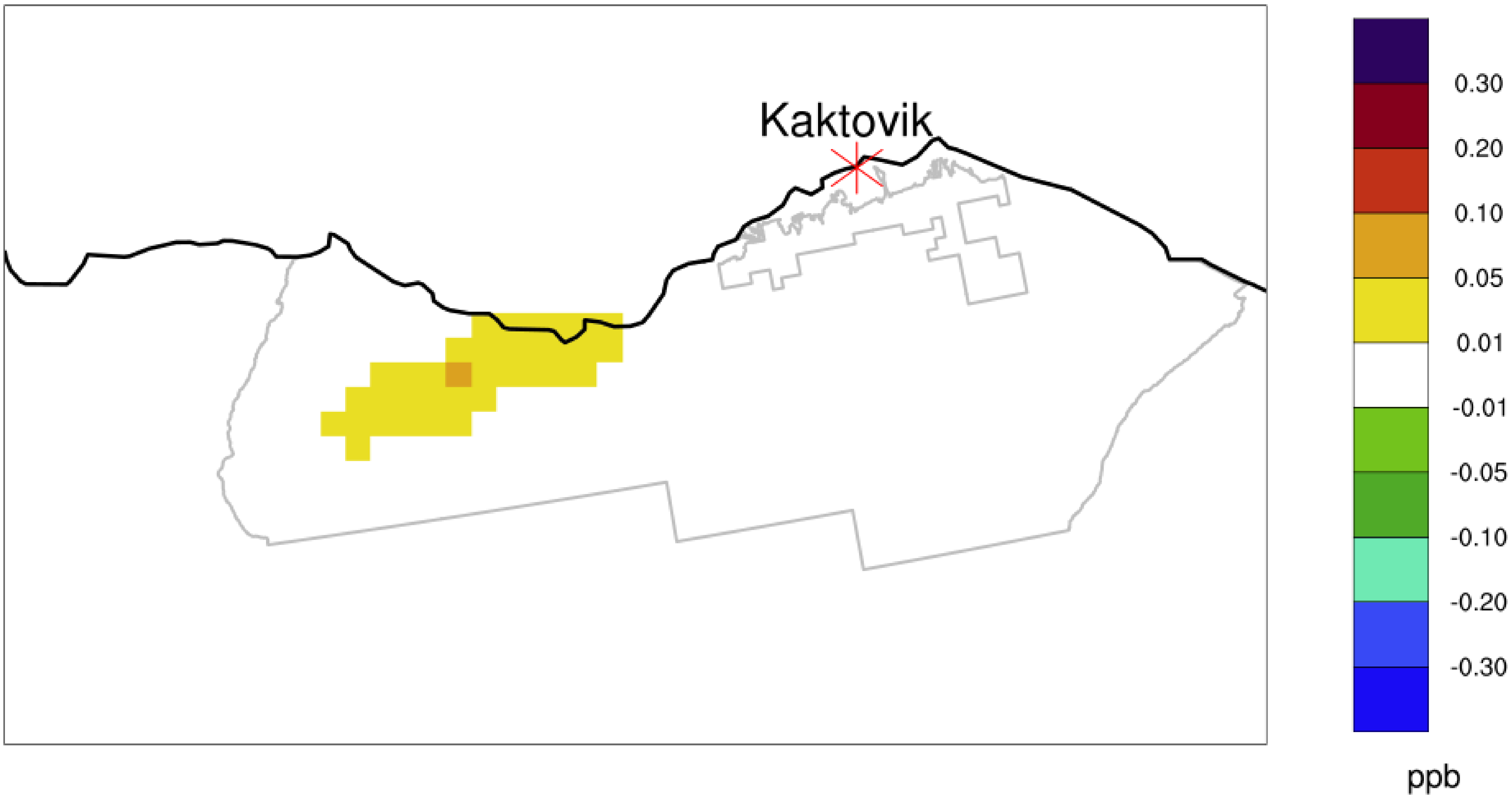
Annual average SO_2 concentration
Low Development Scenario-Cumulative

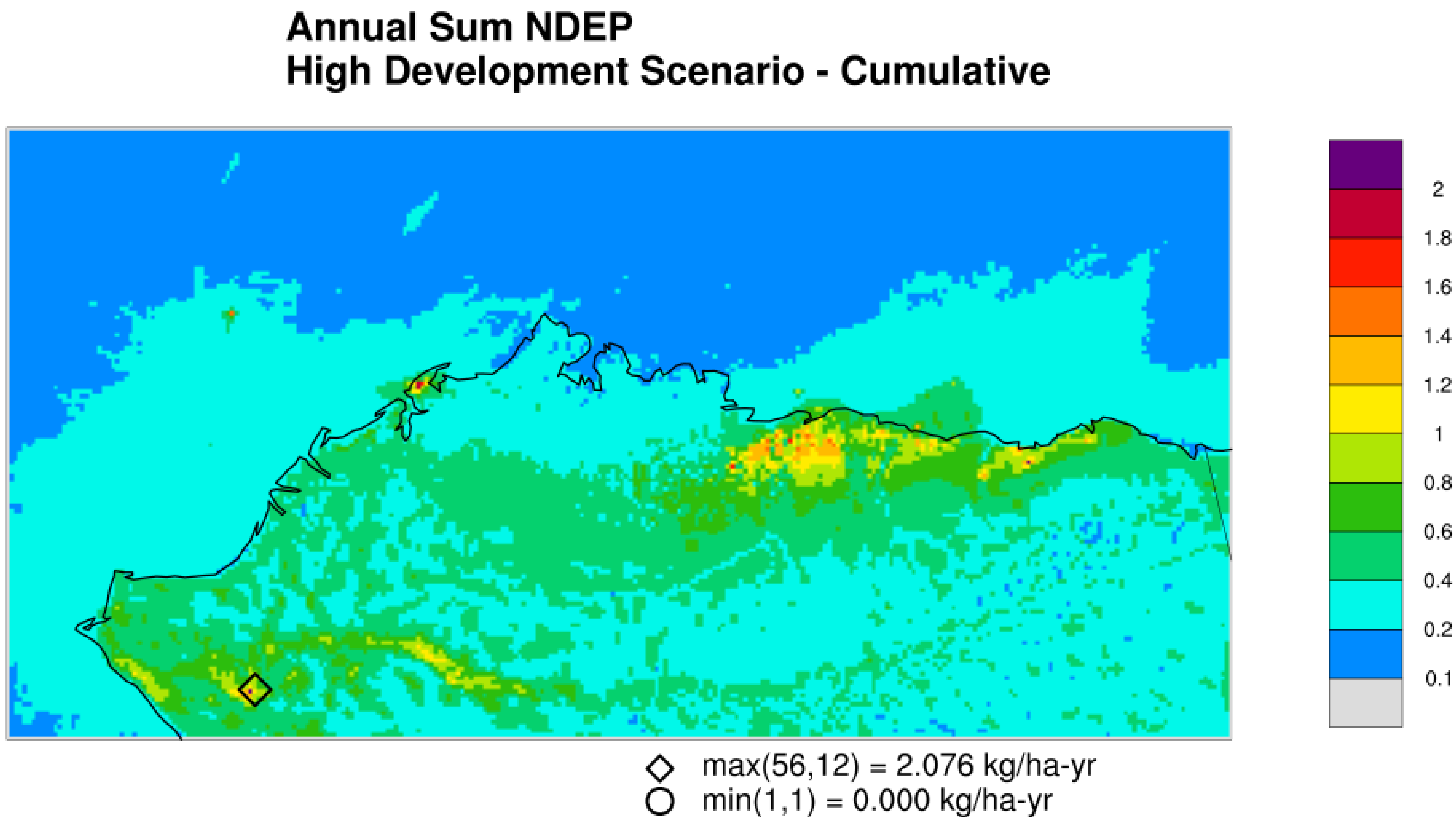
Annual average SO_2 concentration
No Action Alternative-Cumulative

Annual average SO_2 concentration
High Development Scenario-Indirect Impact

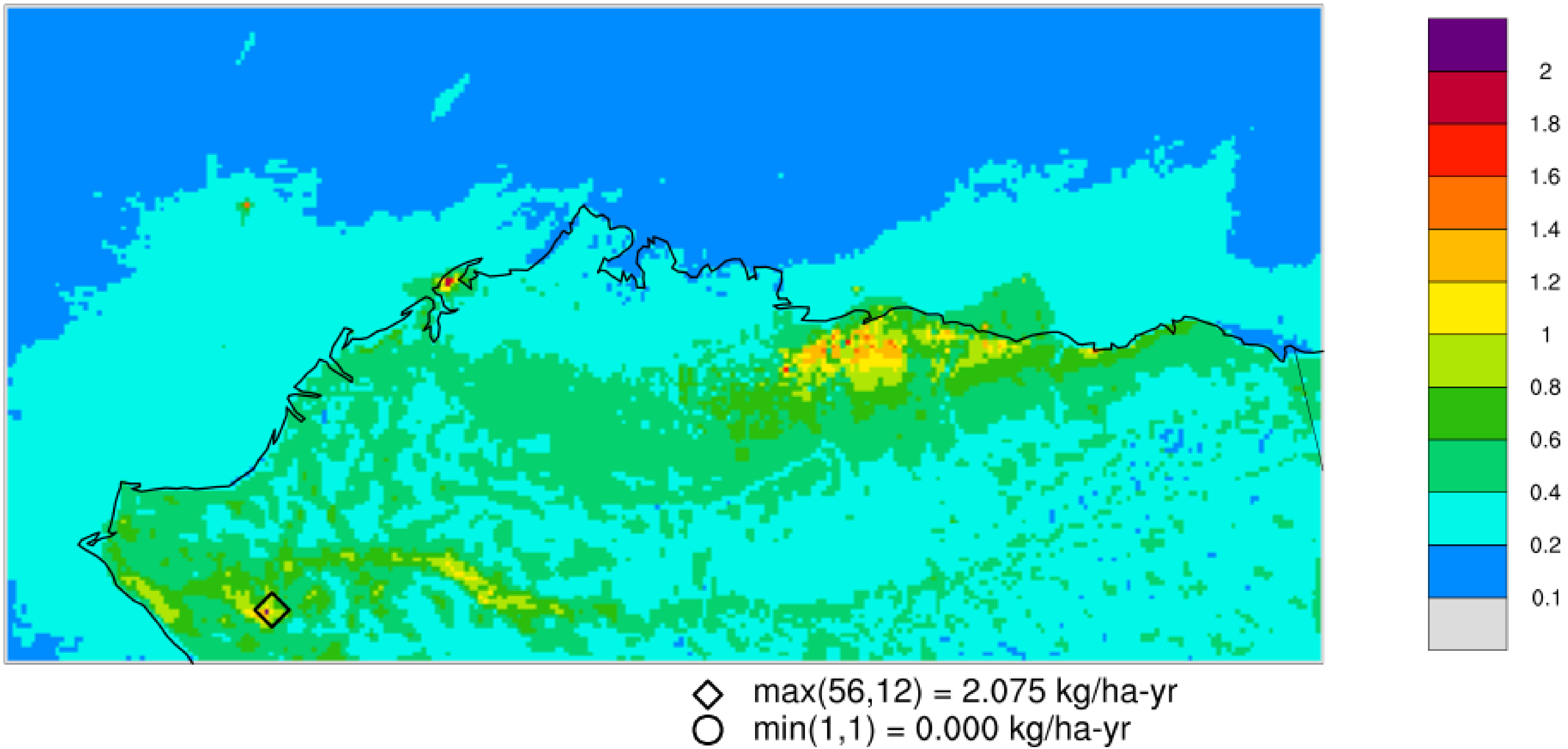


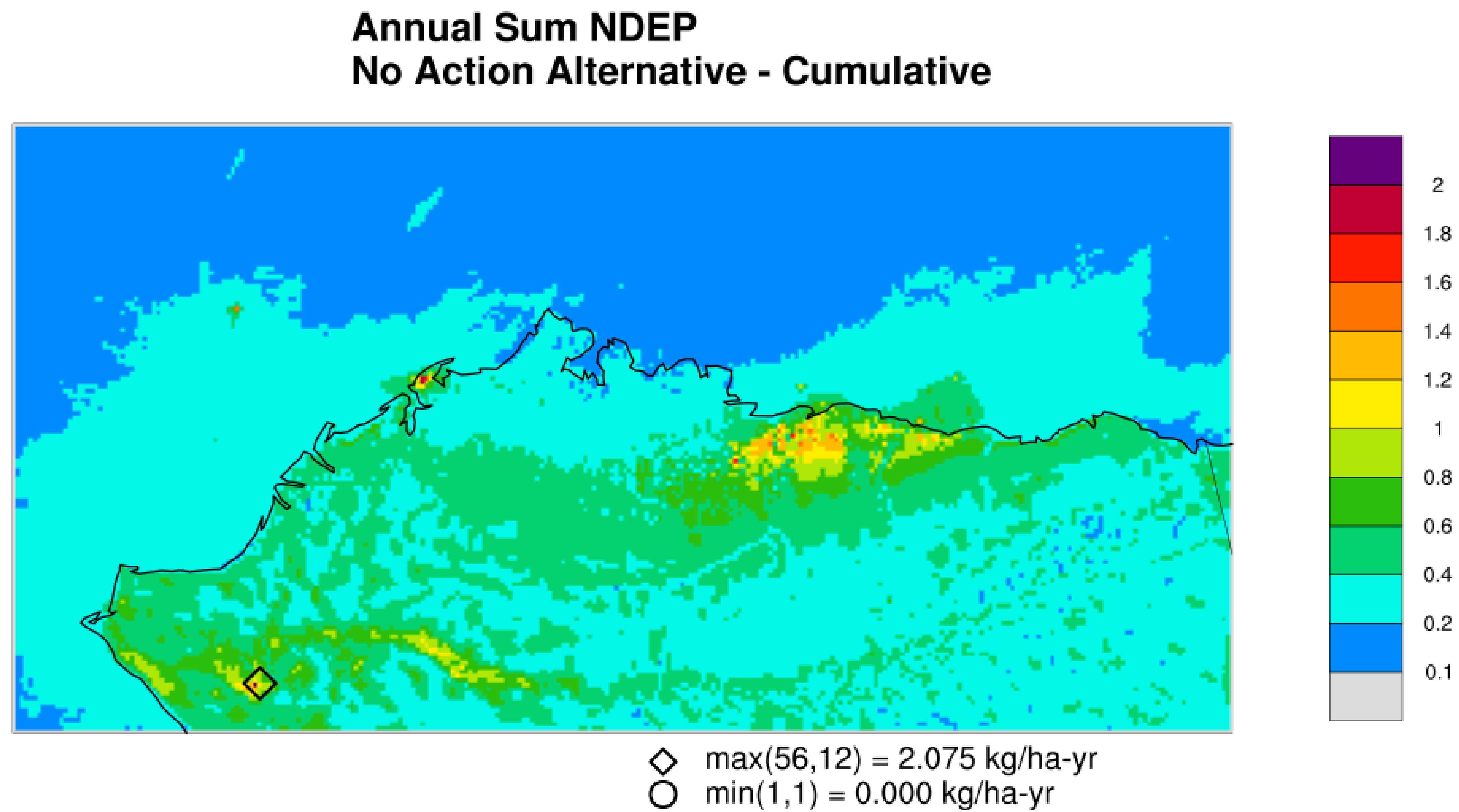
Annual average SO_2 concentration
Low Development Scenario-Indirect Impact




Annual Sum NDEP
High Development Scenario - Cumulative
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0.1
max(56,12) = 2.076 kg/ha-yr
min(1,1) = 0.000 kg/ha-yr

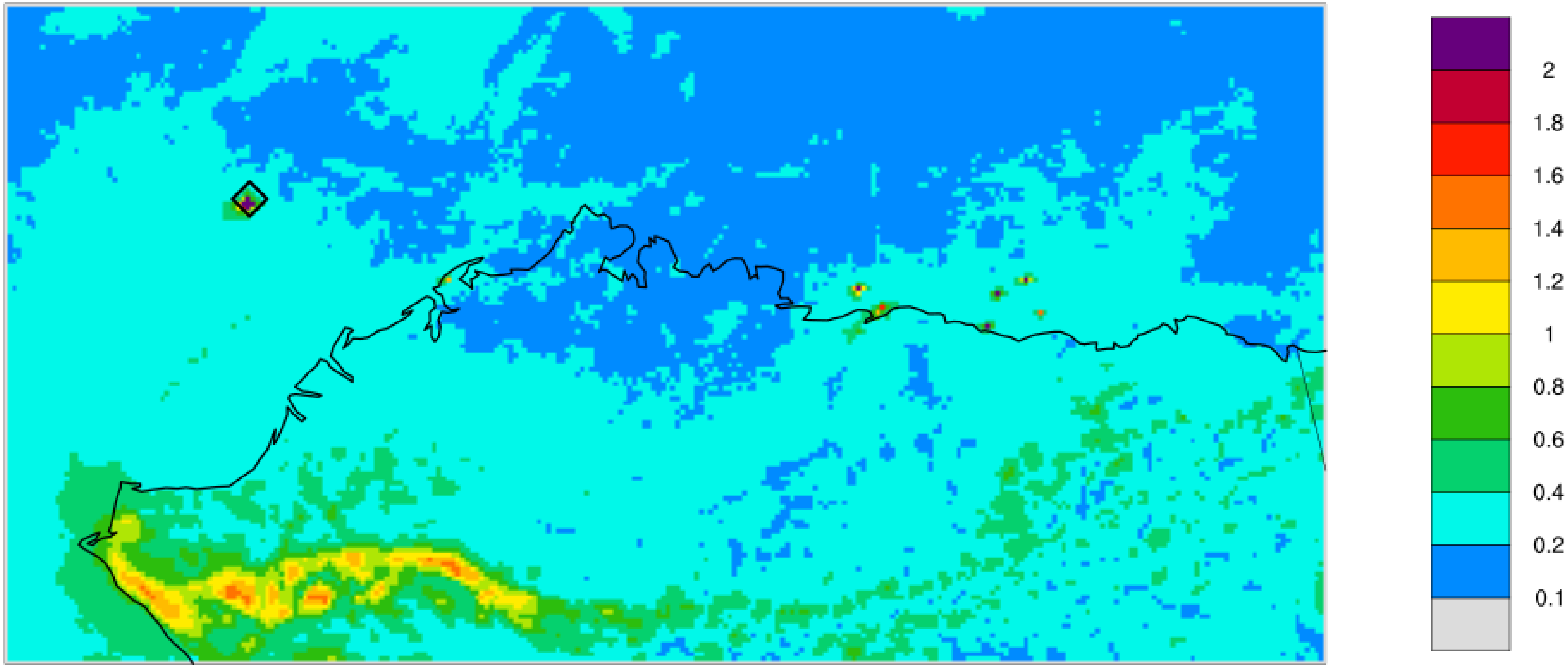
Annual Sum NDEP
Low Development Scenario - Cumulative





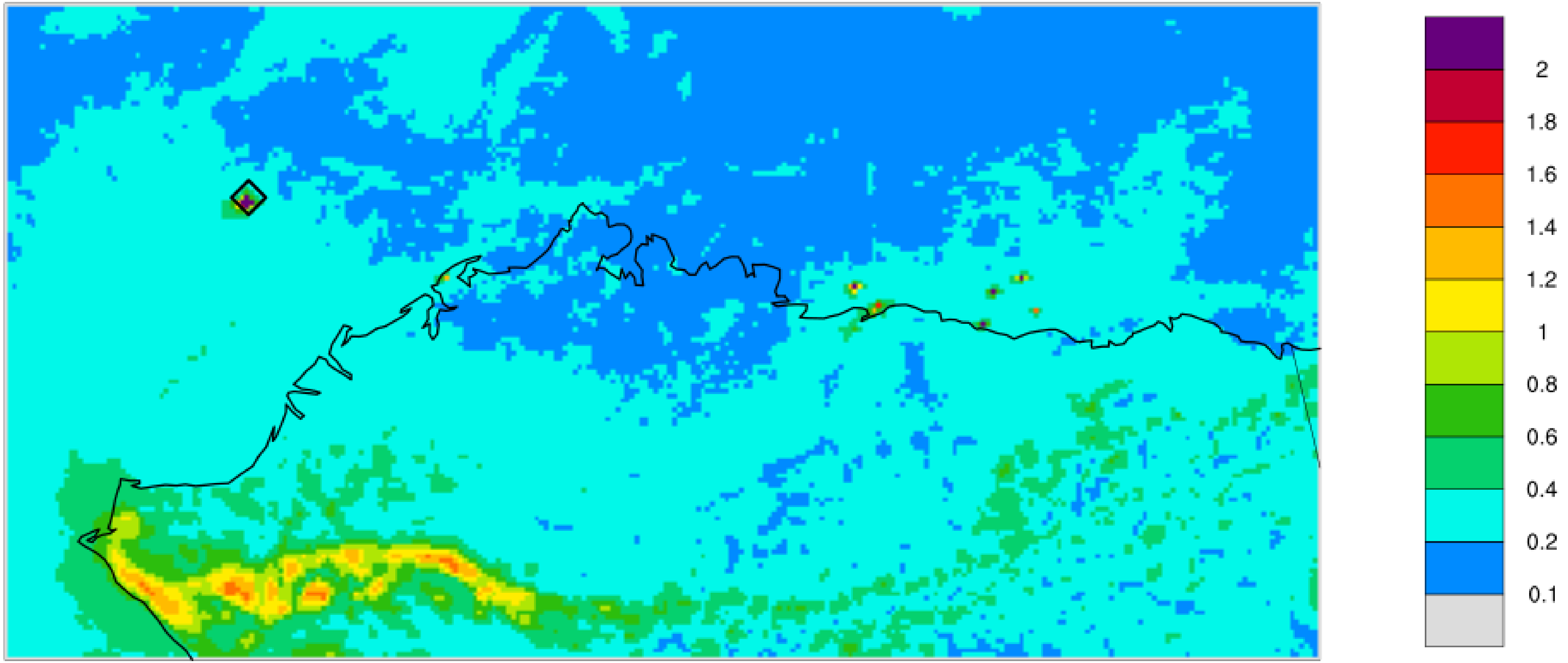
Annual Sum NDEP
No Action Alternative - Cumulative
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0.1
max(56,12) = 2.075 kg/ha-yr
min(1,1) = 0.000 kg/ha-yr

Annual Sum SDEP
High Development Scenario - Cumulative



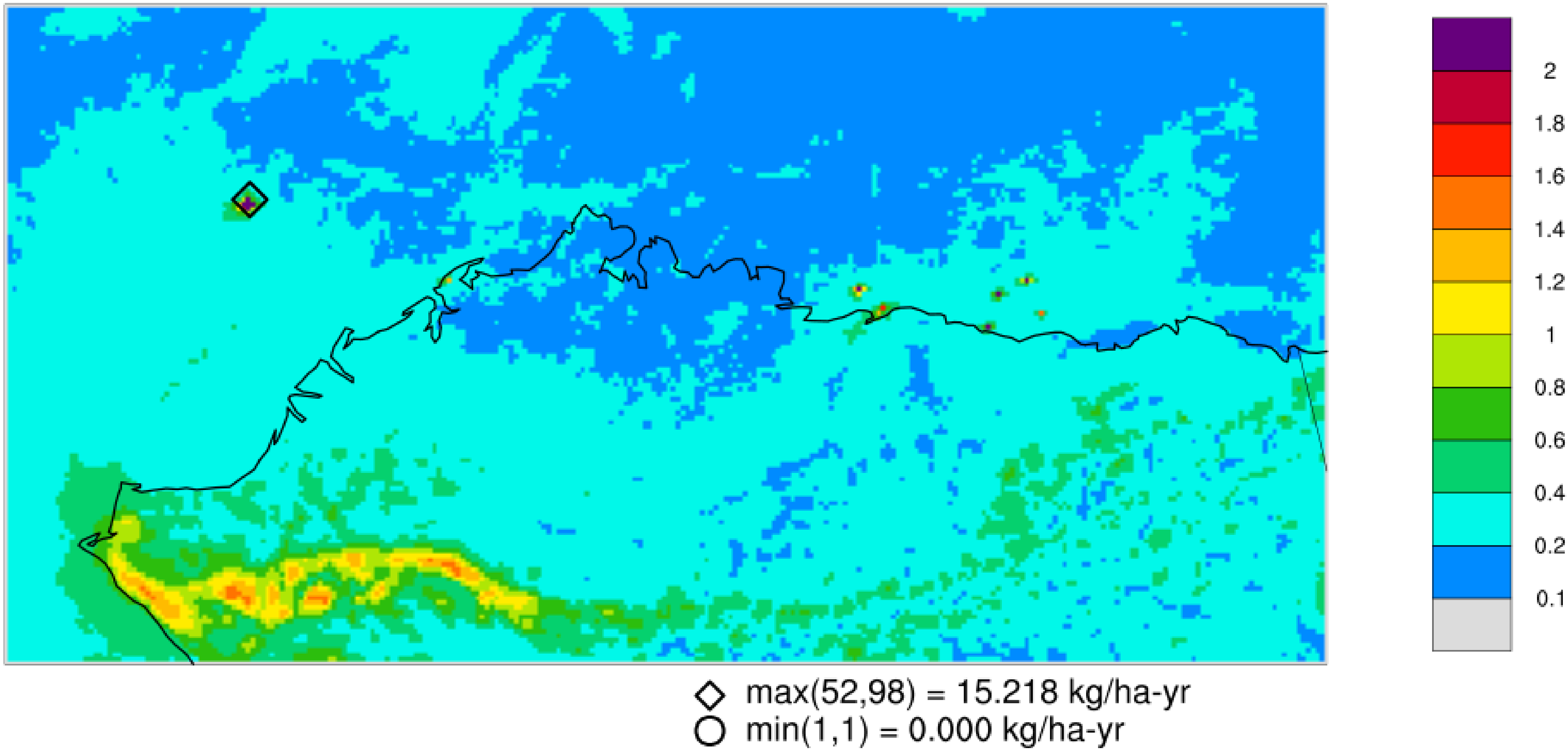
◇ max(52,98) = 15.218 kg/ha-yr
○ min(1,1) = 0.000 kg/ha-yr

Annual Sum SDEP
Low Development Scenario - Cumulative

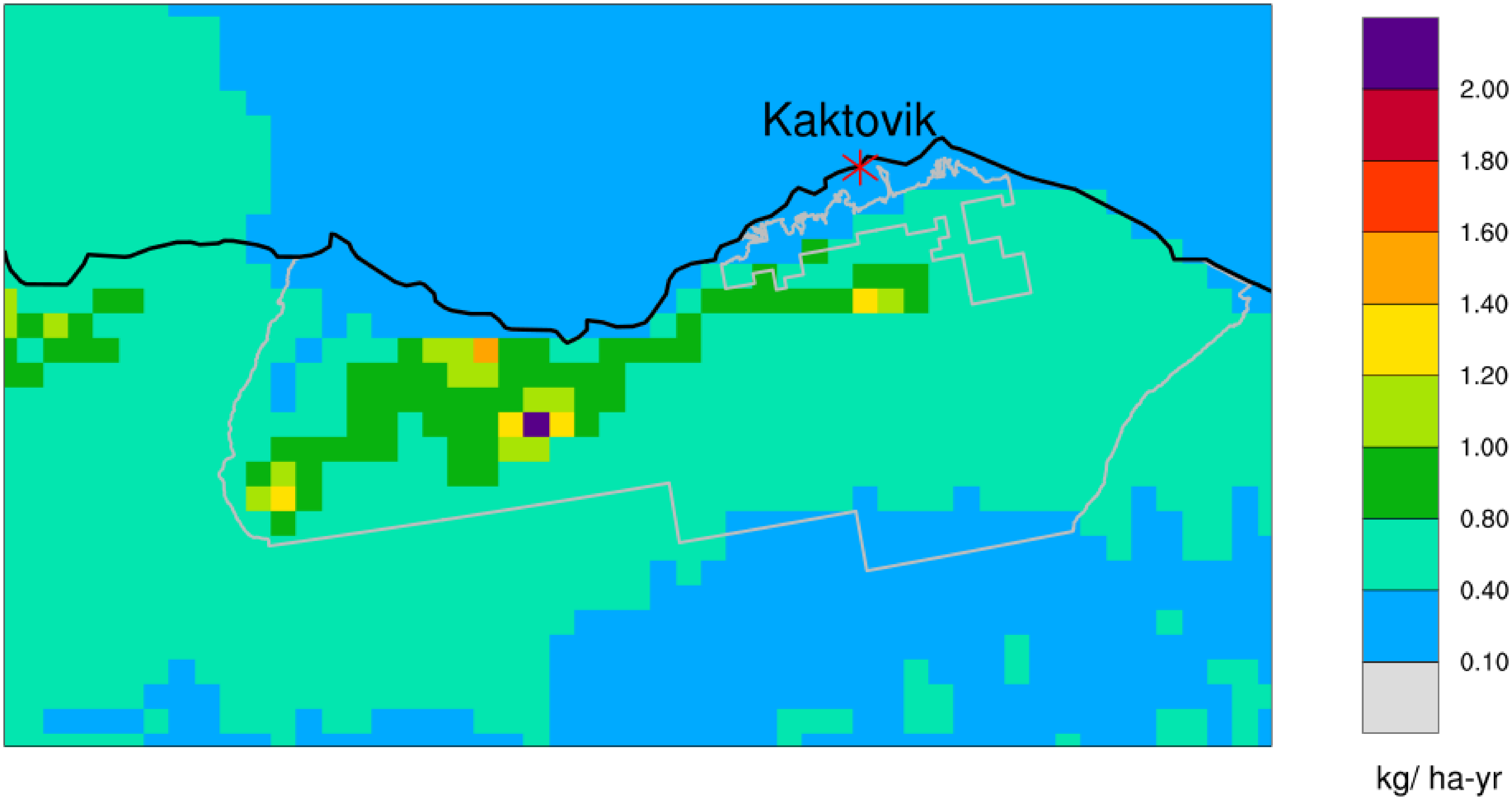


◇ max(52,98) = 15.218 kg/ha-yr
○ min(1,1) = 0.000 kg/ha-yr

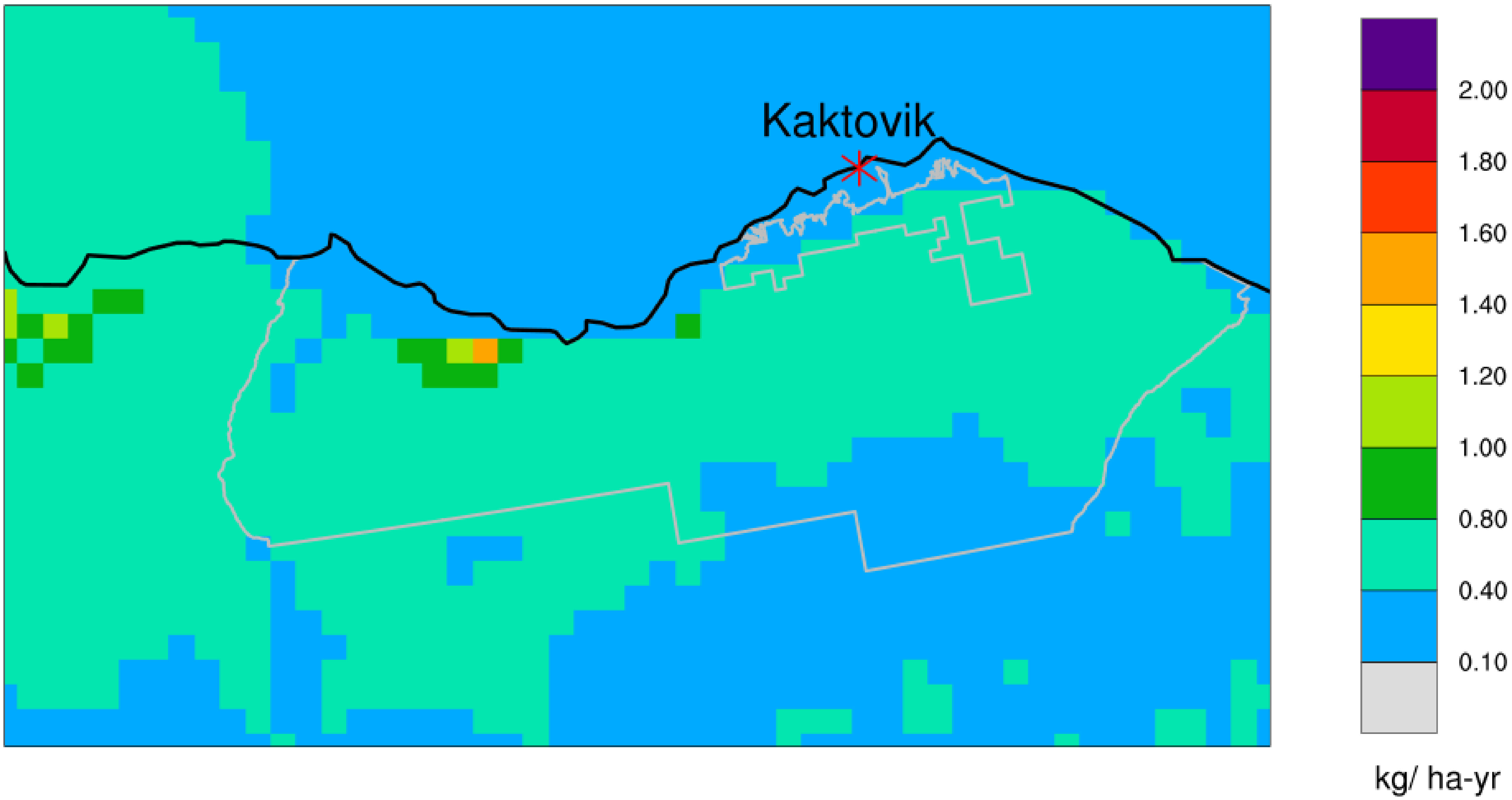
Annual Sum SDEP
No Action Alternative - Cumulative



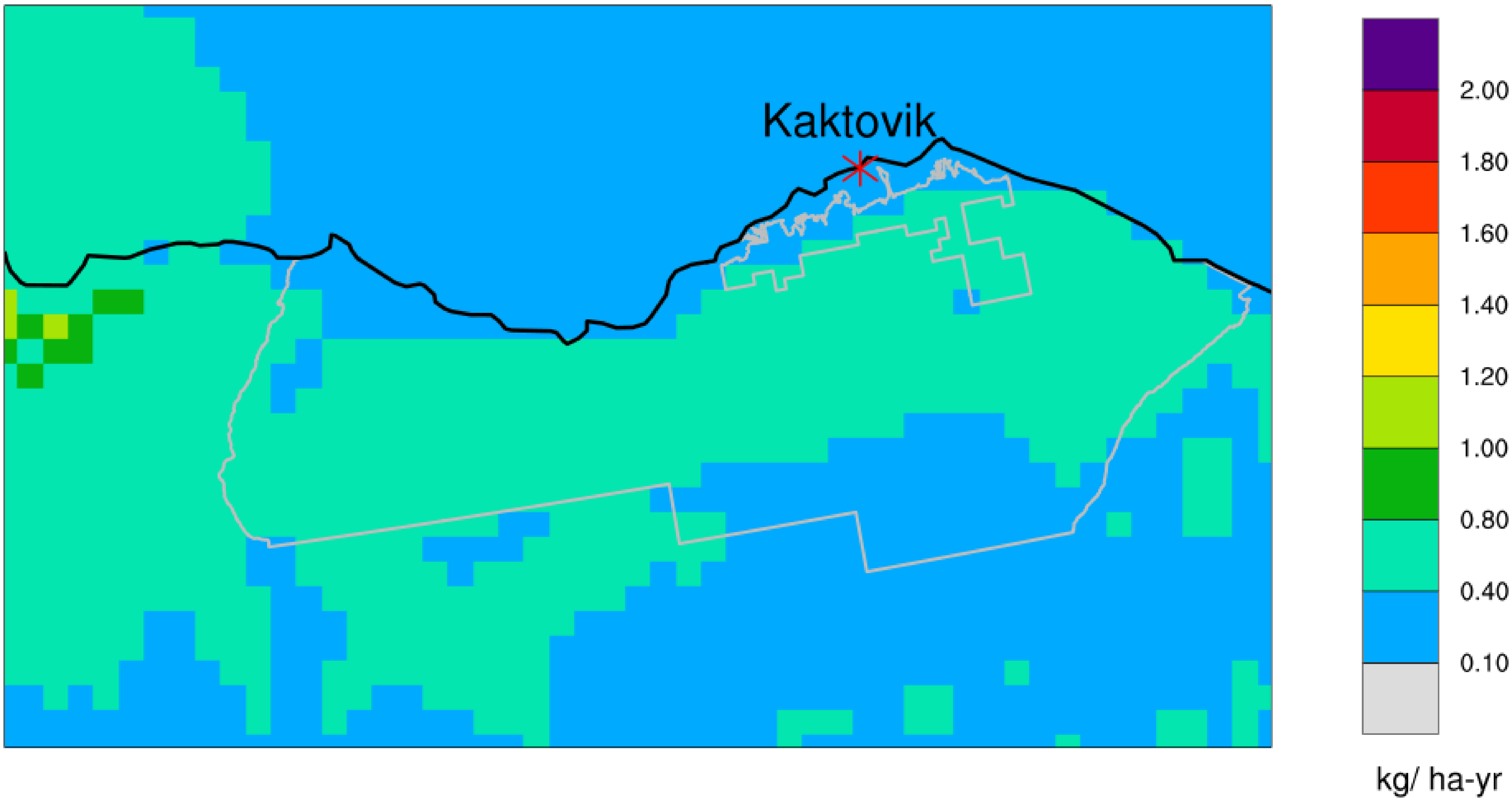
Annual Sum NDEP
High Development Scenario - Cumulative



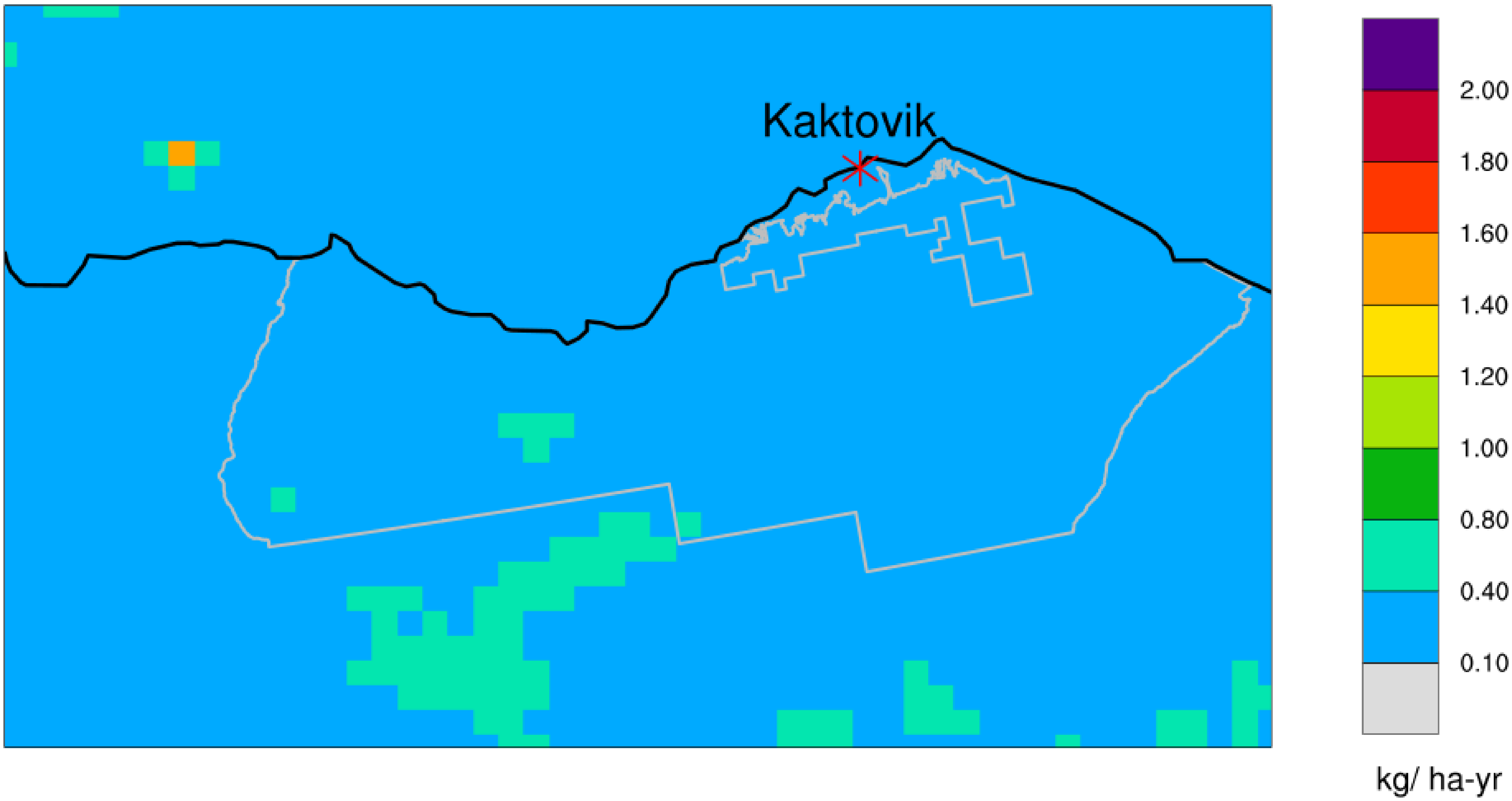
Annual Sum NDEP
Low Development Scenario - Cumulative

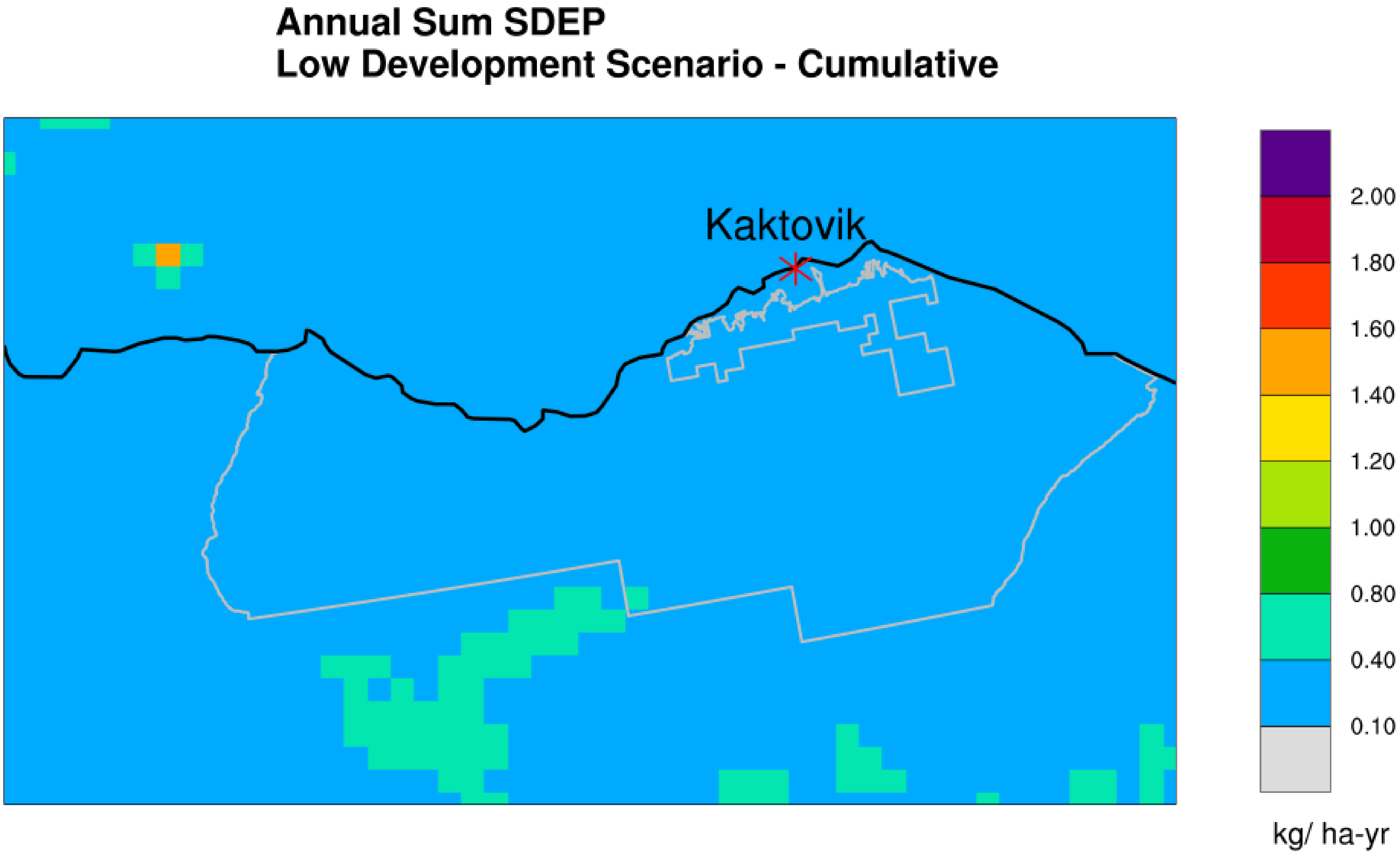


Annual Sum NDEP
No Action Alternative - Cumulative

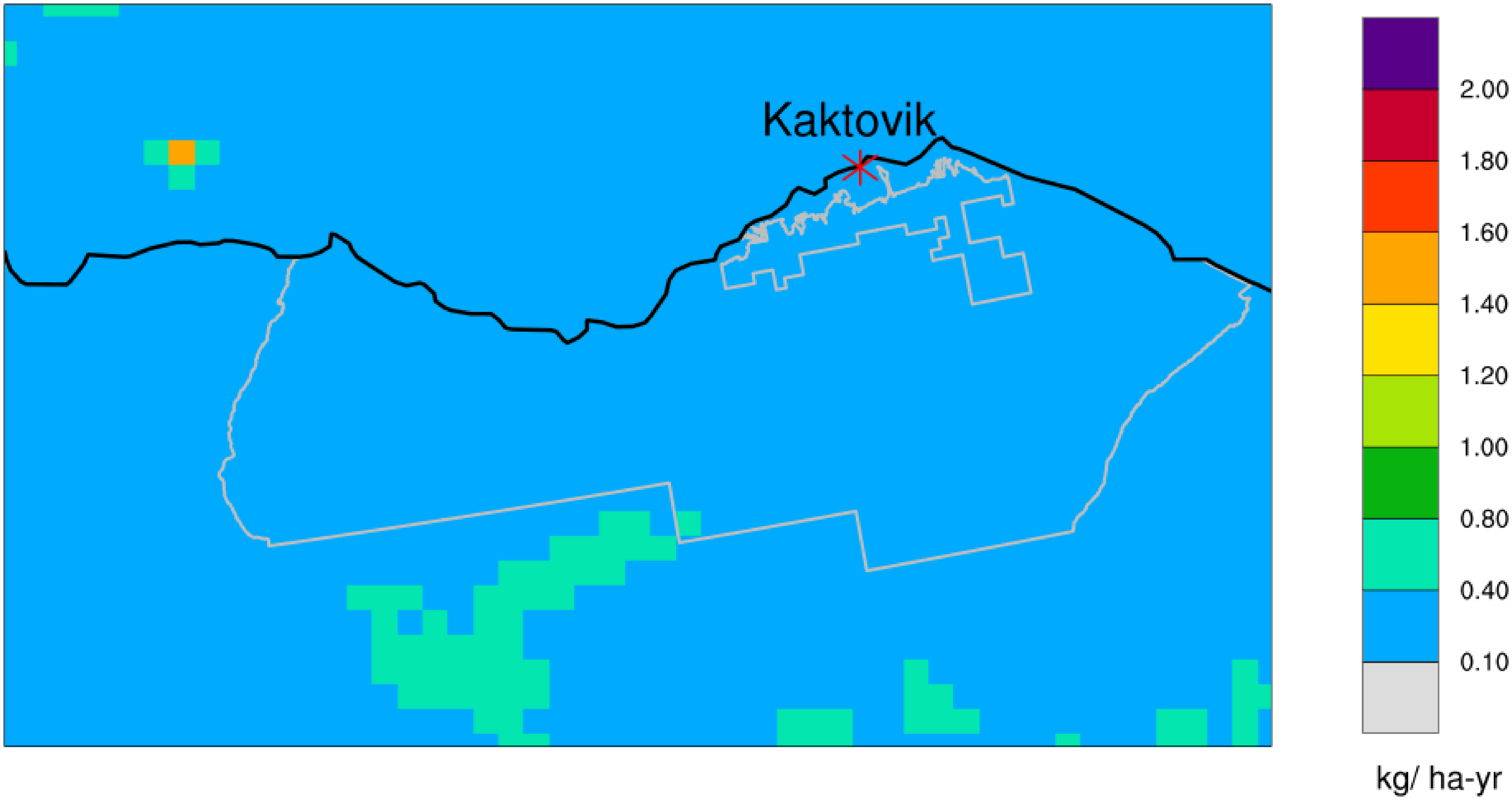


Annual Sum SDEP
High Development Scenario - Cumulative




Annual Sum SDEP
Low Development Scenario - Cumulative
Kaktovik
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.40
0.10
kg/ ha-yr

Annual Sum SDEP
No Action Alternative - Cumulative



Appendix R

Bureau of Land Management Energy Substitution Model

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Abbreviations and Acronyms

AEO	Annual Energy Outlook
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
DOE	Department of Energy
EIA	Energy Information Administration
IEA	International Energy Agency
LNG	Liquefied Natural Gas
MarketSim	Market Simulation Model
NEMS	National Energy Modeling System
OCS	Outer Continental Shelf
UNLV	University of Nevada, Las Vegas

1. Background

The Energy Substitution Model (EnergySub) was developed by the BLM as a tool to compare unobservable long-run market conditions with and without onshore mineral production projected under a reasonable foreseeable development scenario. The BLM developed this model to simulate potential market responses associated with onshore oil, gas, and coal related management actions, including possible substitution between various energy sources and changes in energy prices and consumption, given long-run market conditions projected by the U.S. Energy Administration (EIA).[1] The EnergySub model is not a national forecasting model and it was not designed to be a replacement for the National Energy Modeling System (NEMS) developed and maintained by the EIA, or the long-term energy projections they produce with it. EnergySub was adapted from Bureau of Ocean Energy Management's (BOEM) Market Simulation Model (MarketSim), which assesses potential market impacts associated with the development of offshore oil and gas resources along the Outer Continental Shelf (OCS).[2] Although EnergySub includes substantive updates to enable the model to simulate changes in onshore mineral development, it retains much of the overall structure and functionality of the MarketSim model.

2. Model Overview

EnergySub is an excel-based partial equilibrium model that uses a series of supply and demand equations with a set of assumed long-run elasticities and partial adjustment parameters to create a mathematical representation of U.S. energy markets. This model was adapted from BOEM's MarketSim model to simulate end-use consumption of oil, natural gas, coal and electricity by the domestic residential, commercial, industrial and transportation sectors; production of primary energy fuel sources; and the power sector's generation of electricity from renewable and nonrenewable fuel sources. Although the model primarily represents domestic energy markets, it captures interactions with foreign markets through the inclusion of imports and exports of coal and natural gas and its mathematical representation of a global oil market with aggregated foreign supply and demand.

EnergySub calibrates its supply and demand equations to an initial market equilibrium that reflects projected long-run market conditions developed by the EIA. The EIA is the statistical and analytical branch of the Department of Energy and operates within the U.S. Federal statistical system as the single federal government authority on energy statistics. EIA's Office of Energy Analysis maintains and operates the National Energy Modeling System (NEMS) to produce U.S. energy statistics that are widely regarded to be best available data and are used regularly by Members of Congress, government agencies, industry participants, and other industry observers. [3] While MarketSim, calibrates to long-run projections of market conditions from a special NEMS run where future OCS leasing and development are constrained, EnergySub calibrates to EIA projections published in the Annual Energy Outlook (AEO). AEO projections reflect EIA's best assessment of how U.S. and foreign energy markets will operate

[1] The EIA is the statistical and analytical branch of the Department of Energy and operates within the U.S. Federal statistical system as the single federal government authority on energy statistics. Their mandate is to collect, analyze, and disseminate energy information to inform and promote policymaking, efficient markets, and public understanding of energy and its interactions with the economy and the environment.

[2] See Industrial Economics, Inc. (2017).

[3] NEMS is a modular energy-economy modeling system that captures interactions of macroeconomic changes and energy supply, demand, and prices. An overview of NEMS and detailed information on its 13 modules is publicly available on EIA's website at www.eia.gov/outlooks/aeo/nems/documentation/.

through 2050 based on key assumptions. Since the AEO focuses on domestic energy market conditions, EnergySub's baseline supplements AEO data with additional information from EIA's Short Term Energy Outlook, the International Energy Agency's World Energy Outlook, and natural gas pipeline imports data derived by Industrial Economics, Inc. in order to model interactions with foreign markets in greater detail (EIA 2023a, IEA 2022, EIA 2023d, IEc 2023).

Onshore production volumes for federal oil, natural gas, and coal from a Reasonable Foreseeable Development Scenario (RFD) are then used to shock the supply side of EnergySub's initial market equilibrium, causing the model to solve its system of equation for new equilibrating prices for electricity and primary energy fuel sources in each year of the production scenario. [4] Solving for these equilibrating prices yields a new market equilibrium where quantities of electricity, oil, gas, and coal supplied equal those demanded, while accounting for substitution between alternative energy fuel sources.

Energy markets are highly volatile and projections about future market conditions are inherently uncertain. EIA acknowledges that future changes in technologies, demographics, resources, and regulations may affect future market conditions, but they avoid speculating about unknown events when developing long-run market forecasts. EnergySub was not developed to be a forecasting model and its results should not be interpreted as projections of future market conditions that replace those developed by EIA using NEMS. Despite the uncertainty in future market conditions and the amount of recoverable oil reserves which could be economically produced from the Coastal Plains, simulations from EnergySub are useful because they enable analysts to observe potential market responses to changes in production by comparing long-run market conditions forecasted by EIA with and without oil associated with BLM management decisions.

3. Model Framework

As mentioned above, EnergySub uses a series of equations with assumed long-run supply and demand elasticities and partial adjustment parameters to represent the markets for oil, natural gas, coal, and electricity generation. These elasticities and adjustment parameters facilitate the market equilibrating process that moves the modeled energy market from observable short-run conditions towards long-run equilibrium conditions in each year of the simulation. While these long-run conditions cannot be directly observed, they can be inferred from short-run market conditions and the model's underlying parameters. The following sections outline EnergySub's supply and demand equations and describes how the model equilibrates.

4. Oil Market

EnergySub models a simplified world oil market with sector detail for the domestic market, a single supply equation for foreign oil, and a small number of demand equations that represent non-U.S. consumption of oil produced from both U.S. and non-U.S. sources. While EnergySub can distinguish to a limited degree where oil in the domestic market is produced (i.e., AK onshore, AK offshore, lower-48 onshore, lower-48 offshore), the foreign oil market is represented as a single market made up of supply and demand for oil from U.S. and non-U.S. sources. The estimation of impacts to foreign submarkets within the global oil market is beyond the modeling capabilities of EnergySub.

[4] EnergySub extrapolates baseline energy projections through the life of the production scenario when the modeled time period extends beyond the AEO 2050 baseline projections.

The equations that follow below illustrate how EnergySub estimates U.S. oil demand by the residential, commercial, industrial and transportation sectors[5], foreign oil demand, U.S. oil supply, foreign oil supply, oil imports delivered to the U.S. by tanker, U.S. crude oil exports, and U.S. exports of refined petroleum products.

4.1 U.S. Oil Demand

$$Q_{Doi,t} = A_{oi,t} \cdot P_{o,t}^{\eta_{oi}} \cdot \prod_{j} P_{j,t}^{\eta_{oji}} + (1 - \gamma_{Doi}) Q_{Doi,t-1}$$

for each U.S. end-use sector *i*; and *j* = *g* (gas), *c* (coal), and *e* (electricity) where:

$Q_{Doi,t}$ represents the quantity of oil demanded in sector *i* at time *t*,
$A_{oi,t}$ is a constant calibrated to the AEO market projections,
$P_{o,t}$ is the price of oil at time *t*,
η_{oi} is the long-run price elasticity of oil demand in sector *i*,
$P_{j,t}$ is the price of energy source *j* at time *t*,
η_{oji} is the long-run elasticity of demand for oil with respect to the price of energy source j in sector *I*, and
γ_{Doi} is the rate at which demand for oil in sector *i* adjusts.[6]

The four U.S. end-use sectors *i* are residential, commercial, industrial, and transportation. To estimate cross-price effects in the industrial and other sectors, EnergySub uses a single weighted average minemouth price of coal (instead of the separate regional coal prices described in Section 7 below).[7]

4.2 Foreign Oil Demand

$$Q_{Dox,t} = A_{ox,t} \cdot P_{o,t}^{\eta_{ox}} + (1 - \gamma_{Dox}) Q_{Dox,t-1}$$

Where:

$Q_{Dox,t}$ represents the quantity of foreign oil demand at time *t*,
$A_{ox,t}$ is a constant calibrated to the AEO market projections,
$P_{o,t}$ is the price of oil at time *t*,
η_{ox} is the long-run price elasticity of foreign oil demand, and
γ_{Dox} is the rate at which non-U.S. oil demand adjusts.

Foreign oil demand is strictly a function of the oil price, and no other prices, domestic or foreign. EnergySub specifies three categories of foreign oil demand: (1) foreign demand for U.S. crude oil, (2) foreign demand for U.S. refined products, and (3) foreign demand for foreign oil. The model assumes that these three categories are mutually exclusive.

[5] Oil used for electricity generation is separate from the primary market for oil and oil consumption associated with generating electricity is represented in the electricity section of the model.
[6] Note that this deviates from standard notation used in the empirical literature on demand and supply estimation by using gammas to represent adjustment rather than persistence.
[7] The model uses the weighted average price of coal, using industrial sector consumption as weights.

4.3 U.S. Oil Supply

$$Q_{Sou,t} = B_{ou,t} \cdot P_{o,t}^{\eta_{ou}} + (1 - \gamma_{Sou})Q_{Sou,t-1}$$

for each domestic oil source *u* = lower 48 onshore non-tight oil, lower 48 onshore tight oil, lower 48 offshore, Alaska onshore, Alaska offshore, biofuels, natural gas plant liquids, other, or rest of world; where:

$Q_{Sou,t}$ represents the quantity of oil supplied from U.S. source *u* at time *t*,
$B_{ou,t}$ is a constant calibrated to the AEO market projections,
$P_{o,t}$ is the price of oil at time *t*,
η_{ou} is the long-run elasticity of oil supply from source *u*, and
γ_{Sou} is the rate at which U.S. oil supply *u* adjusts.

Consistent with the EIA classification, the term “oil” includes all liquid fuels that are close substitutes for petroleum products (e.g., biofuels).

4.4 Foreign Oil Supply

$$Q_{Soy,t} = B_{oy,t} \cdot P_{o,t}^{\eta_{oy}} + (1 - \gamma_{Soy})Q_{Soy,t-1}$$

Where:

$Q_{Soy,t}$ represents the quantity of non-U.S. oil supplied at time *t*,
$B_{oy,t}$ is a constant calibrated to the AEO market projections,
$P_{o,t}$ is the price of oil at time *t*,
η_{oy} is the long-run elasticity of non-U.S. oil supply, and
γ_{Soy} is the rate at which non-U.S. oil supply adjusts.

Foreign oil supply is estimated in EnergySub’s equilibrating equations as a separate value that represents tanker imports and pipeline imports combined, consistent with *AEO* reporting.

4.5 Oil Imports Delivered via Pipeline

EnergySub uses the equations outlined above to find changes in oil market consumption, production, and prices under a given development scenario. The model’s calculation for oil imports from Canada is similar to the foreign oil supply formula except with its own parameter, elasticity, and adjustment rate.

$$Q_{Soc,t} = B_{oc,t} \cdot P_{o,t}^{\eta_{oc}} + (1 - \gamma_{Soc})Q_{Soc,t-1}$$

Where:

$Q_{Soc,t}$ represents the quantity of Canadian pipeline oil imports supplied at time *t*,
$B_{oc,t}$ is a constant calibrated to the AEO market projections,
$P_{o,t}$ is the price of oil at time *t*,
η_{oc} is the long-run elasticity of Canadian pipeline oil imports, and
γ_{Soc} is the rate at which the supply of Canadian pipeline oil imports adjusts.

4.6 U.S. Crude Oil Exports

As described above, EnergySub models oil as a global market with supply (i.e., production) and demand (i.e., consumption) specified separately for the U.S. and the rest of the world. To facilitate the estimation of changes in oil exports, EnergySub's demand equations specify the three categories of foreign demand identified above: (1) foreign demand for U.S. crude oil, (2) foreign demand for U.S. refined petroleum products, and (3) foreign demand for foreign oil. The first of these items represents U.S. crude oil exports. Therefore, to estimate the impact of a given BLM development scenario on U.S. crude oil exports, EnergySub calculates the difference between foreign demand for U.S. crude oil between the development scenario and the AEO baseline projections.

4.7 U.S. Exports of Refined Petroleum Products

EnergySub estimates U.S. exports of refined petroleum products based on the specification of foreign demand for refined petroleum products in the model's equilibrating equations.[8] For a given development scenario, the change in U.S. refined petroleum product exports is equal to the estimated change in foreign demand for U.S. refined petroleum products. This approach is similar to that outlined above for U.S. exports of crude oil, which EnergySub estimates based on the change in foreign demand for U.S. crude oil.

5. Natural Gas Market

EnergySub represents the U.S. natural gas market with exports and imports. This stands in contrast to the oil market, which EnergySub simulates as a global market due to the relatively low cost of transporting oil and the large volume of oil traded on international markets. Natural gas use for electricity generation is represented elsewhere in the electricity section of the model. The equations that follow specify EnergySub's estimation of U.S. natural gas demand, demand for U.S. natural gas exports, and U.S. natural gas supply.

5.1 U.S. Natural Gas Demand

$$Q_{Dgi,t} = A_{gi,t} \cdot P_{g,t}^{\eta_{gi}} \cdot \prod_j P_{j,t}^{\eta_{gji}} + (1 - \gamma_{Dgi}) Q_{Dgi,t-1}$$

for each U.S. end-use sector *i*; and *j* = *o* (oil), *c* (coal), and *e* (electricity) where:

$Q_{Dgi,t}$ represents the quantity of natural gas demanded in sector *i* at time *t*,
$A_{gi,t}$ is a constant calibrated to the AEO market projections,
$P_{g,t}$ is the price of natural gas at time *t*,
η_{gi} is the long-run price elasticity of natural gas demand in sector *i*,
$P_{j,t}$ is the price of energy source *j* at time *t*,
η_{gji} is the long-run elasticity of demand for natural gas with respect to the price of energy source *j* in sector *I*, and
γ_{Dgi} is the rate at which demand for natural gas in sector *i* adjusts.

The U.S. natural gas demand sectors represented in EnergySub include the residential, commercial, industrial, and transportation sectors. As in the oil market, EnergySub uses a single weighted average minemouth price of coal instead of separate regional coal prices to estimate cross-price effects in the industrial sector.

[8] As noted above, this category of foreign demand represents one of three included in the model. The other two categories are foreign demand for U.S. crude oil and foreign demand for foreign oil.

5.2 Demand for U.S. Natural Gas Exports

$$Q_{Dgx,t} = A_{gx,t} \cdot P_{g,t}^{\eta_{gx}} + (1 - \gamma_{Dgx})Q_{Dgx,t-1}$$

Where:

$Q_{Dgx,t}$ represents the quantity of U.S. natural gas exports at time t,
$A_{gx,t}$ is a constant calibrated to the AEO market projections,
$P_{g,t}$ is the price of natural gas at time t,
η_{gx} is the long-run price elasticity of export demand for U.S. natural gas, and
γ_{Dgx} is the rate at which export demand for natural gas adjusts.

U.S. natural gas exports are dependent only upon the domestic price of natural gas and no other prices, domestic or international.

5.3 U.S. Natural Gas Supply

$$Q_{Sgu,t} = B_{gu,t} \cdot P_{g,t}^{\eta_{gu}} + (1 - \gamma_{Sgu})Q_{Sgu,t-1}$$

for each domestic or imported natural gas source u = lower 48 conventional, lower 48 unconventional, lower 48 offshore, Alaska onshore, Alaska offshore, other (e.g., synthetic natural gas and coke oven gas), pipeline imports, and LNG imports, where:

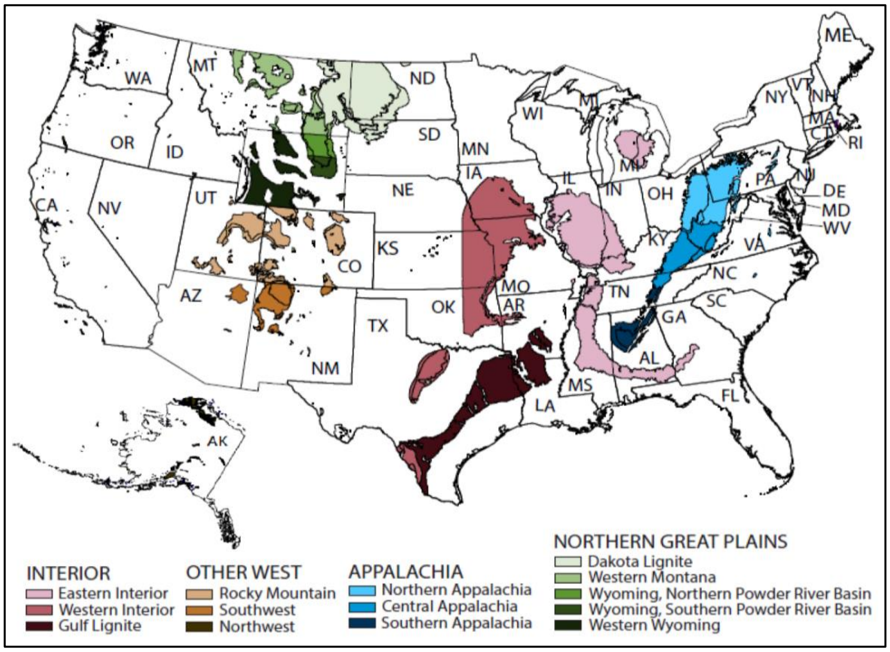
$Q_{Sgu,t}$ represents the quantity of natural gas supplied to the U.S. market from domestic or imported source u at time t,
$B_{gu,t}$ is a constant calibrated to the AEO market projections,
$P_{g,t}$ is the price of natural gas at time t,
η_{gu} is the long-run elasticity of natural gas supply to the U.S. market from source u, and
γ_{Sgu} is the rate at which natural gas from source u adjusts.

6. Coal Market

EnergySub represents the U.S. coal market as 14 separate sub-markets defined according to the region where coal is produced, with exports. The model also includes imports as exogenous to the model. The 14 coal markets in EnergySub correspond to the coal supply regions represented in the Coal Market Module of EIA's NEMS, shown below in Figure 1. These supply regions are modeled separately to account for differences in the sulfur content, thermal value, rank, and production method of different coals. Because coal characteristics often differ by region (e.g, the Southern Powder River Basin region produces *only* low-sulfur, surface mined subbituminous coal), this approach (in most cases) implicitly captures the important differences between domestic sources of coal. With 14 distinct coal markets (one for each supply region), EnergySub estimates 14 equilibrium coal prices for each year.

Coal use for electricity generation is represented elsewhere in the electricity section of the model. The equations that follow present the model's estimation of U.S. coal demand, demand for U.S. coal exports, and U.S. coal supply.

Figure 1. EnergySub Coal Supply Regions



6.1 U.S. Coal Demand

$$Q_{Dcir,t} = A_{cir,t} \cdot P_{cr,t}^{\eta_{ci}} \cdot \prod_j P_{j,t}^{\eta_{cji}} + (1 - \gamma_{Dci}) Q_{Dcir,t-1}$$

for each U.S. end-use sector i, for each coal supply region r; and $j = g$ (gas), o (oil), and e (electricity) where:

$Q_{Dcir,t}$ represents the quantity of coal demanded in sector i from coal supply region r at time t,
$A_{cir,t}$ is a constant calibrated to the AEO market projections,
$P_{cr,t}$ is the minemouth price of coal from supply region r at time t,
η_{ci} is the long-run price elasticity of coal demand in sector i,
$P_{j,t}$ is the price of energy source j at time t,
η_{cji} is the long-run elasticity of demand for coal with respect to the price of energy source j in sector I, and
γ_{Dci} is the rate at which demand for coal in sector i adjusts.

Other than the electricity sector, whose coal demand is modeled separately, EnergySub's domestic demand sectors for coal include industrial and other.

6.2 Demand for U.S. Coal Exports

$$Q_{Dcrx,t} = A_{crx,t} \cdot P_{cr}^{\eta_{cx}} + (1 - \gamma_{Dcx})Q_{Dcrx,t-1}$$

for each coal supply region, *r*, where:

$Q_{Dcrx,t}$ represents the quantity of U.S. coal exports from coal supply region *r* at time *t*,
$A_{crx,t}$ is a constant calibrated to the AEO market projections,
$P_{cr,t}$ is the minemouth price of coal from supply region *r* at time *t*,
η_{cx} is the long-run price elasticity of export demand for U.S. coal, and
γ_{Dcx} is the rate at which export demand for coal adjusts.

Coal exports in EnergySub are only dependent upon the domestic minemouth price of coal from each coal supply region. No other energy prices, domestic or international, affect exports of coal.

6.3 U.S. Coal Supply

$$Q_{Scr,t} = B_{cr,t} \cdot P_{cr,t}{}^{\eta_{cr}}$$

for each coal supply region, *r*, where:

$Q_{Scr,t}$ represents the quantity of coal supplied to the U.S. market from coal supply region *r* at time *t*,
$B_{cr,t}$ is a constant calibrated to the AEO market projections,
$P_{cr,t}$ is the minemouth price of coal for coal supply region *r* at time *t*,
η_{cr} is the long-run elasticity of coal supply to the U.S. market from coal supply region *r*, and
γ_{Sc} is the rate at which coal supply adjusts.

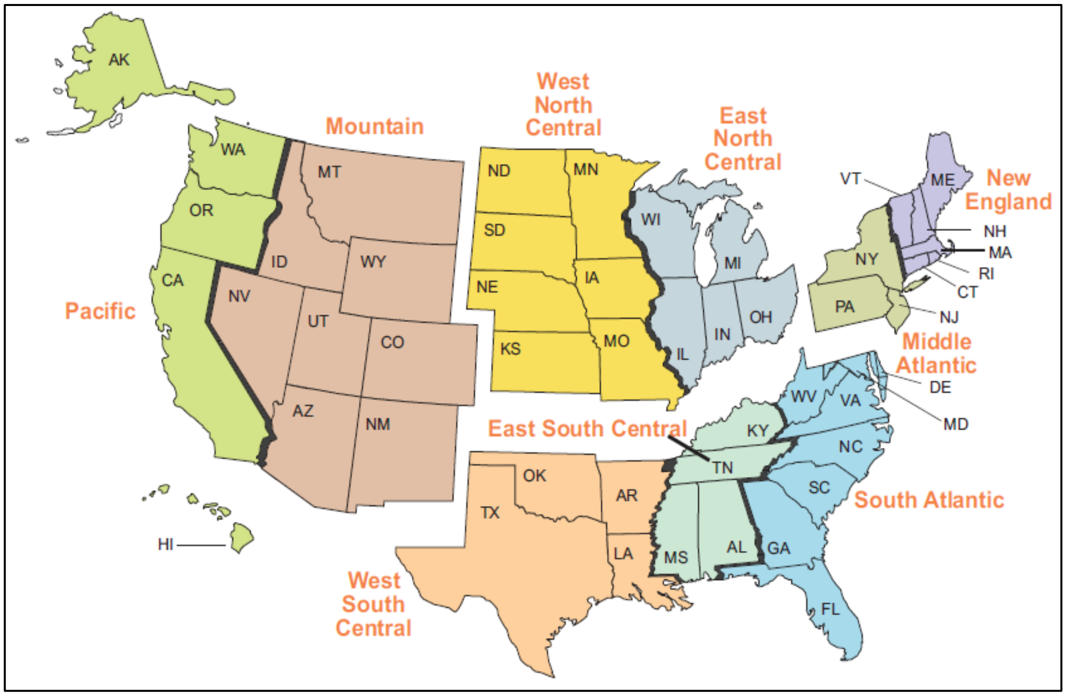
As noted above, EnergySub treats coal imports as exogenous. For each BLM development scenario, imports are assumed to be the same as under the baseline scenario. The model makes this simplifying assumption because imports are projected to make up a *de minimis* fraction (less than 1 percent) of U.S. coal demand according to the AEO and imports do not align with the 14 coal markets specified in the model.

7. Electricity Market

Equations in EnergySub represent the U.S. electricity market and models U.S. exports and imports of electricity as net imports. EnergySub's electricity sector also represents an end-use sector with demand for oil, natural gas, and coal as a fuel source for generating commercial electricity. The equations below present EnergySub's approach for estimating U.S. electricity demand, U.S. electricity supply, and demand for fossil fuels for electricity generation.

To depict the use of coal for electricity generation with greater spatial detail, EnergySub divides the electricity supply market into nine regions based on the U.S. Census Divisions, shown in Figure 2 below. Each electricity supply region is also modeled to receive coal from the 14 separate coal supply regions described above, resulting in a total of 126 total coal supply-electricity supply region combinations.

Figure 2. EnergySub Electricity Supply Regions



7.1 U.S. Electricity Demand

$$Q_{Dei,t} = A_{ei,t} \cdot P_{e,t}^{\eta_{ei}} \cdot \prod_{j} P_{j,t}^{\eta_{eji}} + (1 - \gamma_{Dei}) Q_{Dei,t-1}$$

for each U.S. electricity end-use sector i; and $j = g$ (gas), c (coal), and o (oil), where:

> $Q_{Dei,t}$ represents the quantity of electricity demanded in sector i at time t,
> $A_{ei,t}$ is a constant calibrated to the AEO market projections,
> $P_{e,t}$ is the price of electricity at time t,
> η_{ei} is the long-run price elasticity of electricity demand in sector i,
> $P_{j,t}$ is the price of energy source j at time t,
> η_{eji} is the long-run elasticity of demand for electricity with respect to the price of energy source j in sector i, and
> γ_{Dei} is the rate at which demand for electricity in sector i adjusts.

The U.S. demand sectors for electricity in EnergySub include (1) residential, (2) commercial, (3) industrial, (4) transport, and (5) other. As in the oil and gas markets, EnergySub uses a single weighted average minemouth price of coal instead of separate regional coal prices to estimate cross-price effects in the industrial and other sectors.

7.2 U.S. Electricity Supply

EnergySub uses a separate approach for estimating electricity derived from natural gas, oil, and coal than electricity derived from other sources. While the quantity of electricity generated from gas, oil, and coal is dependent on fossil fuel prices, changes in these prices do not directly factor into the generation of electricity from non-fossil energy sources.[9] In addition, EnergySub accounts for the cost of transporting coal from each coal supply region to each electricity supply region by adding the coal transportation cost to the minemouth price of coal, which yields an estimate of the delivered price of coal. To account for this difference in the economics of electricity generation for different types of power producers, EnergySub specifies electricity supply separately for three classes of generation as follows:

$$Q_{Sej,t} = C_{j,t} \cdot (P_{e,t}/P_{j,t})^{\eta_{ej}} + (1 - \gamma_{Sej})Q_{Sej,t-1}$$

for j = oil and natural gas, where:

$Q_{Sej,t}$ represents the quantity of electricity supplied from fossil fuel energy source j at time t,
$C_{j,tt}$ is a constant calibrated to the AEO market projections,
$P_{e,t}$ is the price of electricity at time t,
$P_{j,t}$ is the price of fossil fuel energy source j at time t,
η_{ej} is the long-run elasticity of electricity supply from fuel j, and
γ_{Sej} is the rate at which electric power from fossil energy j adjusts.

$$Q_{Secrz,t} = C_{crz,t} \cdot [P_{e,t}/(P_{cr,t}+T_{crz})]^{\eta_{ec}} + (1 - \gamma_{Sec})Q_{Secrz,t-1}$$

for c = coal, for each coal supply region r and each electricity supply region z, where:

$Q_{Secrz,t}$ represents the quantity of electricity supplied from coal supply region r to electricity supply region z at time t,
$C_{crz,t}$ is a constant calibrated to the AEO market projections,
$P_{e,t}$ is the price of electricity at time t,
$P_{cr,t}$ is the minemouth price of coal from supply region r at time t,
T_{crz} represents the transportation cost of coal from coal supply region r to electricity supply region z,
η_{ec} is the long-run elasticity of electricity supply from coal, and
γ_{Sec} is the rate at which electric power from coal adjusts.

As noted above, EnergySub accounts for the cost of transporting coal between each of the 14 coal supply regions and each of the nine electricity supply regions. The model therefore includes estimates of the per-ton cost of transporting coal (T_{crz}) for all 126 combinations of coal supply and electricity supply regions.

$$Q_{Sel,t} = C_{l,t} \cdot {P_{e,t}}^{\eta_{el}} + (1 - \gamma_{Sel})Q_{Sel,t-1}$$

for l = nuclear, hydro, wind, solar, other electric, net imports, where:

$Q_{Sel,t}$ represents the quantity of electricity supplied from source l at time t,
$C_{l,t}$ is a constant calibrated to the AEO market projections,

[9] All else equal, renewable electricity generation in EnergySub simulations will increase as fossil fuel prices rise, but the effect is indirect. For a given level of electricity demand, fossil fuel-based generators will supply less electricity as fossil fuel prices rise, which will shift generation toward renewables.

$P_{e,t}$ is the price of electricity at time *t*,
η_{el} is the long-run elasticity of electricity supply from source *l*, and
γ_{Sel} is the rate at which electric power from source *l* adjusts.

7.3 Demand for Fossil Fuels to Produce Electricity

7.3.1 Oil and Natural Gas

$$Q_{Dje,t} = K_{j,t} \cdot Q_{Sej,t}$$

for *j* = oil and natural gas, where:

$Q_{Dje,t}$ represents the quantity of energy source *j* used to produce electricity at time *t*,
$K_{j,t}$ is a constant calibrated to the AEO market projections, and
$Q_{Sel,t}$ represents the quantity of electricity supplied from source *l* at time *t*

7.3.2 Coal

$$\sum_z Q_{Dcerz,t} = K_{cr,t} \cdot \sum_z Q_{Secrz,t}$$

for c= coal, where:

$\sum_z Q_{Dcerz,t}$ is the sum of demand for coal from coal supply region *r* for electricity production across all *z* electricity production regions at time *t*,

$K_{cr,t}$ is a constant calibrated to the AEO market projections, and

$\sum_z Q_{Secrz,t}$ is the sum of coal supplied for electricity production from coal supply region *r* across all *z* electricity production regions at time *t*.

8. Model Calibration

For a given set of elasticities, adjustment parameters, market quantities, and prices in the baseline projections of market conditions through 2050, EnergySub uses the series of supply and demand equations outlined above to calculate the parameters *A*, *B*, *C*, and *K* in these equations. These parameters, having been calculated from data that reflects a baseline market equilibrium, calibrate the model's supply and demand equations directly to the market conditions observed in the baseline projections.

EnergySub has extensive data requirements and needs detailed long-run forecasts for the supply, demand, and prices of electricity and energy fuel sources to derive its calibration parameters and benchmark the system of equations to projected equilibrium market conditions. EnergySub relies heavily on long-run projections developed by EIA for the Annual Energy Outlook because these data represent the most complete impartial data set for long-run U.S. energy market conditions and are developed with rigger using methods and assumptions that are well documented. While other projections for energy market conditions through 2050 exist, AEO data are widely accepted as best available information.

9. Equilibration

Onshore production volumes for federal oil, natural gas, and/ or coal from a RFD are used to shock the supply side of EnergySub's initial market equilibrium, moving its system of equation from a state of equilibrium into disequilibrium. Production under each year of the RFD can be introduced into the model as either a component of or incremental to the equilibrium supply projections for that year. While production under the RFD may represent incremental production from production in the current year, supply projections from the AEO reflect EIA's best guess at future U.S. production from all proved and unproven reserves regardless of mineral ownership or current leasing status. These supply projections reflect total future production and do not disaggregate onshore production from federal and non-federal mineral reserves. EIA may, however, exclude federal mineral resources in areas known to be closed to development from the proved and unproven reserves from which they estimate potential production.

Once EnergySub enters a state of disequilibrium, users can initiate the model's equilibration process to simulate how markets may respond to the introduced changes in the U.S. supply of oil, natural gas, and/ or coal. EnergySub's equilibration calculation selects $P_{o,t}$, $P_{g,t}$, $P_{cr,t}$, and $P_{e,t}$, for each period t such that the quantity of oil, natural gas, coal (by coal supply region), and electricity supplied equals the quantity demanded in each period t. For coal, the national market not only needs to be in equilibrium but the quantity of coal supplied by each coal supply region r at period t must equal the quantity of coal demanded from coal supply region r at each period t. The model specifies these equilibrium conditions as follows:

World Oil Market

$$Q_{Doe,t} + Q_{Dox,t} + \sum_i Q_{Doi,t} = Q_{Soy,t} + \sum_u Q_{Sou,t}$$

where:

$Q_{Doe,t}$ is the U.S. demand for oil to produce electricity at time t,
$Q_{Dox,t}$ is foreign demand for oil at time t,
$\sum_i Q_{Doi,t}$ is the U.S. demand for oil across all other end use sectors i at time t,
$Q_{Soy,t}$ is the oil supply from foreign sources at time t, and
$\sum_u Q_{Sou,t}$ is the domestic oil supply from all domestic sources at time t.

U.S. Natural Gas Market (with exports and imports)

$$Q_{Dge,t} + \sum_i Q_{Dgi,t} + Q_{Dgx,t} = \sum_u Q_{Sgu,t}$$

where:

$Q_{Dge,t}$ is the U.S. demand for natural gas to produce electricity at time t,
$\sum_i Q_{Dgi,t}$ is U.S. demand for natural gas across all end use sectors i at time t,
$Q_{Dgx,t}$ is the demand for U.S. natural gas exports at time t, and

$\sum_u Q_{Sgu,t}$ is the supply of natural gas from all *u* domestic sources at time *t*.

U.S. Coal Markets, by Supply Region

$$\sum_z Q_{Dcerz,t} + \sum_i Q_{Dcir,t} + Q_{Dcxr,t} = Q_{Scr,t}$$

where:

$\sum_z Q_{Dcerz,t}$ is the quantity of coal demanded from coal supply region *r* across all electricity production regions *z* at time *t*,

$\sum_i Q_{Dcir,t}$ is the quantity of coal demanded from each coal supply region *r* across all end-use sectors *i* at time *t*,

$Q_{Dcxr,t}$ is the quantity of coal demanded for exports from each coal supply region *r* at time *t*, and

$Q_{Scr,t}$ is the quantity of coal supplied by each coal supply region *r* at time *t*.

U.S. Electricity Market (with net imports)

$$\sum_i Q_{Dei,t} = \sum_j Q_{Sej,t} + \sum_z \sum_r Q_{Secrz,t} + \sum_l Q_{Sel,t}$$

where:

$\sum_i Q_{Dei,t}$ is the demand for electricity across all end-use sectors *i* at time *t*,

$\sum_j Q_{Sej,t}$ is the supply of fossil fuel electricity (excluding coal), for all other *j* fossil fuel sources at time *t*,

$\sum_r \sum_z Q_{Secrz,t}$ is the supply of coal-fired electricity across all $r \times z$ electricity production regions at time *t*, and

$\sum_l Q_{Sel,t}$ is the supply of renewable electricity across all *l* renewable sources at time *t*.

The equilibration process is initiated once a Reasonable Foreseeable Development Scenarios (RFD) for onshore federal oil, natural gas, and coal is introduced into the model. The RFD serves as a supply shock, moving the system of equations into a state of disequilibrium. These supply shocks can reflect an increase or decrease in the future supply of the corresponding energy source depending on whether production under the RFD is incremental to or a component of projected baseline supply. Once EnergySub's system of equations is moved out of equilibrium, the model uses reduced gradient methods to solve its system of equation for new equilibrating prices for electricity and energy fuel sources. Solving for these new prices yields equilibrium supply and demand quantities, accounting for substitution between energy fuel sources. When zero disparity between supply and demand across all 17 fuel markets is achieved, EnergySub saves the market-clearing prices and proceeds to the next year in the production scenario to perform the same equilibration.

10. Adjustment Rates and Elasticities

All elasticities and adjustment rates in EnergySub have default values that were obtained from the literature, derived from NEMS supply curves, inferred from NEMS output, or obtained from BOEM's MarketSim Model.[10] The sections below document the default adjustment rates and elasticities used in EnergySub when modeling alternative production scenarios in support of the CPSEIS.

To the extent possible, EnergySub relies upon values from peer-reviewed studies in the empirical economics literature. Reliance on peer-reviewed data is central to ensuring that EnergySub's simulated market responses reflect the best information available. In the few cases where peer-reviewed values are not available, elasticity estimates were derived from NEMS outputs or from expert input.

10.1 Adjustment Rates

EnergySub includes a series of adjustment rates in the supply and demand equations to capture the transition from short-run to long-run market effects. These adjustment rates account for the portion of demand or supply that is allowed to change from one year to the next. No data on the adjustment rates for specific energy sources are readily available. In the absence of such data, EnergySub assumes that adjustment rates are related to the retirement of energy producing and consuming capital (i.e., equipment that produces energy or consumes energy), as indicated by their average lifespan. Adjustment rates can also be set to 1 by users and allowed to drop out of the supply and demand equations. This may be required when there are very large year over changes in the supply of energy fuel sources which outpace the retirement of existing capital.

10.2 Demand Elasticities

EnergySub's demand elasticities measure changes in the consumption of energy and energy sources relative to a percent change in price. EnergySub utilizes own-price and cross-price demand elasticities for each energy source included in the model to capture the complex interactions between different segments of U.S. energy markets. For each major energy consuming sector (e.g., the residential sector), BLM prioritized using own-price and cross-price demand elasticities from the same empirical study to ensure that each sector's simulated responses were based on price sensitivities derived using the same methods, assumptions, and data. The selection of demand elasticities also considered the quality of the estimates produced by each study. BLM's assessment of quality for individual elasticity estimates considered, among other factors, (1) whether they are statistically significant, (2) methods by which they were derived, and (3) the richness of the data supporting each estimate (e.g., whether they are based on a multi-year panel or reflect energy market data for a single year).

Based on these criteria, EnergySub relies heavily on own-price and cross-price demand elasticities from Serletis *et al.* (2010) for the residential and commercial sectors and Jones (2014) for the industrial sector. Serletis *et al.* (2010) investigate inter-fuel substitution possibilities for energy demand across four fuels (i.e., oil, gas, electricity, and coal) using EIA data for the 1960–2007 period. Based on these data, Serletis *et al.* estimated own-price and cross-price elasticities for the commercial, residential, and industrial

[10] Many of the elasticities used from the BOEM MarketSim model were provided by energy economist Dr. Stephen Brown (2011) of the University of Nevada, Las Vegas (UNLV). See Industrial Economics, Inc. (2017).

sectors, using a flexible translog functional form. Across most sectors, Serletis *et al*. produced statistically significant elasticity values of the expected sign.

Jones (2014) focuses on inter-fuel substitution in the industrial sector, using EIA data for the 1960–2011 period for the same fuels included in Serletis *et al.* (2010) plus biomass. Jones specifies a dynamic linear logit model to estimate own-price and cross-price elasticities, and within this framework, estimates both short-run and long-run elasticities. In addition, to assess the role of biomass in industrial sector inter-fuel substitution, Jones develops two sets of models, one including the four energy sources traditionally included in industrial sector energy models (i.e., natural gas, oil, coal, and electricity) and another that includes these energy sources plus biomass. Jones finds that the addition of biomass reduces both the own-price and cross-price elasticities of demand for the four traditionally modeled fuels. The effect is most significant for those values associated with electricity. In both models, the four traditional energy sources are found to be substitutes with each other with the exception of electricity and oil; the cross-price elasticities for these energy sources are not statistically significant.

Table 1 presents the default own-price and cross-price demand elasticities used in EnergySub for the residential, commercial, industrial, and transport sectors. The table also shows the default elasticity values for miscellaneous demand sectors included in EnergySub (e.g., natural gas demand in U.S. export markets). As indicated in the table, EnergySub uses results from Serletis *et al*. (2010) as defaults for the commercial and residential sectors, except for the elasticity of demand for natural gas with respect to the price of oil and the elasticity of demand for oil with respect to the price of natural gas. The estimates for these cross-price elasticities in Serletis *et al.* were of the unexpected sign (negative) and were not statistically significant. Therefore, in lieu of Serletis *et al.*, EnergySub uses results from Newell and Pizer (2008) for these values, for both the commercial and residential sectors. Newell and Pizer (2008) estimate these cross-price relationships for the commercial sector only. While EnergySub would ideally use default values specific to the residential sector, alternative values for these cross-price elasticities were not readily available for the residential sector. Given the similarities between the commercial and residential sectors, EnergySub uses these two cross-price demand elasticities from Newell and Pizer (2008) as a reasonable approximation of the corresponding residential sector values.

For the industrial sector, EnergySub relies almost exclusively on demand elasticities from Jones (2014) as defaults. Although Serletis *et al.* (2010) estimate elasticity values for the industrial sector, the values in Jones (2014) are based on fuel consumption data that exclude fuel use for purposes other than energy (e.g., petroleum products used as lubricants). As described above, Jones (2014) estimates long-run demand elasticities with two specifications, one including biomass as a substitute and another excluding biomass. Based on the statistical significance of the elasticities with biomass included, EnergySub uses the elasticities from the specification that includes biomass. The two exceptions to this are the cross-price elasticity of demand for oil with respect to the price of electricity and the cross-price elasticity of electricity in response to oil prices, as Jones' estimates for these values are not statistically significant. For these values, EnergySub uses estimates from Serletis *et al.* (2010).

Table 3 also shows EnergySub's default own-price demand elasticities for the transport sector and various miscellaneous demand categories. For these categories, EnergySub relies upon elasticity values from multiple sources. For oil demand in the transportation sector, EnergySub uses a U.S.-specific elasticity value obtained from Dahl's (2012) review of price elasticities estimated for more than 100 countries. This value represents the average of the elasticity values identified in the empirical literature. For non-U.S. oil demand, EnergySub applies the value reported in a Huntington *et al.* (2019) review of crude oil demand elasticities in major industrializing economies. For U.S. natural gas exports, EnergySub uses estimates from Dahl's prior (2010) review of the elasticity literature as defaults.

Two categories for which appropriate demand elasticity values were not identified in the literature are miscellaneous coal demand and demand for U.S. coal exports. EnergySub uses the same industrial sector value obtained from Jones (2014) for the former and assumes a value of -1.00 for the latter.

Table 1. EnergySub Default Demand Elasticities

	ELASTICITY WITH RESPECT TO CHANGE IN OIL PRICE	ELASTICITY WITH RESPECT TO CHANGE IN GAS PRICE	ELASTICITY WITH RESPECT TO CHANGE IN ELECTRICITY PRICE	ELASTICITY WITH RESEPCT TO CHANGE IN COAL PRICE
***Commercial Sector*[1]**				
Oil	-0.939	0.2	1.08	-
Natural Gas	0.07	-0.296	0.419	-
Electric	0.092	0.041	-0.134	-
Coal	-	-	-	-
***Residential Sector*[1]**				
Oil	-1.002	0.2	1.151	-
Natural Gas	0.07	-0.313	0.507	-
Electric	0.214	0.072	-0.287	-
Coal	-	-	-	-
***Industrial Sector*[2]**				
Oil	-0.264	0.249	0.01	0.090
Natural Gas	0.172	-0.468	0.178	0.050
Electric	0.009	0.118	-0.125	0.061
Coal	0.440	0.351	0.652	-1.468
Miscellaneous Demand Categories				
Oil – Transport Sector[3]	-0.300	-	-	-
Oil – Rest of World Demand for US Crude[4]	-0.15	-	-	-
Oil – Rest of World Demand for US Refined Products[4]	-0.15			
Oil – Rest of World Demand for non-US oil[4]	-0.15			
Natural Gas – Transport[5]	-	-1.00	-	-
Natural Gas – US Export Markets[6]	-	-0.89	-	-
Electricity – Transport[5]	-	-	-1.00	-
Electricity – “Other”[7]	-	-	-0.18	-
Coal – Other[8]	-	-	-	-1.468
Coal – US Export Markets[5]	-	-	-	-1.00

Notes:

1. Commercial and residential sector values are from Serletis *et al.* (2010), except for the cross-price elasticity for gas in response to oil prices and the cross-price elasticity of oil in response to gas prices. For these latter two values, EnergySub uses demand elasticities from Newell and Pizer (2008). Also, Deryugina et al. (2020) estimate a range of residential elasticity values for electricity consistent with the value in Serletis et al. (2010).
2. For the industrial sector, EnergySub uses demand elasticities from Jones (2014), except for the cross-price elasticity of electricity in response to oil prices and the cross-price elasticity of oil in response to electricity prices. For these values, EnergySub uses demand elasticities from Serletis *et al*. (2010).
3. Dahl (2012)
4. Huntington *et al*. (2019)
5. Assumed to be -1.00.
6. Dahl (2010)
7. Assumed to be average of own-price elasticity values for industrial, commercial, and residential sectors.
8. Industrial sector value from Jones (2014).

10.3 Supply Elasticities

EnergySub includes default supply elasticities, summarized in Table 2, for every production category modeled for a given fuel (e.g., onshore tight oil production in the lower 48 states). These supply elasticities measure how responsive energy producers are to changes in market prices. Consistent with the demand elasticities summarized above, several of EnergySub's supply elasticities were obtained from the economic literature, with data sources varying by fuel type.

For tight oil and other lower 48 onshore oil, EnergySub uses elasticities from a recent study by Newell and Prest (2019). The paper specifically compares the price responses of conventional and unconventional (tight) oil drilling and production. Using micro-data for more than 150,000 oil wells in Texas, North Dakota, California, Oklahoma, and Colorado, Newell and Prest (2019) estimate the elasticity of well drilling and the elasticity of oil production, separately for conventional and unconventional wells. To estimate drilling elasticities, they use multiple model specifications, estimating changes in drilling activity as a function of price in some cases and as a function of revenue in other cases. The production elasticities estimated by Newell and Prest (2019), however, all represent the change in production as a function of the change in revenue, rather than price. To align the supply elasticities in EnergySub with the specification of supply, EnergySub uses the elasticity of well drilling with respect to the oil price from Newell and Prest (2019), which they estimate separately for both conventional and unconventional wells.

Luchansky and Monks (2009) serves as the source for EnergySub's default supply elasticity for domestic biodiesel. This paper uses monthly data for 1997 through 2006 to estimate the market supply and demand for ethanol at the national level. Applying these data to four specifications of supply, Luchansky and Monks (2009) estimated supply elasticities ranging from 0.224 to 0.258. EnergySub uses the midpoint of this range (0.24) as the default supply elasticity for biodiesel.

For a number of oil supply elasticities, EnergySub relies on values included in BOEM's MarketSim model based on expert input provided to BOEM by three energy economists: Dr. Charles Mason of the University of Wyoming, Dr. Seth Blumsack of Penn State University, and Dr. Gavin Roberts of Weber State University. EnergySub relies on input provided to BOEM by these experts for the oil supply elasticities related to lower 48 offshore, rest-of-world oil production, Canadian pipeline imports, natural gas plant liquids, and other oil production. For oil production in Alaska, EnergySub uses supply elasticities derived from specialized simulations of NEMS, as described in detail below.

For gas production, EnergySub draws on a variety of sources for elasticities, depending on the production source. For domestic onshore conventional and unconventional shale gas production in the lower 48, EnergySub uses values from Newell, Prest & Vissing (2019), who use data from approximately 62,000 gas wells drilled in Texas between 2000-2015 to determine price-responsiveness across the supply process. The study assesses the decision to drill the well, well completion, and produce gas over time and, of these, finds drilling activity to be the most responsive to changes in price. EnergySub makes use of the gas price response values broken out for conventional and unconventional wells, though the study notes that these values may not differ significantly from each other statistically. For offshore production in the lower 48, EnergySub uses the same 0.19 elasticity as for offshore oil production in the lower 48, obtained through the expert input process described above. For onshore and offshore production in Alaska, EnergySub uses elasticity values derived from specialized simulations of NEMS, as detailed below. For other gas production, EnergySub applies the supply elasticity reported in Brown (1998).

Table 2. EnergySub Default Supply Elasticities

FUEL	SOURCE/ SUPPLY ELASTICITY			
Oil	Lower 48 Onshore Non-Tight[1]	0.93	Other[2]	0.67
	Lower 48 Onshore Tight[1]	0.73	Biodiesel[4]	0.24
	Lower 48 Offshore[2]	0.19	Rest of World[2]	0.28
	Alaska Onshore[3]	0.42	Natural Gas Plant Liquids[2]	0.67
	Alaska Offshore[3]	0.58	Canadian Pipeline Imports[2]	0.38
Natural Gas	Lower 48 Conventional[5]	0.75	Alaska Offshore[3]	1.29
	Lower 48 Unconventional[5]	0.68	Other[7]	0.51
	Lower 48 Offshore[6]	0.19	Pipeline Imports[8]	0.52
	Alaska Onshore[3]	1.29	LNG Tanker Imports[9]	1.00
Electricity	Oil[10]	0.22	Hydro[3]	0.05
	Natural Gas[3]	1.50	Wind Onshore[3]	0.65
	Coal[10]	0.27	Wind Offshore[3]	0.01
	Nuclear[3]	0.53	Solar[3]	2.03
	Other Electric[3]	0.68	Imports[3]	0.36
Coal	Northern Appalachia[11]	2.66	WY PRB – North[10]	5.50
	Central Appalachia[11]	4.62	WY PRB – South[11]	3.15
	Southern Appalachia[11]	1.50	Western Wyoming[11]	0.73
	East Interior[11]	7.40	Rocky Mountain[11]	2.43
	West Interior[11]	0.47	Arizona/New Mexico[11]	3.78
	Gulf Lignite[11]	1.72	Alaska/Washington[11]	0.60
	Dakota Lignite[11]	4.46	Imports[3]	1.00
	Western Montana[11]	5.46		

Notes:

1. Newell and Prest (2019).
2. Expert input from C. Mason, G. Roberts, & S. Blumsack, as cited in Industrial Economics Inc. (2021).
3. Derived from AEO (2020).
4. Luchansky and Monks (2009).
5. Newell, Prest & Vissing (2019)
6. Assumed to be the same as Oil, Lower 48 Offshore
7. Brown (1998).
8. Derived from specialized NEMS run of the AEO 2015 provided to DOI by EIA.
9. Assumed value.
10. Derived from AEO 2018, as provided by BOEM (2018).
11. Derived from NEMS 2019 Reference Case supplemental data provided to BLM by EIA.

For coal supply, EnergySub uses supply elasticities unique to each of the 14 coal supply regions, as derived from annual supply curve data generated by NEMS' Coal Market Module (CMM).[11] The annual supply curve data provided by EIA represent 41 distinct coals for a given year for combinations of coal supply region, sulfur content, mining method, and rank. For example, the Central Appalachia coal supply region has five different supply curves for a given year, representing a mix of low- and medium-sulfur coal, underground and surface mines, and premium and bituminous coals. In addition, the annual supply curve for each of the 41 coals is represented as 11 data points, with each data point representing production at a given price point.

Using the EIA data, we estimated supply elasticities for each of the 41 coal types, for every year between 2019 and 2040. To generate elasticity values, we applied the standard econometric method of regressing the log-transformed price on the log-transformed quantity, which yielded the elasticity of supply as the

[11] While not publicly available, EIA provided these supply curve data for the purposes of this project and provides them to other modelers on a regular basis.

coefficient. Each regression was performed over the three central points of the appropriate supply curve. The following equation displays this regression:

$$\ln(Q_{s,t}) = \beta_{s,t}\ln(P_{s,t}) + \beta_0$$

Where:

$Q_{s,t}$ represents the quantity supplied on supply curve *s* in year *t*,

$\beta_{s,t}$ represents the elasticity of supply for supply curve *s* in year *t*[12],

$P_{s,t}$ represents the price of coal on supply curve *s* in year *t*, and

β_0 represents the regression constant.

Running the above regression for each of the 41 supply curves for every year between 2019 and 2040 yields an initial set of elasticities. To convert the year-specific and supply curve-specific results to regional supply elasticities, we developed a weighted average coal supply elasticity for each of the 14 coal supply regions across all years, using the quantity associated with the coals produced by each coal supply region as weights. Table 4 above displays the results of the supply elasticity calculation for each coal supply region.

Where appropriate economic research does not exist or could not be obtained for a specific supply elasticity value, projections from the *AEO* were used to infer these values.[13] Elasticity estimates may be inferred from the *AEO* projection for a given year by comparing the differences in energy prices between two scenarios with the differences in energy quantities. For a given energy source and fuel, an annual inferred elasticity value was calculated three times: (1) based on the low oil price case vs. the high oil price case, (2) the low price case vs. the reference case, and (3) the reference case vs. the high price case, for all *AEO* projection years from 2017 through 2040. The formula for this annual inferred elasticity is as follows.

$$\eta_t = \frac{\ln\left(\frac{Q_{A,t}}{Q_{B,t}}\right)}{\ln\left(\frac{P_{A,t}}{P_{B,t}}\right)}$$

Where η_t is the inferred elasticity in year *t*, $Q_{A,t}$ and $Q_{B,t}$ represent the quantities supplied in year *t* for cases *A* and *B* respectively (each case is compared with both of the other cases), and $P_{A,t}$ and $P_{B,t}$ are the prices at time *t* for cases *A* and *B*. The resulting series of inferred elasticities are averaged, excluding extreme outlier results derived from the *AEO* data.[14]

For a limited number of producing sectors, elasticity values were unavailable from the literature and the data generated by the constrained NEMS run or recent editions of the AEO yielded elasticity values that

[12] Coal supply elasticities are also represented as η_{cr} in Equation 1.

[13] In some cases, the supply elasticities were derived from prior releases of the AEO rather than AEO 2020 when results from the 2020 data resulted in unrealistic elasticity values.

[14] More specifically, elasticities were estimated based on differentials between the low-price case and reference case, the reference case and the high-price case, and the low-price case and the high-price case. They then were averaged across these three variants and across years.

appeared unrealistically high or were insufficient to support estimation of a supply elasticity. In such cases, EnergySub uses a default supply elasticity of 1.0.

11. Limitations

As described above, EnergySub uses a system of equations to create a mathematical representation of complex energy markets which enables analysts to gain insights into the potential market impacts associated with BLM management decisions. While the methods applied in EnergySub are transparent and well documented, EnergySub is subject to limitations like any other model that tries to simplify real world phenomenon.

EnergySub is not a national forecasting model or a replacement for EIA's NEMS model or the energy projections they develop with it. As designed, EnegySub assesses energy market impacts associated with a specific production scenario at a relatively high level and lacks much of the detail that enables NEMS to disaggregate energy supply and demand to a fine degree (e.g., for individual residential uses of natural gas, such as home heating and cooking). EnergySub includes a simpler representation of supply and demand decisions than NEMS, with supply and demand responses for a given energy source estimated based on its price and the price of substitutes. In contrast, NEMS simulates energy supply and demand decisions based on a number of factors not explicitly represented in EnergySub. On the demand side, such factors may include projected changes in building shell characteristics over time and demand for the underlying services that energy supports (e.g., transportation services), while on the supply side such factors may include mineral ownership, differences in drilling costs across basins or the physical characteristics of oil in different basins (e.g., API gravity or sulfur content). Although many of these factors are captured implicitly in EnergySub modeling through the model's calibration to the long-run market conditions developed with the more detailed NEMS model, EnergySub is unable to provide insight into effects on narrowly defined segments of foreign or domestic energy submarkets, or how more nuanced aspects of producer or consumer decision-making may affect energy market conditions.

Related to the level of detail in which EnergySub represents individual energy markets, its electricity market represents the supply and demand for power at a high level, both temporally and across different sources of energy. While EnergySub assesses all energy markets—including electricity—on an annual basis, more detailed models of electricity markets capture variation in demand and the composition of electricity supply between peak, off-peak, and shoulder periods during the year. More detailed models, like NEMS, also capture temporal variations in the availability of renewable electricity resources, and the extent to which generation from these resources coincides with peak electricity demand. Because different electricity production technologies may be on margin at different times of the day, the representation of timing of renewable energy availability can be an important factor in modeling substitution between renewables and non-renewable fuel source. EnergySub's representation of the electricity sector also does not explicitly include transmission constraints, reliability requirements, or emissions limits (e.g., the regional cap on power sector CO2 emissions for states participating in the Regional Greenhouse Gas Initiative), all of which affect the degree to which fuel switching can occur within electricity supply regions.

Another nuance not captured in EnergySub is imperfect competition. EnergySub uses a simplifying assumption that all energy markets are perfectly competitive, though there are a number of clear departures from perfect competition in the U.S. and across the globe. For example, OPEC engages in non-competitive behavior in world oil markets that affect oil production and the price of oil (and therefore its substitutes). Imperfect competition can also be observed in the U.S. market for electricity, where a number of domestic policies mandate that a certain portion of the electricity consumed in some jurisdictions be produced from renewable sources. Because EnergySub does not capture these and other elements of imperfect competition, it provides a parsimonious representation of potential market responses which may lead to the overestimation or underestimation of some market metrics.

EnergySub relies on elasticity parameters from empirical literature, across all sectors of the energy market, to model how supply and demand may change in response to changes in prices. Estimates from empirical literature reflect historical relationships between energy prices and the behavioral responses of energy producers and consumers. As energy markets continue to evolve in the future, elasticity parameters reflecting historical behavioral responses may become less representation of future production and consumption responses. For example, as electric heat pumps become more efficient for building heating, the residential and commercial elasticity of demand for electricity (and the cross-price elasticity relationship between natural gas and electricity in these sectors) may change over time. In the transportation sector, cross-price elasticity values for oil and electricity are likely to become increasingly important as electric vehicles becomes a more viable option for many U.S. vehicle owners. Although real-world energy consumption patterns and market responses may change over the long run, elasticities within EnergySub are held constant because simulations for long-run production scenarios cannot be broken into shorter segments with model specifications adjusted manually between different segments of time. Changes in behavior responses of energy producers and consumers over time are, however, implicit in the supply, demand, and price projects from NEMs which EnergySub calibrates to.

BLM acknowledges there are limitations to EnergySub and that some potential market responses may have been over or underestimated. Nevertheless, results from EnergySub modeling still provide valuable insights into how BLM management decisions may affect future energy market conditions.

12. Application of EnergySub to the CPSEIS

EnergySub was used as a tool to compare unobservable long-run market conditions with and without potential oil produced from the Coastal Plains region to gain insights to how oil produced from this region may affect future energy prices, production, and consumption. As discussed above, EnergySub relies on long-run energy projections developed by the EIA to establish an initial market equilibrium that simulated market responses could be calibrated to. EnergySub was calibrated to domestic supply, demand, and price projections for electricity and energy fuel sources from the AEO 2023 Reference case, with supplemental information from EIA's June 2023 Short Term Energy Outlook, the International Energy Agency's 2022 World Energy Outlook, and natural gas pipeline imports data derived by Industrial Economics, Inc. in order to model interactions with U.S. and non-U.S. markets in greater detail (EIA 2023a, IEA 2022, EIA 2023d, IEc 2023). These projections reflect leading energy expert's best assessment of how U.S. and foreign energy markets will operate through 2050 based on key assumptions. Although alternative projections exist, EIA describes the Reference case as an experimental control which serves as a baseline from which the impacts of alternative scenarios and assumptions can be compared against (EIA, 2023c). The BLM considered using alternative energy projections developed as AEO side cases but decided to refrain from introducing its own assumptions about long-term market conditions and calibrated the model to supply and demand projections from the Reference case.[15]

AEO projections for domestic oil and gas production are developed within NEM's Oil and Gas Supply Module based on estimates of total technically recoverable resources within the U.S. AEO 2023 supply projections include production in Alaska between 2023 and 2050 from both existing fields, expansion fields where operators have announced projects, and undiscovered fields that most likely exist based on

[15] When developing annual energy projections, EIA runs side cases to show how NEMS responds to changes in key input variables compared with the modeled results from the Reference case.

the region's geology. AEO 2023 also includes assumptions about future production from the Coastal Plains in ANWR (EIA, 2023c). Since AEO projections reflect what market conditions may look like with production from the Coastal Plains, EnergySub was used to simulate market responses to foregoing oil projected under the RFDs for Alternatives B, C, and D in order to create a counterfactual of what energy market conditions may look like in the absence of oil from the Coastal Plains.

Substitution effects estimated by EnergySub include estimates of alternative energy fuel sources likely to be consumed in place of forgone oil production from the Coastal Plains and net changes in the overall demand for electricity and energy fuel sources over the 30-year planning period. Conversely, these energy substitutions can be interpreted as the consumption of alternative energy sources displaced by oil produced from the Coastal Plains. Simulated market responses also yield insights into how future foreign oil consumption (i.e., foreign demand for U.S. and non-U.S. produced oil) may change in response to changes in the supply of U.S. oil. Substitution effects and changes in foreign oil consumption were there used as inputs to calculate potential net changes in emissions.

12.1 Energy Substitution Effects

EnergySub estimates displaced energy substitutes by converting all consumption of energy into barrel of oil equivalents (BOE) to enable the comparison of energy consumption across fuel sources and energy uses. Estimates of electricity and energy fuel sources potentially displaced by oil produced under Alternatives B, C, and D are reported below in Table 3. Over the 30-year planning period, simulated substitution effects were similar across these three action alternatives. Results from modeling revealed that oil produced from the Coastal Plains would primarily displace oil produced from other domestic reserves, including from Alaska offshore minerals and onshore and offshore minerals in the lower-48, or imported from foreign producers. Approximately 18% of oil produced under Alternatives B, C, and D was simulated to displace oil that would have been produced elsewhere domestically, while 64% of oil likely to be produced under these alternatives was simulated to displace oil that would have otherwise been imported via tankers or pipelines.

Crude oil is a global commodity traded in a world market where prices are determined by global supply and demand. Increased U.S. oil production from Alaska's Coastal Plains was simulated to have a marginal effect on global oil prices, even during peak production under the alternatives. Increases in the U.S. oil supply during peak production were simulated to decrease the price of a barrel of oil by 0.33% (~ 35¢) under Alternative B, 0.32% (~ 32¢) under Alternative C, and 0.17% (~ 15¢) under Alternative D. Although these are small decreases in the per barrel price of oil, they are likely to serve as a catalyst for fuel switching, where consumption of oil increases as energy derived from alternative fuel sources becomes less cost competitive with oil.

These simulations revealed that nearly 11% of oil produced over the next 30 years under each of the action alternatives would displace energy that the residential, commercial, transportation, and electricity sectors would have consumed from other renewable and non-renewable fuel sources had this production been foregone. As shown in table 3, approximately 1.9% of this displaced demand for energy from alternative sources stemmed from reduced consumption of energy derived from burning natural gas and coal. The energy equivalency of about 8% of the oil that would be produced under the alternatives was simulated to replace energy that would have come from biofuels and natural gas liquids, while another 0.9% of oil produced from the Coastal Plains over the next 30 years would crowd out electricity that would have been generated from low-carbon sources – including wind, solar, hydro or nuclear power.

In addition to displacing energy from alternative energy sources, oil production in the Coastal Plains was simulated to increase overall U.S. energy demand over the 30-year planning period. While reductions in the consumption of electricity, coal, and natural gas would be the energy equivalency to slightly less than 3% of oil projected to be produced under the action alternatives, nearly 10% of total oil produced under the alternatives would represent new demand for oil that would have been unrealized at higher prices. The net effect of future oil production in the Coastal Plains on overall energy demand over the 30-year planning period would be positive, ranging from 28 MMBOE under Alternative D to 75MMBOE under Alternative B.

Table 3: Displaced Fuels and Changes in Demand

Substitution Effects 2032 - 2053			
	Alt B	Alt C	Alt D
Percent of Oil from Coastal Plains that:			
Displaces Domestic Oil	17.7%	17.8%	17.9%
Displaces Oil Imports	64.4%	64.4%	64.4%
Displaces Natural Gas	1.5%	1.5%	1.5%
Displaces Natural Gas Imports	0.1%	0.1%	0.1%
Displaces Coal	0.3%	0.3%	0.3%
Displaces Biofuels and NGL	8.0%	7.9%	7.8%
Displaces Electricity from non-Fossil Fuel Sources	0.9%	0.9%	0.9%
Changes in Demand *			
Oil	9.7%	9.7%	9.7%
Natural Gas	-1.3%	-1.3%	-1.3%
Coal	-0.2%	-0.2%	-0.2%
Electricity	-1.1%	-1.1%	-1.0%

*Change in demand does not represent displaced consumption of electricity or energy from substitute energy sources.

12.2 Changes in Foreign Oil Consumption

As outlined in Section 4 (Oil Market), EnergySub models a single foreign oil market using a limited number of supply and demand equations. Foreign oil consumption is equal to non-U.S. demand for U.S. crude oil plus non-U.S. demand for U.S. refined products and non-U.S. demand for oil from non-U.S. sources. Changes in foreign oil consumption are strictly a function of global oil prices, where demand for both U.S. and non-U.S. oil increases as global oil prices decrease.

As discussed above, production under the action alternatives would contribute to lower oil prices. Since oil is a global commodity, lower oil prices are beneficial to domestic and foreign consumers and spur additional demand for oil produced from both U.S. and non-U.S. sources. Price effects associated with peak production were simulated to increase total foreign demand by 17.8 million barrels (MMb) under Alternative B, 16.7 MMb under Alternative C, and 8.5 MMb under Alternative D. Relative to market conditions where oil from the Coastal Plains is foregone, total foreign demand for oil would increase by 244.4 MMb under Alternatives B, 229.6 MMb under Alternative C, and 92.5 MMb under Alternative D over the 30-year planning period. Although some of this demand constitutes new demand for U.S. crude and refined oil products, approximately 88% of this increased foreign demand was simulated to be met with oil produced from non-U.S. reserves. Since modeling impacts to narrowly defined segments of energy submarkets is beyond the modeling capabilities of EnergySub, it is unclear which foreign and domestic submarkets would increase production to meet this additional demand by non-U.S. consumers.

12.3 Uncertainty

The EnergySub results presented above reflect modeled market responses and energy substitutes that may be displaced by oil from the Coastal Plains. These energy substitutes also reflect the energy source most likely to replace foregone oil if production in the Coastal Plains did not occur. They were derived using baseline projections of what energy markets will look like through 2050, elasticities which provide measures for how supply and demand between alternative energy sources may change in response to changes in prices, and production schedules developed with limited information on the amount of recoverable oil reserves which could be economically produced from the Coastal Plains. Results from the modeling are an estimation of what may happen in the future based on key assumptions about market conditions and production under alternative production scenarios.

Energy markets are dynamic and projections about future market conditions are inherently uncertain because many of the events that shape patterns of energy consumption and production cannot be predicted with certainty. The baseline projections used for this modeling reflect EIA's best assessment of how markets will operate through 2050 under a simplifying assumption that current regulations and consumption patterns will not change over the long term (EIA 2023).[16] BLM acknowledges that new laws and policies governing energy production, efficiency, and GHG emissions are likely to be enacted, and that these regulations may have significant implications for energy markets and substitutes in the coming decades. EIA will continue to incorporate new legislature and regulations into their modeling as funding and implementing regulations for them are enacted, and BLM will continue to evaluate the suitability of new data for future calibration of EnergySub.

The EnergySub modeling for the CPSEIS does not account for structural changes that would have to occur within energy markets to meet climate commitments and achieve net-zero emission goals. As the U.S. works towards achieving net-zero, energy production and consumption patterns will change. Energy markets may become increasingly electrified through greater deployment of renewable energy sources, enabling sectors that have historically been heavily reliant on fossil fuels to reduce their demand and consumption of carbon intensive energy sources. Technological innovation will also play a significant role in transforming how energy will be produced and consumed, though its implications for specific fuel sources and uses is not known at this time since many of the technologies have yet to be developed or economically scaled for widespread adoption.

Even in a low carbon future, fossil fuels are likely to continue to play a role in the U.S.'s energy portfolio. Princeton's Net-Zero America Project has been developing pathways to achieve net-zero emissions by 2050 using existing technologies. Four of their five pathways projected that oil and gas consumption would continue beyond 2050, and that carbon capture and sequestration technology would play an

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[16] The version of NEMS used by EIA to produce the AEO 2023 included current legislation and environmental regulations for which implementing regulations were available as of the end of November 2022. The potential effects of proposed or hypothetical federal and state legislation, regulations, and standards—or sections of legislation that have been enacted but lacked funds to execute or did not have the required implementing regulations in place as of the end of November 2022—were not reflected in NEMS when the AEO 2023 projections were developed. Additional information on the assumptions underlying the AEO 2023 Reference case are available at www.eia.gov/outlooks/aeo/assumptions/

important role in offsetting emissions. Under their fifth scenario, oil and gas are phased out by 2050 but oil continues to account for more than 20% of the energy fuel mix until the late 2030’s (Larson et al. 2020). Researchers and industry experts are continuing to explore potential pathways for decarbonization and the role of fossil fuels and other energy sources in a low carbon economy is still uncertain. Specific data on how the energy transition will affect demand for fossil fuels and alternative energy sources is not yet available.

BLM acknowledges that energy substitutes for oil produced from the Coastal Plains may look significantly different in a low carbon future, and that modeling substitution effects using data that depicts current energy markets and historical market responses produces results that may overestimate and underestimate some energy market metrics. As the energy transition progresses, reliance on other supply sources of oil (including other domestic production in the Lower 48 and foreign imports) to replace energy associated with oil from the Coastal Plains may wane over the 30-year planning period. However, the timing and degree to which domestic energy markets may become less reliant on these alternative sources of supply is highly uncertain. BLM will continue to evaluate and update its methods for estimating energy substitutes as new energy statistics and information becomes available.

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