TOTAL E&P PNG LIMITED

PAPUA LNG

Upstream Environmental Impact Statement

Volume 3: Technical Studies

Part 2

Air Quality Modeling for Impact Assessment

TOTAL

TOTAL E&P PNG LIMITED

PAPUA LNG PROJECT

Air Quality Modeling for Impact Assessment

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FOREWORD

The air dispersion modeling study presented in this report for the Papua LNG Project included emissions estimation and dispersion modeling for two different operations phase scenarios for the proposed upstream central processing facility (CPF):

- **HP/incineration:** High pressure (HP) mode without acid gas injection and no additional compression of product gas, with transport of the gas to the PNG LNG Plant by gravity.
- **MP/LP and Acid Gas Injection:** Acid gas injection into Elk reservoir with additional gas compression for transport, and thermal oxidizer on standby.

Since the modeling was performed, the Base Case design for the HP/incineration phase has changed. The stack and emission data used in the modeling for this scenario were based on a pre-FEED design option of using a sulfur recovery unit to remove 95% of the hydrogen sulfide (H_2S) from the acid gas prior to incineration in the thermal oxidizer which would then convert the remaining 5% of the H_2S to sulfur dioxide (SO_2) before emission to atmosphere. The revised Base Case design for this phase of operations now has the acid gases first being incinerated using a thermal oxidizer to convert all of the H_2S to sulfur dioxide (SO_2), with the exhaust gases then undergoing treatment to remove 95% of the SO_2 from the flue gas, via a caustic wash, prior to discharge to the atmosphere.

While the SO_2 emission rate for both options is the same, the revised Base Case design will result in changes in the exhaust gas flowrate and stack conditions (temperature, moisture content and exit velocity) compared to the values used in the modeling. The implications of these changes on the modeling results presented for this scenario are discussed in an addendum appended to this report.

EXECUTIVE SUMMARY

Joint venture partners are currently planning the development of the Elk-Antelope gas field, which is located within Petroleum Retention License 15 (PRL-15) in Gulf Province, Papua New Guinea. Total E&P PNG Limited, a wholly owned subsidiary of TOTAL, has the largest interest in the Elk-Antelope gas field and is the operator of the Papua LNG Project (the Project) on behalf of the other joint venture partners. The Project will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to a LNG Plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby.

This technical report presents the method and results of an air dispersion modeling study undertaken for the Project. The objective of the air quality modeling study was to provide predictions of worst-case off-site concentrations of air pollutants that are anticipated to be emitted during the operations phase of the CPF, to inform the assessment of the potential impact of these emissions on biophysical environmental values for the environmental impact statement (EIS).

This report also presents the methods and results of a qualitative risk-based assessment used to assess potential impacts on surrounding sensitive uses associated with fugitive dust emissions from construction activities proposed as part of the Project.

Air Dispersion Modelling Study for the CPF

Emissions estimation and dispersion modeling was performed for two different operations phase scenarios for the CPF. The operating scenarios selected for modeling were identified in consultation with TOTAL and were chosen to represent normal operations at different stages in the life of Project. The operating scenarios modeled were:

- **HP/incineration:** High pressure (HP) mode without acid gas injection, with the acid gases undergoing treatment to remove the sulfur from the gas and then being incinerated using a thermal oxidizer to convert residual hydrogen sulfide to sulfur dioxide, prior to discharge to the atmosphere. No additional compression of product gas (transport of the gas to the PNG LNG Plant by gravity).
- **MP/LP and Acid Gas Injection:** Acid gas injection into Elk reservoir with additional gas compression for transport, and thermal oxidizer on standby.

Upset operating conditions, involving flaring of gas at the CPF, are beyond the scope of this modeling study and are considered as part of the hazard risk assessment in the EIS.

The pollutants that were assessed for each operating scenario were:

- Nitrogen dioxide (NO_2).
- Sulfur dioxide (SO_2).
- Carbon monoxide (CO).
- Volatile organic compounds (VOCs, including benzene, toluene, ethylbenzene and xylene).

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Air dispersion modeling was performed using the United States Environmental Protection Agency (US EPA) approved CALPUFF (Version 6.42) modeling system. The CALPUFF model requires hourly temperature, wind and other meteorological data on a three-dimensional gridded modeling domain that are required as inputs. For this study, the meteorological data inputs were compiled using the Weather Research and Forecast (WRF) and CALMET meteorological models. As part of the meteorological modeling, two one-year (2014 and 2015 calendar years), three-dimensional meteorological datasets based were compiled, covering the CPF and surrounding area. No significant differences in the meteorological datasets for 2014 and 2015 were observed in relation to the key parameters associated with plume dispersion, hence the 2015 year was used in the modeling.

The modeling was performed using a 15 km by 15 km receptor grid with 100-m spacing, centered over the CPF. In addition to the gridded receptors, discrete receptors were included in the model to represent identified sensitive receptor locations in the surrounding area. Background concentrations of the modeled pollutants were assumed to be negligible given the absence of any significant combustion or industrial sources in the region surrounding the CPF.

As PNG does not have any ambient air quality standards, these criteria have been identified based on a review of relevant air quality criteria and guidelines for NO_2, SO_2 and VOCs set by the World Health Organization (WHO) and other agencies, including (in order of priority):

- International Finance Corporation (IFC) EHS guidelines.
- World Health Organization (WHO) Air Quality Guidelines.
- United States Environmental Protection Agency (US EPA) standards.
- European Commission Air Quality Standards.
- Texas Commission of Environmental Quality (TCEQ) Effects Screening Levels (ESLs) for individual VOCs.

The maximum predicted ground level NO_2, SO_2 and CO concentrations are presented in **Table ES-1** compared to the ambient air quality criteria adopted for the assessment. Results are presented for the three nearest sensitive receptors identified in the vicinity of the CPF and as 'maximum off-site' predictions. These maximum off-site concentrations have been extracted from the model output files based on the area proposed to be cleared as part of the CPF construction. They are therefore considered to be worst case estimates of maximum off-site concentrations as the fence line will most likely be further away from the cleared area and the sources than that assumed in the modeling.

Under normal operations scenarios, modeled maximum off-site concentrations do not exceed adopted ambient air quality criteria for any of the pollutants assessed. The maximum predicted benzene, ethylbenzene, toluene and xylene concentrations were all less than 0.01 $\mu g/m^3$.

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Table ES1 Modeling Results

Pollutant	Averaging Period	Maximum Predicted Ground Level Concentrations (µg/m^3)				Ambient Air Quality Criteria (µg/m^3)
		Poroi 1	Mapaio Fish Camp	Herd Base	Maximum Off-site	
Years 1 to 4 Normal Operations						
NO_2	1-hour	44.7	13.6	27.3	109.6	**200**
	Annual	0.3	0.1	0.6	5.9	**40**
SO_2	10-minutes	13.1	1.9	9.6	47.5	**500**
	1-hour	9.2	1.4	6.7	33.2	**200**
	24-hours	0.6	0.1	0.5	4.7	**20**
CO	1-hr	9.0	2.9	5.9	62.3	**30,000**
	8-hr	2.6	1.1	1.0	18.2	**10,000**
Years 5 to 10 Normal Operations						
NO_2	1-hour	50.1	26.8	55.4	129.3	**200**
	Annual	0.6	0.1	1.0	15.5	**40**
SO_2	10-minutes	4.7	1.5	3.4	33.8	**500**
	1-hour	3.3	1.0	2.4	23.6	**200**
	24-hours	0.4	0.1	0.2	3.4	**20**
CO	1-hr	11.9	6.9	16.2	123.7	**30,000**
	8-hr	3.7	2.9	3.2	57.9	**10,000**

Construction Dust Impact Assessment Method

To assess the potential for impacts from fugitive dust emissions that will be generated by the various construction activities proposed as part of the Project, the Institute of Air Quality Management (IAQM) *Guidance on the Assessment of Dust from Demolition and Construction* (IAQM, 2014) has been used to provide a risk-based approach to assess the potential for these activities to result in any off-site air quality impacts. While the IAQM guidance is anticipated to provide a conservative assessment of the potential risks, it is the method that has been adopted in a number of PNG air quality impact assessments.

The IAQM method uses a four-step process for assessing dust impacts from construction activities:

- Step 1: Screening based on distance to the nearest sensitive receptor; whereby the sensitivity to dust deposition, human health impacts and ecological impacts of the identified sensitive receptors is determined.
- Step 2: Assessing risk of dust effects from activities if no controls are applied based on:
  - (a) the scale and nature of the works, which determines the potential dust emission magnitude.
  - (b) the sensitivity of the area surrounding dust-generating activities.

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- Step 3: Determining the levels of mitigation required based on the identified risk of off-site impacts.
- Step 4: Assessing risk of residual dust effects after management measures have been considered.

Based on the IAQM method approach, the risk of air quality impacts associated with fugitive dust emissions from each construction activity has been derived as presented in **Table ES2**.

Table ES2 Assessment of Potential Fugitive Dust Impacts from Construction

Value	Construction Activity	Sensitivity of the Area	Magnitude of Dust Emissions		Risk of Air Quality impacts	
			Earthworks	Construction	Earthworks	Construction
Dust soiling Human heath	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Export pipeline route	Low	Medium	Small	Low	Negligible
	Export pipeline shore crossing site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Low	Medium	-	Low	-
	Purari Airstrip extension	Low	Large	Medium	Low	Low
Ecological	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Export pipeline route	Medium	Medium	Small	Medium	Low
	Export pipeline shore crossing site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Medium	Medium	-	Medium	-
	Purari Airstrip extension	Low	Large	Medium	Low	Low

Note: While pre-mitigation risk assessment is not generally applied in this EIS, an exception is made in this instance due to application of the IAQM method.

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1 Introduction

Joint venture partners are currently planning the development of the Elk-Antelope gas field, which is located within Petroleum Retention License 15 (PRL-15) in the Gulf Province, Papua New Guinea. Total E&P PNG Limited (hereafter referred to as TEP PNG), a wholly owned subsidiary of TOTAL, has the largest interest in the Elk-Antelope gas field and is the operator of the Papua LNG Project (the Project) on behalf of the other joint venture partners.

The Elk-Antelope gas field is a significant gas discovery in Papua New Guinea consisting of a gas reservoir with an estimated 7.2 trillion cubic feet (Tcf) of gas reserves and up to 100 million stock tank barrels (MMstb) of condensate located approximately 120 km inland from the township of Kerema, and 360 km northwest of Port Moresby (refer **Figure 1**).

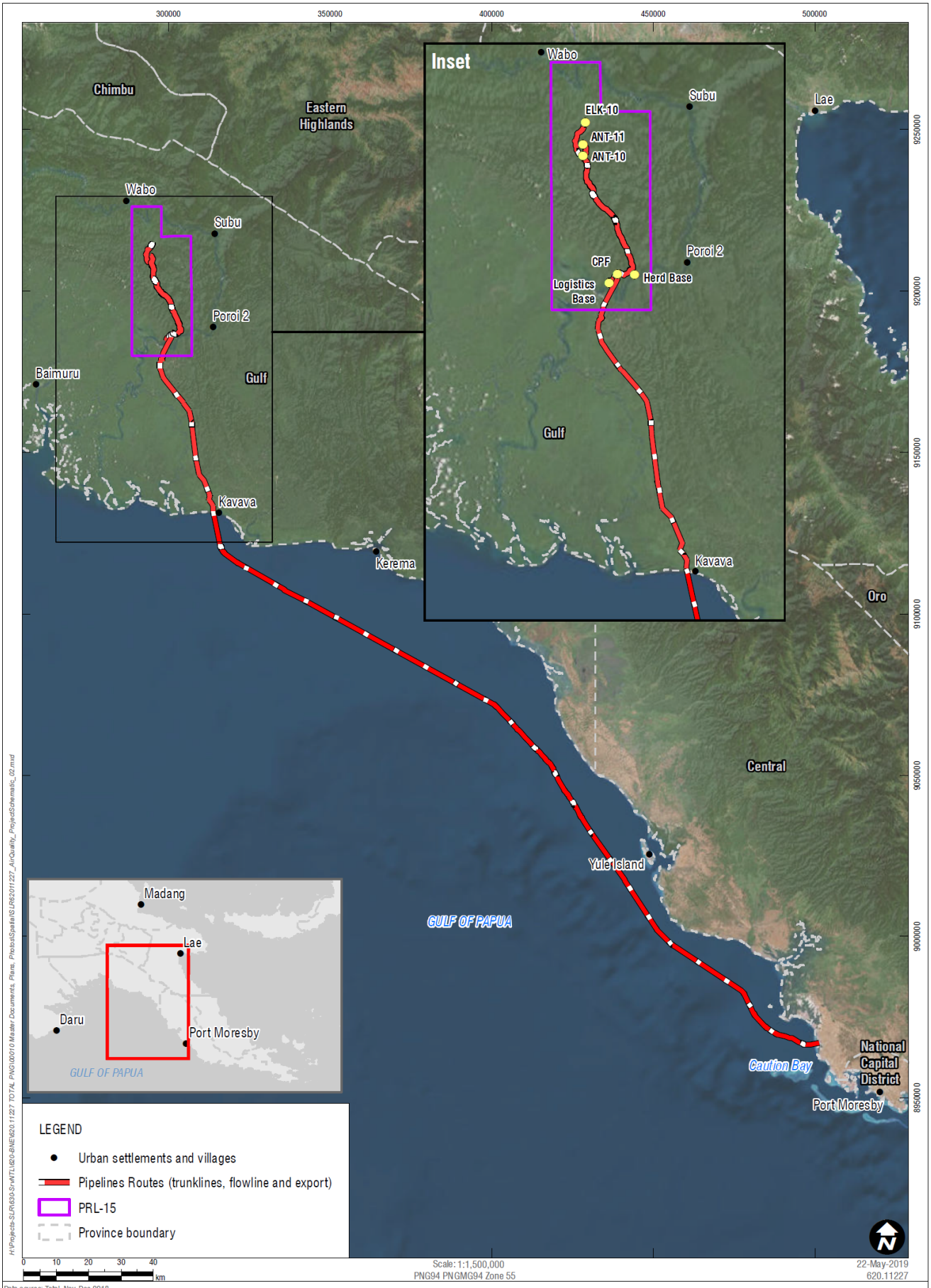
The Project will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to new Liquefied Natural Gas (LNG) facilities to be co-located within existing PNG LNG facilities at Caution Bay, Central Province, 20 km northwest of Port Moresby. The new LNG facilities at Caution Bay are subject to a separate environment impact statement (EIS) and approvals process. The design life for the Project will be 25 years.

The Project area comprises the physical footprint of the various Project components and associated infrastructure as detailed below.

- Producing and processing the gas:
  - Wellpads and the associated gathering system (including flowlines and trunklines).
  - CPF.
- Transporting the gas:
  - Onshore export pipeline to shore crossing on the Gulf coast including valve stations.
  - Offshore section of the export pipeline to LNG Plant site, Caution Bay.
- Infrastructure:
  - Camps.
  - Pipeyards.
  - New roads and upgrades.
  - Quarries.
  - Waste facilities including landfills.
  - Logistics base and river offloading facilities.
  - Purari airstrip extension.

River transport will be via the Purari and Ivo-Urika rivers.

This report presents the method and results of an air dispersion modeling study undertaken for the Project. It also presents a summary of the qualitative risk-based assessment method used to assess potential air quality impacts associated with fugitive dust emissions from construction activities proposed as part of the Project.



Project Schematic

FIGURE 1

2 Study Objectives

SLR Consulting Pty Ltd (SLR) has been commissioned by ERIAS Group on behalf of TEP PNG to undertake an air quality assessment as part of the Papua LNG Environmental Impact Statement (EIS). This report presents the following:

- A review of the potential air emissions sources associated with the Project and identification of those requiring assessment.
- The method, inputs and results of an air dispersion modeling study undertaken to assess the potential off-site air quality impacts associated with the most significant air emission sources identified for the Project, i.e., the proposed stack emission sources at the CPF.
- The method, inputs and assumptions used to perform a qualitative risk-based assessment of potential air quality impacts associated with fugitive dust emissions from construction activities proposed as part of the Project.

The objective of the air dispersion modeling study was to provide predictions of potential worst-case off-site concentrations of air pollutants that are anticipated to be emitted during the operations phase of the CPF, to inform the assessment of the potential impact of these emissions on biophysical environmental values. A biophysical environmental value is generally defined as a quality or physical characteristic of the environment that is important to ecological health or public amenity.

The outputs from the CPF air dispersion modeling study presented in this report have been used to inform the air quality impact assessment for the Project that is presented in the EIS (Volume 1). The modeling is supported by the air quality baseline study prepared by SLR for the upstream Project area, which included the compilation of a one-year, three-dimensional meteorological dataset suitable for use in the dispersion model, identification of sensitive receptor locations and characterization of the existing air quality within the study area[1] (Part 19 of Volume 2).

Activities with a lower potential for impacts on local air quality have been assessed qualitatively. To assess the potential for impacts from construction dust, the *IAQM Guidance on the Assessment of Dust from Demolition and Construction* (IAQM, 2014) has been used to provide a risk-based approach to assess the potential for these activities to result in any off-site air quality impacts. This report presents details of the method used to assess the risk of potential impacts from construction dust at sensitive receptor locations, the results of the risk assessment, and thus the level of mitigation anticipated to be required.

[1] The study area for the air quality baseline assessment was defined as any area where air quality may be directly impacted as a result of Project activities, including construction and operation of facilities and infrastructure for the Project. For the purposes of this modeling report, the study area is restricted to areas where air quality may be directly impacted as a result of proposed operations at the CPF.

3 Air Emissions Associated with the Project

Potential emissions to air from the construction, operations and decommissioning phases of the Project have been identified in **Table 1**.

Products of fuel gas combustion and process emissions from the CPF operation have been identified as requiring a detailed quantitative assessment using air dispersion modeling due to potential human health impacts associated with NO_X, CO, SO_2 and VOC emissions.

The construction phase activities identified as requiring an assessment of potential fugitive dust emissions using the IAQM method are earthworks and construction activities associated with the:

- CPF.
- Logistics Base.
- Onshore export pipeline (including the shore crossing area at Orokolo Bay).
- Access roads.
- Purari Airstrip extension.

For other potential emission sources, e.g., wellpads, flowline and trunklines, a qualitative assessment of potential air quality impacts has been performed based on the nature and scale of activities proposed and the distance to sensitive receptors, and is presented in the EIS (Volume 1).

Table 1 Summary of Identified Potential Air Emissions

Project Component	Emissions to Air	Activities/Air Emission Sources
Construction Phase		
Wellpads	Particulate matter	Clear and grade activities, earthworks
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from drill rigs, mobile machinery and generators
CPF	Particulate matter	Clear and grade activities, earthworks
	NO_x, CO, SO_2, VOCs	Exhaust emissions from construction equipment and generators
Logistics Base	Particulate matter	Clear and grade activities, earthworks
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from construction equipment and generators
		Exhaust emissions from barges/ferries travelling to/from the Logistics Base and from barges and forklifts during unloading
Roads	Particulate matter	Clear and grade activities, earthworks
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from road construction equipment, and wheel-generated dust and exhaust emissions from construction-related traffic using roads once built
Pipelines	Particulate matter	Clear and grade activities, earthworks
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from pipeline construction equipment (including offshore export pipeline construction vessels)
Purari Airstrip	Particulate matter	Clear and grade activities, earthworks during upgrade works
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from aircraft and ground equipment

Project Component	Emissions to Air	Activities/Air Emission Sources
Quarries	Particulate matter	Quarrying, materials handling, wind erosion
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from quarrying equipment and diesel generators
Waste Management	Particulate matter, odor	Disposal of waste via landfill
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs, metals, dioxins and furans, acid gases	Disposal of waste via incineration
	Odor	Wastewater/sewage treatment
Operations Phase		
Wellpads	VOCs	Venting of gas from pig launcher, vent knockout drums
CPF	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Fuel gas combustion and process emissions, including flaring. There will also be minor VOC emissions from leaks and vents.
Logistics Base		Exhaust emissions from barges/ferries travelling to/from the Logistics Base and from barges and forklifts during unloading.
Roads		Wheel-generated dust and exhaust emissions from vehicles using road
Pipelines	VOCs	Venting of gas during pigging and maintenance activities, as well as VOC emissions from leaks and vents
Purari Airstrip	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Emissions from aircraft and ground equipment
Waste Management	Particulate matter, odor	Disposal of waste via landfill
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs, metals, dioxins and furans, acid gases	Disposal of waste via incineration
	Odor	Wastewater/sewage treatment
Decommissioning Phase		
Wellpads	Particulate matter	Earthworks and rehabilitation activities
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from diesel powered equipment
	VOCs	Venting of gas during decommissioning and capping
CPF	Particulate matter	Earthworks and rehabilitation activities
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from diesel powered equipment plus
	VOCs	Venting of gas during pipeline and vessel blowdowns.
Logistics Base	Particulate matter	Earthworks and rehabilitation activities
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from diesel powered earthworks equipment
		Exhaust emissions from barges/ferries travelling to/from the Logistics Base and from barges and forklifts during unloading

Project Component	Emissions to Air	Activities/Air Emission Sources
Road	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Wheel-generated dust and exhaust emissions from decommissioning-related traffic
Pipeline	VOCs	Venting and pipeline blowdowns
Airstrip	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from aircraft and ground equipment
Quarries	Particulate matter	Quarrying, materials handling, wind erosion
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs	Exhaust emissions from quarrying equipment and diesel generators
Waste Management	Particulate matter, odor	Disposal of waste via landfill
	PM_{10}, $PM_{2.5}$, NO_x, CO, SO_2, VOCs, metals, dioxins and furans, acid gases	Disposal of waste via incineration
	Odor	Wastewater/sewage treatment

4 Environmental Criteria

The Conservation and Environment Protection Authority (CEPA) is the government agency responsible for administering the *Environment Act 2000*. It replaces the former Department of Environment and Conservation (DEC).

The *Environment Act 2000* (Environment Act) is the primary legislation in PNG which regulates the environmental impact of development activities and how adverse effects of such activities should be avoided, remedied or mitigated. The Environment Act caters for the sustainable management of the biological and physical components of the land, air and water resources of the country.

Relevant guidelines have also been published by CEPA (then DEC), including *Guideline for submission of an application for an environmental permit to discharge waste* GL-Env/03/2004, which includes a Technical Guideline (Additional Information) for Air Discharges IB-ENV/02/2004 (DEC, 2004). This document sets out the information that should be provided as part of an application for an Environment Permit where air emissions may be generated. This includes:

- Details of the source, nature, composition and rate of air emissions.
- Information on emissions control equipment and proposed methods to minimize air discharges (specific information for fabric filters, afterburners and wet scrubbers is requested).
- Maintenance procedures and contingency procedures to avoid air discharges from process failure and shut down.
- Stack emission details.
- Calculated ground level concentrations of pollutants proposed to be discharged to air under normal and maximum operating conditions and start up and shutdown conditions.
- An assessment of the impact of the proposal on the environment.

Papua New Guinea does not currently have any statutory ambient air quality standards or stack emission limits, nor are any specified in the Technical Guideline (Additional Information) for air discharges. A review of relevant air quality criteria and guidelines set by other agencies was therefore performed as part of the Upstream Air Quality Baseline Report (Part 19 of Volume 2), including (in order of priority):

- International Finance Corporation (IFC) EHS guidelines (IFC, 2007).
- World Health Organization (WHO) Air Quality Guidelines (WHO, 2000, WHO, 2005).
- United States Environmental Protection Agency (US EPA) standards (US EPA, 2016).
- European Commission Air Quality Standards (EU, 2010).
- Texas Commission of Environmental Quality (TCEQ) Effects Screening Levels (ESLs) for individual VOCs (TCEQ, 2018).

Table 2 summarizes the ambient air quality criteria identified for the Project based on this review. Where multiple guidelines are available from different agencies, the most stringent criteria have been used. The TCEQ ESLs have been used for individual VOCs where standards are not available from other agencies.

Table 2 Identified Project Ambient Air Quality Criteria

Pollutants	Averaging Period	Limit (µg/m^3)	Source
Nitrogen dioxide (NO_2)	1-hour	200	IFC, 2007, WHO, 2005, EU 2010
	Annual	40	IFC, 2007, WHO, 2005, EU 2010
Sulfur dioxide (SO_2)	10-minutes	500	IFC, 2007, WHO, 2005
	1-hour	200	US EPA, 2016
	24-hours	20	IFC, 2007, WHO, 2005
Carbon monoxide (CO)	1-hour	30,000	WHO, 2000, EU 2010
	8-hours	10,000	EU 2010
Benzene	1-hour	170	TCEQ, 2018
	Annual	4.5	TCEQ, 2018
Toluene	1-hour	4,500	TCEQ, 2018
	Annual	1,200	TCEQ, 2018
Ethylbenzene	1-hour	26,000	TCEQ, 2018
	Annual	570	TCEQ, 2018
Xylenes	1-hour	2,200	TCEQ, 2018
	Annual	180	TCEQ, 2018

5 Assessment Method

This section presents the method, inputs and results of an air dispersion modeling study undertaken to assess the potential off-site air quality impacts associated with the proposed stack emission sources at the CPF, as well as the method, inputs and assumptions used to perform a qualitative risk-based assessment of potential air quality impacts associated with fugitive dust emissions from the construction activities proposed as part of the Project.

5.1 Dispersion Modeling

5.1.1 The CALPUFF Model

Emissions from the Project have been modeled using the United States Environmental Protection Agency (US EPA) approved CALPUFF (Version 6.42) air quality modeling system. CALPUFF (Earth Tech, 2000a) is a transport and dispersion model that advects 'puffs' of material emitted from modeled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the fields generated by a meteorological pre-processor CALMET (Earth Tech, 2000b), a meteorological modeling system, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processing package (Earth Tech, 2000a) is then used to process these files, producing tabulations that summarize results of the simulation for user-selected averaging periods.

The CALPUFF model requires inputs of hourly temperature, wind and other meteorological data on a three-dimensional gridded modeling domain. For this study, the meteorological data inputs have been compiled using the Weather Research and Forecast (WRF) (NCAR, 2019) and CALMET meteorological models as described in **Section 5.1.2**.

5.1.2 Meteorological Data

As outlined in the Upstream Air Quality Baseline Report (Part 19 of Volume 2), meteorological modeling was performed by SLR using the WRF and CALMET V6.334 models to compile two one-year (2014 and 2015 calendar years), three-dimensional meteorological datasets based on an hourly time step, covering the CPF and surrounding area. No significant differences in the meteorological datasets for 2014 and 2015 were observed in relation to the key parameters associated with plume dispersion. The 2015 modeling dataset was validated by comparison of the predicted and observed records of wind speed, wind direction and temperature at Wabo. The conclusions of this analysis was that the method and model configurations used in the meteorological modeling study provided a synthetic three-dimensional meteorological dataset that is representative of the key meteorological features of the study area relevant to pollutant dispersion, and which is suitable for use in the atmospheric dispersion modeling. The most recent calendar year dataset, 2015, was used in the modeling.

5.1.3 Topographical and Land Use Data

Topographical data was sourced from the Shuttle Radar Topography Mission (SRTM3) dataset, which is three-second arc (90 m) resolution data. LIDAR data provided to SLR for the study area was integrated into the GEO file to replace the SRTM3 data in areas where LIDAR data is available. To account for future topography across the CPF site after construction (and to ensure accurate base height elevations for the stacks within the model), the topographical data across the CPF site was then leveled to a pad height of 35 m above mean sea level. This refined topographical dataset was used in the model runs to predict ground level pollutant concentrations.

5.1.4 Receptor Locations

The modeling was performed using a 15 km by 15 km receptor grid with 100-m spacing, centered over the CPF. In addition to the gridded receptors, four discrete receptors were included in the model to represent the closest identified sensitive receptor locations in the surrounding area, as listed in **Table 3** and shown in **Figure 2**.

Table 3 Sensitive Receptors Included in the Model

Receptor	Location (MGA 94 Zone 55)	Distance/Direction from CPF
Poroi 1	300,457 mE, 9,182,433 mN	4.3 km south
Mapaio Fish Camp	292,023 mE, 9,185,351 mN	8.8 km west-southwest
Herd Base	303,840 mE, 9,186,527 mN	3.2 km east
Purari Airstrip House	296,941 mE, 9,183,112 mN	4.8 km southwest

Modeling results are also presented in **Section 0** for the 'maximum off-site' prediction. As information on the proposed fence line for the CPF is not currently available, these concentrations have been extracted from the model output files based on the area proposed to be cleared as part of the CPF construction, as shown in **Figure 2**. This approach will result in worst case estimates of maximum off-site concentrations, given that the fence line will likely be further away from the sources than assumed in the modeling.

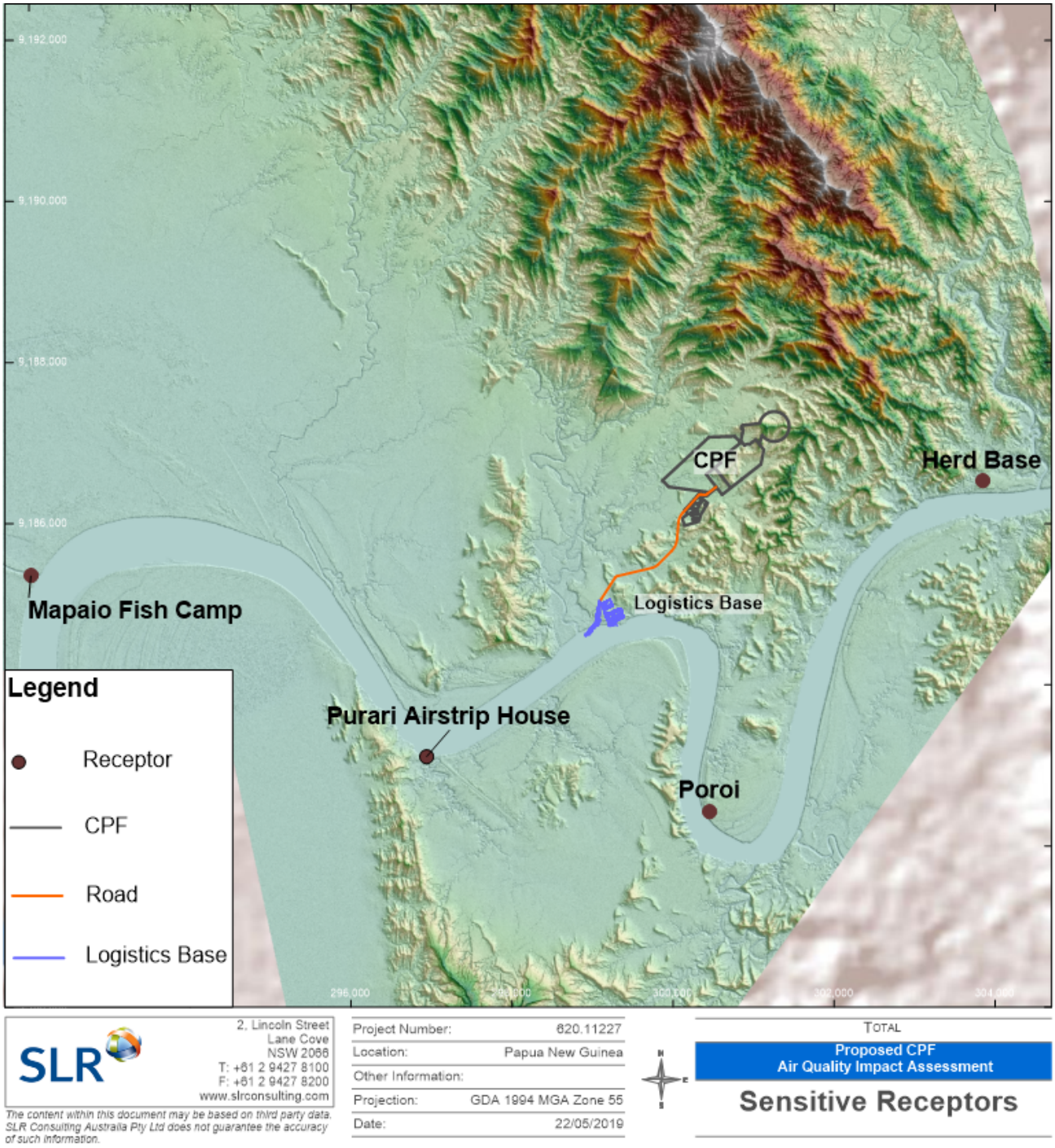
5.1.5 Background Concentrations

As outlined in **Section 6.1**, the pollutants modeled included NO_X, SO_2, CO and VOCs (benzene, toluene, ethylbenzene and xylenes). Background concentrations of these pollutants were assumed to be negligible given the absence of any significant combustion or industrial sources in the region surrounding the CPF (refer Part 19, Volume 2).

5.1.6 Building Wake Effects

Building wakes were not considered in the modeling. Building wakes will only impact the near-field predictions. Concentrations predicted by the modeling at the sensitive receptor locations (more than 3 km downwind) will not be affected by building wakes. Building wakes for the sources being modeled would also be expected to have a minor impact on the model predictions, as the emissions are being discharged via elevated stacks (20 to 50 m height).

Figure 2 Sensitive Receptor Locations



5.1.7 Modeling of NOx Chemistry

NO_X emissions from fossil fuel combustion are primarily nitric oxide (NO), with only a few volume percent as nitrogen dioxide (NO_2). However, once the gases are discharged into the atmosphere, chemical reactions take place which result in the transformation of NO to NO_2 in the plume.

There are various methods for estimating NO_2 concentrations from model predictions of NO_X as the plume is emitted from the emission point. For this assessment, maximum off-site ground level NO_2 concentrations were estimated from the downwind NO_X concentrations predicted by CALPUFF using the US EPA's Ozone Limited Method (OLM) (US EPA, 2015). The OLM is based on the assumption that approximately 10% of the NO_X emissions are generated as NO_2 (AE, 2003). If the ozone (O_3) concentration is greater than 90% of the predicted NO_X concentrations, all the NO_X is assumed to be converted to NO_2, otherwise:

$$NO_2 = 0.1 * NO_X + (46/48) * O_3.$$

A background ozone concentration of 40 parts per billion (ppb) (86 µg/m^3) was used in the calculations based on studies that have shown that ambient ozone concentrations in remote dense tropical forest locations typically range from 20 to 40 ppb (CGER, 1991).

5.1.8 Assumptions

The key assumptions made in relation to the modeling method were:

- Building wake effects will have a negligible impact on the predicted downwind concentrations at sensitive receptor locations. This is considered to be appropriate given the proposed stack heights, separation distance between the sources and surrounding sensitive receptors.
- The effects of the surrounding vegetation are not accounted for in the prediction downwind ground level concentrations. The dense vegetation surrounding the CPF can be expected to assist in the dispersion and filtration of pollutants prior to the plume reaching ground level. Air dispersion models like CALPUFF are not able to account for these effects, and there is very limited information available in the literature to enable the impact of vegetation on plume behavior and pollutant concentrations to be assessed. The fact that vegetation effects are not included is expected to provide conservative predictions of ground level pollutant concentrations, i.e., predicted concentrations would be higher.
- To estimate NO_2 concentrations from the ground level NO_X concentrations predicted by the modeling, the background ozone concentration was assumed to be 40 ppb. If a higher background ozone concentration was assumed, then the estimated NO_2 concentrations would be higher than the levels presented in this report. However use of the Ozone Limiting Method to perform these calculations is a very conservative approach as it assumes instantaneous conversion of NO to NO_2 close to source, where NO_X predictions will be highest. Thus even if the background ozone concentration is higher than that assumed, the methodology is still expected to be conservative.

5.2 Construction Dust Assessment

Due to the high rainfall and dense vegetation present in the onshore Project area, published fugitive dust (i.e., TSP) emission factors are unlikely to be representative of the emissions of dust from construction activities in Papua New Guinea. In addition, modeling of dust emissions from construction projects is generally not considered appropriate, as emission rates can vary depending on a combination of the construction activity and prevailing meteorological conditions (e.g., rainfall and wind speed), which cannot be reliably predicted.

For this assessment, IAQM Guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2014) has been used to provide a qualitative approach to assess the potential for Project construction activities to result in any off-site air quality impacts. It is noted that the IAQM method has been developed for an urbanized environment and has limitations in its applicability to a remote undeveloped location, such as the onshore Project area. However, it is anticipated to provide a conservative assessment of the potential risks and has been adopted in a number of PNG air quality impact assessments.

The IAQM method uses a four-step process for assessing dust impacts from construction activities:

- Step 1: Screening based on distance to the nearest sensitive receptor; whereby the sensitivity to dust deposition, human health impacts and ecological impacts of the identified sensitive receptors is determined.
- Step 2: Assessing the risk of dust effects from activities based on:
  - (a) the scale and nature of the works, which determines the potential dust emission magnitude.
  - (b) the sensitivity of the area surrounding dust-generating activities.
- Step 3: Determining site-specific mitigation for remaining activities with greater than negligible effects.
- Step 4: Assessing the residual risk of dust effects from activities after management measures have been considered.

5.2.1 Step 1 – Screening Criteria

The Step 1 screening criteria provided by the IAQM guidance suggests an assessment will normally be required where:

- A human receptor is located within 350 m of the boundary of the site, 50 m from the route used by construction vehicles on public roads, or within 500 m of the site entrance.
- An ecological receptor is located within 50 m of the boundary of the site, 50 m from the route used by construction vehicles on public roads, or within 500 m of the site entrance

This step is noted as having deliberately been chosen to be conservative, and is expected to require assessments for most projects.

5.2.2 Step 2(a) – Dust Emission Magnitude

Step 2(a) of the assessment method provides 'dust emissions magnitudes' for each of four dust-generating activities: demolition, earthworks, construction and track-out of dust onto public roads. The magnitudes are: large, medium or small, with suggested definitions for each category. The definitions given in the IAQM guidance for earthworks and construction activities, which are relevant to this Project, are as follows:

- **Earthworks**:
  - **Large:** Total site area greater than 10,000 m^2, potentially dusty soil type (e.g., clay, which will be prone to suspension when dry due to small particle size), more than 10 heavy earth-moving vehicles active at any one time, formation of bunds greater than 8 m in height, total material moved more than 100,000 tonnes (t).
  - **Medium:** Total site area 2,500 m^2 to 10,000 m^2, moderately dusty soil type (e.g., silt), 5 to 10 heavy earth-moving vehicles active at any one time, formation of bunds 4 to 8 m in height, total material moved 20,000 to 100,000 t.

- **Small**: Total site area less than 2,500 m^2, soil type with large grain size (e.g., sand), less than five heavy earth-moving vehicles active at any one time, formation of bunds less than 4 m in height, total material moved less than 20,000 t, earthworks during wetter months.

- **Construction**:
  - **Large**: Total building volume greater than 100,000 m^3, piling, on-site concrete batching, sandblasting.
  - **Medium**: Total building volume 25,000 m^3 to 100,000 m^3, potentially dusty construction material (e.g., concrete), piling, on-site concrete batching.
  - **Small**: Total building volume less than 25,000 m^3, construction material with low potential for dust release (e.g., metal cladding or timber).

5.2.3 Step 2(b) – Sensitivity of the Area

Step 2(b) of the assessment method requires the sensitivity of the area to be defined. The sensitivity of the area takes into account:

- The specific sensitivities that identified sensitive receptors have to dust deposition and human health impacts.
- The proximity and number of those receptors.
- In the case of PM_{10}, the local background concentration.
- Other site-specific factors, such as whether there are natural shelters such as trees, to reduce the risk of wind-blown dust.

Individual receptors are to be classified as having high, medium or low sensitivity to dust soiling (dust deposition), human health and ecological impacts.

The IAQM method provides the guidance summarized in **Table 4** regarding categorizing the sensitivity of different receptor types to dust soiling, health effects and ecological impacts. It is noted by IAQM that user expectations of amenity levels (dust soiling) is dependent on existing deposition levels.

Table 4 IAQM Guidance for Categorizing Receptor Sensitivity

Value	High Sensitivity Receptor	Medium Sensitivity Receptor	Low Sensitivity Receptor
Dust soiling	Users can reasonably expect a high level of amenity; or The appearance, aesthetics or value of their property would be diminished by soiling, and the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods as part of the normal pattern of use of the land.	Users would expect* to enjoy a reasonable level of amenity, but would not reasonably expect* to enjoy the same level of amenity as in their home; or The appearance, aesthetics or value of their property could be diminished by soiling; or The people or property wouldn't reasonably be expected* to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land.	The enjoyment of amenity would not reasonably be expected*; or Property would not reasonably be expected* to be diminished in appearance, aesthetics or value by soiling; or There is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land.
	Examples: dwellings	*Examples: parks and places of work.*	*Examples: farmland and subsistence gardens, footpaths*
Health effects	Locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where human exposure is transient.
	Examples: residential properties, hospitals, schools	*Examples: office and shop workers, but will generally not include workers occupationally exposed to PM10.*	*Examples: public footpaths, markets.*
Ecological effects	Locations with an international or national designation and the designated features may be affected by dust soiling. Locations where there is a community of a particularly dust sensitive threatened species.	Locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown. Locations with a national designation where the features may be affected by dust deposition.	Locations with a local designation where the features may be affected by dust deposition.

Source: IAQM, 2014. *People's expectations will depend on the existing dust deposition in the area.

In the IAQM method, the sensitivity of the identified individual receptors (as described above) is then used to assess the sensitivity of the area surrounding the active construction area to dust soiling, health effects and ecological impacts, taking into account the proximity and number of those receptors, the local background PM_{10} concentration (in the case of potential health impacts) and other site-specific factors.

Table 5 summarizes the IAQM guidance for assessing the sensitivity of an area to dust soiling.

Table 5 IAQM Guidance for Categorizing the Sensitivity of an Area to Dust Soiling

Receptor Sensitivity	Number of Receptors	Distance from Source			
		<20 m	<50 m	<100 m	<350 m
High	More than 100	High	High	Medium	Low
	10 to 100	High	Medium	Low	Low
	1 to 10	Medium	Low	Low	Low
Medium	More than 1	Medium	Low	Low	Low
Low	More than 1	Low	Low	Low	Low

Note: Estimate the total number of receptors (one dwelling unit = 1 receptor) within the stated distance. Only the highest level of area sensitivity from the table needs to be considered. < means less than.

The IAQM guidance for assessing the sensitivity of an area to health impacts is shown in **Table 6**. As noted, for high sensitivity receptors, the method takes the existing background concentrations of PM_{10} (as an annual average) experienced in the area of interest into account. The classifications are also based on the air quality objectives for PM_{10} in the UK set by the UK Department for Environment, Food and Rural Affairs. As these objectives differ from the ambient air quality criteria adopted for use in this assessment, and given that site-specific background monitoring data are not available for the sensitive receptors considered in this assessment, the IAQM method has been adapted slightly, based on the adoption of conservative values for the background PM_{10} level thresholds. All receptors have been classified based on the sensitivity classifications for a background annual average PM_{10} concentration of 15 µg/m^3 as determined in the air quality baseline assessment (Part 19 of Volume 2 of the EIS).

This approach is consistent with the IAQM guidance, which notes that in using the tables to define the sensitivity of an area, professional judgement may be used to determine alternative sensitivity categories, taking into account the following factors:

- Any history of dust-generating activities in the area.
- The likelihood of concurrent dust-generating activity on nearby sites.
- Any pre-existing screening between the source and the receptors.
- Any conclusions drawn from analyzing local meteorological data which accurately represent the area, and if relevant the season during which the works will take place.
- Any conclusions drawn from local topography.
- Duration of the potential impact, as a receptor may become more sensitive over time.
- Any known specific receptor sensitivities which go beyond the classifications given in the IAQM document.

Table 7 shows the IAQM guidance for assessing the sensitivity of an area to ecological impacts.

Table 6 IAQM Guidance for Categorizing the Sensitivity of an Area to Human Health Impacts

Receptor Sensitivity	Annual Mean Background PM_{10} Concentration [c]	Number of Receptors [a,b]	Distance From Source			
			<20 m*	<50 m	<100 m	<350 m
High	Less than 24 µg/m^3	More than 100	Medium	Low	Low	Low
		10 to 100	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low
Medium	Less than 24 µg/m^3	More than 10	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low
Low	-	More than 1	Low	Low	Low	Low

(a) Estimate the total within the stated distance (e.g., the total within 350 m and not the number between 200 and 350 m), noting that only the highest level of area sensitivity from the table needs to be considered.

(b) In the case of high sensitivity receptors with high occupancy (such as schools or hospitals) approximate the number of people likely to be present. In the case of residential dwellings, just include the number of properties.

(c) The estimated background annual average PM_{10} concentration is taken from the Upstream Air Quality Baseline Report (Part 19 of Volume 2) and the matrix presented is an abridged version of that in the IAQM guidance based on this background value (15 µg/m^3).

* < means less than.

Table 7 IAQM Guidance for Categorizing the Sensitivity of an Area to Ecological Impacts

Receptor Sensitivity	Distance from Source	
	<20 m	<50 m
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Note: Only the highest level of area sensitivity from the table needs to be considered.

5.2.4 Step 2 – Risk Assessment

The dust emission magnitude from Step 2a and the receptor sensitivity from Step 2b are then used in the matrix shown in **Table 8** to determine the risk category with no mitigation applied.

Table 8 IAQM Risk Matrix for Dust from Earthworks and Construction Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Once the risk categories are determined for each of the relevant activities, site-specific management measures (Step 3) can be identified based on whether the site is a low, medium or high risk site. Following this, the residual impact can be determined after management measures are considered (Step 4).

6 CPF Operations Modeling Assessment

6.1 Operating Scenarios and Pollutants Modeled

In order to address the potential impacts on local air quality of the Project, emissions estimation and dispersion modeling has been performed for two different operations phase scenarios for the CPF. The operational scenarios selected for modeling were identified in consultation with TOTAL and were chosen to represent normal operations at different stages in the life of Project. The operational scenarios modeled are summarized in **Table 9**.

Table 9 Operating Scenarios Assessed

Operating Mode	Description	Sources Modeled			
		Power Gas Turbines (PGT)	Heating Boilers (HB)	Thermal Oxidizer (TO)	MP Compressors (MPC)
HP/Incineration	High pressure (HP) mode without acid gas injection, but with sulfur recovery and thermal oxidizer	3 units online	2 units online	Online	-
MP/LP and Acid Gas Injection	Acid gas injection and additional export gas compression with thermal oxidizer on standby	3 units online	2 units online	On standby	5 units online

Off-site air quality impacts during upset operating conditions, involving flaring of gas at the CPF, are beyond the scope of this modeling study and are considered as part of the hazard risk assessment in the EIS.

The pollutants that were assessed for each operational scenario were:

- NO_X (as NO_2).
- SO_2.
- CO.
- Benzene.
- Toluene.
- Ethylbenzene.
- Xylenes.

6.2 Stack and Emission Data Used in the Modeling

A summary of the stack and emission data used in the modeling study is provided in **Table 10**. Further details are provided in **Appendix A** for each emission source, including fuel gas consumption rates, exhaust gas flowrates, in-stack pollutant concentrations and individual VOC emission rates.

Table 10 Stack and Emission Data Used in the Modeling Study

Parameter	Units	Power Gas Turbines			Heating Boilers		Thermal Oxidizer	Medium Pressure Compressors					TOTAL SITE
		PGT1	PGT2	PGT3	HB1	HB2	TO1	MPC1	MPC2	MPC3	MPC4	MPC5	
General													
Easting	m	300,636	300,651	300,620	300,715	300,705	300,715	300,926	300,919	300,911	300,872	300,857	-
Northing	m	9,186,600	9,186,580	9,186,621	9,186,666	9,186,658	9,186,871	9,186,676	9,186,670	9,186,664	9,186,634	9,186,622	-
Stack height	m	20	20	20	40	40	50	20	20	20	20	20	-
Base elevation	m	35	35	35	35	35	35	35	35	35	35	35	-
Stack diameter	m	3.4	3.4	3.4	2.2	2.2	3.0	3.4	3.4	3.4	3.4	3.4	-
Exhaust gas temperature	°C	250	250	250	165	165	853	250	250	250	250	250	-
HP/Incineration - HP Mode without Acid Gas Injection, with Sulfur Recovery													
Exhaust gas velocity	m/s	10.8	10.8	10.8	6.7	6.7	26.9	-	-	-	-	-	**-**
NO_X emission rate	kg/hr	17.89	17.89	17.89	12.25	12.25	37.49	-	-	-	-	-	**115.7**
SO_2 emission rate	kg/hr	0.23	0.23	0.23	2.11	2.11	30.75	-	-	-	-	-	**35.7**
CO emission rate	kg/hr	5.44	5.44	5.44	0.05	0.05	0.15	-	-	-	-	-	**16.6**
VOC emission rate	kg/hr	8.71	8.71	8.71	0.34	0.34	0.49	-	-	-	-	-	**27.3**
MP/LP+Acid Gas Injection - MP Mode with Acid Gas Injection, Additional Compression and Thermal Oxidizer on Standby													
Exhaust gas velocity	m/s	10.8	10.8	10.8	6.7	6.7	1.2	10.8	10.8	10.8	10.8	10.8	**-**
NO_X emission rate	kg/hr	17.89	17.89	17.89	12.25	12.25	1.63	17.89	17.89	17.89	17.89	17.89	**169.2**
SO_2 emission rate	kg/hr	0.23	0.23	0.23	2.11	2.11	0.30	0.23	0.23	0.23	0.23	0.23	**6.4**
CO emission rate	kg/hr	5.44	5.44	5.44	0.05	0.05	0.01	5.44	5.44	5.44	5.44	5.44	**43.7**
VOC emission rate	kg/hr	8.71	8.71	8.71	0.34	0.34	0.05	8.71	8.71	8.71	8.71	8.71	**70.4**

The key data sources and assumptions used in compiling the stack and emission data for input into in the modeling were:

- Equipment types, stack heights, exhaust gas flowrates, exhaust temperatures and fuel gas consumption rates as provided by TOTAL.
- Stack diameters and exit velocities either as provided by TOTAL or as calculated by SLR based on the exhaust gas flowrate provided.
- Stack locations extracted by SLR from site plans provided by TOTAL for the proposed CPF layout.
- The sulfur content of the fuel or acid gas combusted in each unit as calculated by SLR based on information provided by TOTAL regarding the composition of sulfur-containing compounds in each gas stream and the molecular weights of those compounds. It was assumed that all sulfur in the feed stream(s) to each unit was combusted and released as SO_2 via the stack.
- NO_X emission rates from the PGTs as calculated by SLR based on the exhaust gas flowrate and a maximum in-stack NO_x concentration of 50 ppm, as advised by TOTAL.
- NO_X emission rates from the thermal oxidizer and heating boilers as calculated by SLR based on the exhaust gas flowrate and a maximum in-stack NO_X concentration of 118 parts per million (ppm) (equivalent to 240 mg/Nm^3), as per the emission limit value set out in the International Finance Corporation (IFC) *Environmental, Health, and Safety (EHS) Guidelines for Thermal Power Plants* (IFC, 2008).
- Total VOC emissions from the PGTs as estimated based on an anticipated maximum in-stack concentration of 20 ppm as provided by TOTAL. Total VOC emissions from the heating boilers and thermal oxidizer were estimated based on emission factors for gas combustion published in Chapter 1.4, Table 1.4-2 of the *US-AP-42 Emission Factor Handbook* (US EPA, 2000). Fugitive VOC emissions from the CPF were assumed to be negligible and were not included in the model.
- Individual VOC emission rates (benzene, toluene, ethylbenzene and xylenes) as estimated from the estimated total VOC emission rate and the concentrations of these compounds in the fuel gas combusted in each unit.
- To complete the emission calculations, assumptions were required regarding the oxygen (O_2) and moisture (H_2O) contents of the exhaust gases. These assumptions were as follows, based on SLR's experience in performing stack emission tests on these types of plant at other gas processing facilities in Australia:
  - PGTs and MP compressor engines: 15% O_2 and 3% H_2O.
  - Heating boilers: 7% O_2 and 8% H_2O.
  - Thermal oxidizer: 5% O_2 and 7% H_2O.

6.3 Modeling Results

The results of the modeling are presented in **Table 11** (HP/Incineration) and **Table 12** (MP/LP and Acid Gas Injection). Results are presented for the four nearest sensitive receptors identified in the vicinity of the CPF and as 'maximum off-site' predictions. As discussed in **Section 5.1.4**, the maximum off-site concentrations have been extracted from the model output files based on the area proposed to be cleared as part of the CPF construction. They are therefore considered to be worst case estimates of maximum off-site concentrations, as the fence line will likely be further away from the sources than that assumed in the modeling.

The maximum off-site concentrations predicted for the normal operations scenarios modeled do not exceed adopted ambient air quality criteria for any of the pollutants assessed.

Contour plots showing the maximum predicted ground level concentrations are presented in **Appendix B**.

Table 11 Modeling Results - HP/Incineration

Pollutant	Averaging Period	Maximum Predicted Ground Level Concentrations (µg/m^3)					Ambient Air Quality Criteria (µg/m^3)
		Poroi 1	Mapaio Fish Camp	Herd Base	Purari Airstrip House	Maximum Off-site	
NO_2	1-hour	44.7	13.6	27.3	22.8	109.6	**200**
	Annual	0.3	0.1	0.6	0.2	5.9	**40**
SO_2	10-minutes	13.1	1.9	9.6	8.4	47.5	**500**
	1-hour	9.2	1.4	6.7	5.9	33.2	**200**
	24-hours	0.6	0.1	0.5	0.5	4.7	**20**
CO	1-hr	9.0	2.9	5.9	3.7	62.3	**30,000**
	8-hr	2.6	1.1	1.0	1.0	18.2	**10,000**
Benzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**170**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**4.5**
Toluene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**4,500**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**1,200**
Xylene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**26,000**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**570**
Ethylbenzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**2,200**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**180**

Table 12 Modeling Results - MP/LP and Acid Gas Injection

Pollutant	Averaging Period	Maximum Predicted Ground Level Concentrations (µg/m^3)					Ambient Air Quality Criteria (µg/m^3)
		Poroi 1	Mapaio Fish Camp	Herd Base	Purari Airstrip House	Maximum Off-site	
NO_2	1-hour	50.1	26.8	55.4	35.6	129.3	**200**
	Annual	0.6	0.1	1.0	0.3	15.5	**40**
SO_2	10-minutes	4.7	1.5	3.4	2.7	33.8	**500**
	1-hour	3.3	1.0	2.4	1.9	23.6	**200**
	24-hours	0.4	0.1	0.2	0.2	3.4	**20**
CO	1-hr	11.9	6.9	16.2	8.7	123.7	**30,000**
	8-hr	3.7	2.9	3.2	2.5	57.9	**10,000**
Benzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**170**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**4.5**
Toluene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**4,500**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**1,200**
Xylene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**26,000**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**570**
Ethylbenzene	1-hour	<0.1	<0.1	<0.1	<0.1	<0.1	**2,200**
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	**180**

7 Construction Dust Assessment

7.1 Step 1 – Screening Criteria

The Step 1 screening criteria set out by the IAQM guidance to identify when an assessment is required are as follows:

- For human receptors: within 350 m of the boundary of the site, 50 m from the route used by construction vehicles on public roads, or within 500 m of the site entrance.
- For ecological receptors: within 50 m of the boundary of the site, 50 m from the route used by construction vehicles on public roads, or within 500 m of the site entrance

Activities that will occur within 350 m of human receptors, therefore requiring an assessment of the potential for human health or nuisance impacts, include construction of the onshore export pipeline and the Purari Airstrip extension.

Due to the separation distances between the proposed Project components and the nearest villages or other occupied areas, the other construction areas (the CPF and Logistics Base in particular) would not require assessment for human health or nuisance impacts as they are located more than 350 m away. However, these construction activities will be undertaken in areas surrounded by dense vegetation, i.e., within 50 m, therefore an assessment of the potential effects on ecological receptors has been performed for these activities, and for completeness, an assessment of their potential for human health or nuisance impacts is also presented.

7.2 Step 2(a) - Dust Emission Magnitude

The descriptions given in the IAQM guidance document for small, medium and large earthworks and construction activities have been used to categorize the magnitude of works proposed during the construction of the CPF, Logistics Base, terrestrial pipelines, access roads and Purari Airstrip extension as shown in **Table 13**.

Table 13 Categorization of Dust Emission Magnitudes for Construction Activities

Construction Site	Dust Emission Magnitude		Basis
	Earthworks	Construction	
CPF	Large	Large	Total area cleared estimated at 98 ha (983,536 m^2), more than ten heavy earth moving vehicles active at any one time, formation of bunds greater than 8 m in height, total material moved will be more than 100,000 t. Total building volume will be greater than 100,000 m^3, and works will include piling and on site concrete batching.
Logistics Base	Large	Large	Total area cleared estimated at 6.9 ha (68,975 m^2), more than ten heavy earth moving vehicles active at any one time, total material moved expected to be more than 100,000 t. Total building volume will be greater than 100,000 m^3, and works will include piling and on site concrete batching
Onshore export pipeline	Medium	Small	Total active work area up to approximately 2.5 ha (24,500 m^2) (based on a nominal 700 m long and 35 m wide work zone), 5 to 10 heavy earth moving vehicles assumed to be active at any one time. Will involve minimal construction-type activities aside from earthworks.

Export pipelines shore crossing site at Orokolo Bay	Medium	Small	Total active work area estimated at approximately 2.5 ha (25,000 m^2), 5 to 10 heavy earth moving vehicles assumed to be active at any one time, soil type with large grain size (e.g., sand). Will involve minimal construction-type activities aside from earthworks.
Access roads	Medium	N/A	Total active work area being approximately 0.7 ha (7,000 m^2) (based on a nominal 700 m long and 10 m wide work zone), and 5 to 10 heavy earth moving vehicles assumed to be active at any one time
Purari Airstrip extension	Large	Medium	Total area cleared is estimated at 104 ha (1,040,000 m^2), more than ten heavy earth moving vehicles will be active at any one time, and total material moved is expected to be more than 100,000 t Total building volume (terminal building) is expected to be less than 25,000 m^3, using construction materials with low potential for dust generation.

N/A = Not applicable.

7.3 Step 2(b) - Sensitivity of the Area

The sensitivity of the identified human receptors in the onshore Project area (villages and dwellings) is concluded to be of high sensitivity for both dust soiling and health impacts, based upon the following assumptions:

- The identified sensitive receptor locations are dwellings where members of the local community have the potential to be exposed to PM_{10} levels for eight hours (or more) in a day.
- In general, the local community could reasonably expect a high level of amenity (i.e., low TSP concentrations and dust deposition rates) given the high rainfall and highly vegetated nature of the area, which would result in little natural wind-blown dust and low background dust levels.

Details of the dust sensitivity of plant species in areas close to the proposed construction activities is not available, although it may be expected that vegetation in the area would be accustomed to a low dust environment. Nonetheless, the high rainfall in the region means that dust will be regularly washed from leaves, thereby naturally mitigating the impact of fugitive dust emissions from construction activities. In addition, the dense and tall vegetation present in the area around the construction sites will assist in screening and filtering dust particles from the air. This will assist in containing the dust within the area close to the works, compared to a more open environment.

The pipeline shore crossing site at Orokolo Bay is expected to be less sensitive to dust impacts than the area surrounding the CPF site, Logistics Base and Purari Airstrip extension for example, as the area is more densely settled and is a coastal location where plants would be expected to be hardier and more tolerant to particulate matter associated with salt spray and wind-blown sand.

Based on the above, the ecological sensitivity of vegetation in the onshore Project area is assumed to be of medium sensitivity for all areas except the pipeline shore crossing site at Orokolo Bay, which has been categorized as low sensitivity.

On the basis of the information provided above, the sensitivity of the areas surrounding the proposed construction activities has been determined as shown in **Table 14.**

Table 14 Assessment of Sensitivity of Areas Surrounding Construction Sites

Value	Area	Sensitivity of Receptors	Number of Receptors	Distance from Source	Sensitivity of Area
Dust soiling	CPF site	High	0	No receptors within 350 m	Low
	Logistics Base	High	0	No receptors within 350 m	Low
	Onshore export pipeline route*	High	10 to 100	100 to 350 m	Low
	Export pipeline shore crossing site at Orokolo Bay	High	1 - 10	300 - 350 m	Low
	Access roads	High	0	No receptors within 350 m	Low
	Purari Airstrip extension	High	1	200 m	Low
Human health	CPF site	High	0	No receptors within 350 m	Low
	Logistics Base	High	0	No receptors within 350 m	Low
	Onshore export pipeline route*	High	10 to 100	100 to 350 m	Low
	Export pipeline shore crossing site at Orokolo Bay	High	1 - 10	300 - 350 m	Low
	Access roads	High	0	No receptors within 350 m	Low
	Purari Airstrip extension	High	1	85 m from proposed perimeter road	Low
Value	**Area**	**Sensitivity of Receptors**		**Distance from Source #**	**Sensitivity of Area**
Ecological	CPF site	Medium		>20 m	Low
	Logistics Base	Medium		>20 m	Low
	Onshore export pipeline route	Medium		<20 m	Medium
	Export pipeline shore crossing site at Orokolo Bay	Low		<20 m	Low
	Access roads	Medium		<20 m	Medium
	Purari Airstrip extension	Medium		<20 m	Medium

* Based on Aivai as the nearest sensitive receptor to Pipe Yard 4.

Distance between the main dust-generating construction activities (earthworks, haul routes, plant foundations, stockpiles etc.) and the edge of the cleared area where sensitive vegetation may be located was assumed to be greater than 20 m for the CPF site and Logistics Base. For the export pipeline and access roads, it has been assumed that construction activities will potentially occur within 20 m of areas where sensitive vegetation may be located.

7.4 Risk Assessment

Based on the area sensitivities derived in **Table 14**, the resulting risk of air quality impacts has been derived for each construction activity using the IAQM impact matrix in **Table 8**, as presented in **Table 15**. As per the IAQM impact matrices, the risk of air quality impacts assumes no mitigation is applied, in order to identify what level of control may be required to mitigate potential off-site impacts.

Table 15 Assessment of Potential Fugitive Dust Impacts from Construction

Value	Construction Activity	Sensitivity of the Area	Magnitude of Dust Emissions		Risk of Air Quality Impacts	
			Earthworks	Construction	Earthworks	Construction
Dust soiling Human heath	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Onshore export pipeline route	Low	Medium	Small	Low	Negligible
	Export pipeline shore crossing site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Low	Medium	-	Low	-
	Purari Airstrip extension	Low	Large	Medium	Low	Low
Ecological	CPF site	Low	Large	Large	Low	Low
	Logistics Base	Low	Large	Large	Low	Low
	Onshore export pipeline route	Medium	Medium	Small	Medium	Low
	Export pipeline shore crossing site at Orokolo Bay	Low	Medium	Small	Low	Negligible
	Access roads	Medium	Medium	-	Medium	-
	Purari Airstrip extension	Medium	Large	Medium	Medium	Medium

Note: While pre-mitigation risk assessment is not generally applied in this EIS, an exception is made in this instance due to application of the IAQM method.

8 References

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ADDENDUM

The stack and emission data used in the modeling for the HP/Incineration scenario were based on a pre-FEED design option of using a sulfur recovery unit to remove 95% of the H_2S from the acid gas prior to incineration in the thermal oxidizer. Since the modeling was completed, the Base Case design has changed to the acid gases first being incinerated in the thermal oxidizer to convert all H_2S to SO_2, with the exhaust gases then undergoing treatment to remove 95% of the SO_2 using a caustic wash process.

While the SO_2 emission rate for the new design is unchanged (based on 95% sulfur control efficiency for both options), the revised Base Case design will result in changes to the exhaust gas flowrate and stack conditions compared to those used in the modeling. A comparison of the thermal oxidizer stack and emission data modeled for the HP/Incineration scenario with the updated parameters for the revised current Base Case design is provided in **Table ADD-1**. This table shows that the stack gases will be emitted at a significantly lower exit temperature than that modeled (81°C compared to 853°C). The moisture content increases from 7% to 47%, however the normalized exhaust gas flowrate will still be lower than that used in deriving the stack and emission data for input into the modeling. This, combined with the much lower in-stack temperature, means that the flowrate at stack conditions is approximately half that assumed in the modeling study. To keep the exit velocity similar to that used in the modeling, the thermal oxidizer stack diameter has been reduced from 3 m to 2 m.

Table ADD-1 Comparison of Modeled and Current Proposed Design Stack Data for the Thermal Oxidizer

Parameter	Units	Thermal Oxidizer		Total Site Emissions	
		Modeled Scenario	Revised Base Case	Modeled Scenario	Revised Base Case
General					
Easting	m	300,705	300,705	-	-
Northing	m	9,186,658	9,186,658	-	-
Stack height	m	50	50	-	-
Base elevation	m	35	35	-	-
Stack diameter	m	3.0	**2.0**	-	-
Exhaust gas temperature	°C	853	**81**	-	-
Normalized exhaust gas flowrate	Nm^3/hr, dry	154,664	**135,666**	-	-
Actual exhaust gas flowrate	Am^3/hr, wet	685,279	**332,114**	-	-
Moisture Content	%	7	**47**	-	-
Exhaust gas velocity	m/s	26.9	**29.4**	**-**	**-**
NO_X emission rate	kg/hr	37.5	**32.9**	115.7	**111.1**
SO_2 emission rate	kg/hr	30.8	30.8	35.7	35.7
CO emission rate	kg/hr	0.15	0.15	16.6	16.6
VOC emission rate	kg/hr	0.49	0.49	27.3	27.3

The implications of the changes in the thermal oxidizer stack parameters, to reflect the revised Based Case, on the SO_2 dispersion modeling results presented in this report for the HP/Incineration scenario are:

- The significantly lower exit temperature means that the plume will have less thermal buoyancy. This has potential for ground level concentrations to increase as the centerline of the plume will be closer to the ground and there is greater potential for the plume to impinge on the surrounding elevated terrain. This would be off-set to a limited extent by the slightly higher exit velocity (29.4 m/s compared to 26.9 m/s) for the proposed design.
- The thermal oxidizer emissions account for approximately 85% of the total site SO_2 emissions, therefore any changes in the behavior of the plume from this source (e.g. due to the reduced thermal buoyancy discussed above) have potential to have a noticeable impact on the total site cumulative SO_2 impacts predicted off-site.
- The maximum ground level SO_2 concentrations predicted by the modeling at the sensitive receptor locations were very low, at less than 5% of the relevant ambient air quality criteria. Based on SLR's experience in air dispersion modeling studies, while the predicted ground level concentrations for the revised Based Case may increase due to the changed stack parameters for the thermal oxidizer, they would not have potential to approach or exceed the associated criteria at these locations.
- The maximum off-site ground level SO_2 concentrations predicted by the modeling were less than 25% of the relevant ambient air quality criteria. Again, based on SLR's experience in air dispersion modeling studies, while these predicted concentrations may increase for the revised Base Case due to the lower stack temperature for the thermal oxidizer, it is considered highly unlikely that they would have potential to approach or exceed the associated criteria.

As shown in **Table ADD-1**, the NO_X emission rate from the thermal oxidizer stack is slightly (12%) lower for the revised Base Case compared with the value used in the modeling. This is because the NO_X emission rates have been calculated based on a maximum in-stack NO_X concentration limit of 118 ppm and the normalized gas flowrate given for the revised Base Case is approximately 12% lower than that provided for the modeled scenario. In addition, the NO_X emissions from the thermal oxidizer stack only represent approximately 30% of the total site emissions (see **Table 10**), therefore changes in the dispersion of emissions from this stack will have much less impact on the predicted cumulative ground level concentrations compared to the SO_2 emissions. Given these mitigating factors, it is SLR's opinion that while the predicted off-site NO_2 concentrations may increase slightly due to the lower stack temperature for the thermal oxidizer, it is highly unlikely that they would have potential to approach or exceed the associated criteria at any location off-site.

The modeled scenario maximum off-site concentrations of CO and VOCs are far below the relevant air quality criteria, and any changes in these predictions that may be anticipated as a result of the changes to the thermal oxidizer stack parameters (for the revised Base Case) would be inconsequential.

The modeling has not been repeated using the new stack data for the thermal oxidizer at this stage. Once the detailed design has been completed and all stack parameters have been confirmed, then an updated modeling study will be performed to assess the changes in the predicted concentrations and to confirm that no exceedances of relevant ambient air quality criteria are predicted beyond the proposed facility boundary.

APPENDIX A

Stack and Emission Data

Table A.1 Stack and Emission Data - HP/Incineration - HP Mode without Acid Gas Injection, with Sulfur Recovery

Parameter	Units	PGT1	PGT2	PGT3	PGT4	HB1	HB2	HB3	TO1	
Description	-	Power Gas Turbine 1	Power Gas Turbine 2	Power Gas Turbine 3	Power Gas Turbine 4	Heating Boiler 1	Heating Boiler 2	Heating Boiler 3	Thermal Oxidiser	
Capacity	MW	22.37	22.37	22.37	22.37	40.0	40.0	40.0	-	
Operational load		100%	100%	100%	standby	100%	100%	standby	100%	
Fuel		HP Fuel Gas	HP Fuel Gas	HP Fuel Gas	-	LP Fuel Gas	LP Fuel Gas	-	LP Fuel Gas	Acid Gas
Fuel gas consumption	m^3/hr (20°C, 1 atm)	5,404	5,404	5,404	-	3,906	3,906	-	5,579	64,999
	kg/hr	4,029	4,029	4,029	-	3,470	3,470	-	4,437	117,423
	kmol/hr	228.6	228.6	228.6	-	165.2	165.2	-	236.0	2,749.0
Sulfur content of fuel gas combusted	% (mol)	0.0016%	0.0016%	0.0016%	-	0.0199%	0.0199%	-	0.0199%	0.0158%
Sulfur in	kg/hr	0.117	0.117	0.117	-	1.054	1.054	-	1.505	13.885
Stack Parameters										
Easting	m, UTM	300,636	300,651	300,620	300,605	300,715	300,705	300,695	300,715	
Northing	m, UTM	9,186,600	9,186,580	9,186,621	9,186,641	9,186,666	9,186,658	9,186,650	9,186,871	
Stack height	m	20	20	20	20	40	40	40	50	
Ground Elevation	m (amsl)	35	35	35	35	35	35	35	35	
Diameter	m	3.36	3.36	3.36	3.36	2.15	2.15	2.15	3.00	
Temperature	°C	250	250	250	-	165	165	-	853	
Velocity	m/s	10.8	10.8	10.8	-	6.7	6.7	-	26.9	
Volumetric flow rate - Actual	Am^3/hr	343,932	343,932	343,932	-	87,961	87,961	-	685,279	
- O_2 content for the actual gas flowrate	*%*	*15%*	*15%*	*15%*	-	*7%*	*7%*	-	*5%*	
- H_2O content for the actual gas flowrate	*%(vol)*	*3%*	*3%*	*3%*	-	*8%*	*8%*	-	*7%*	

Parameter	Units	PGT1	PGT2	PGT3	PGT4	HB1	HB2	HB3	TO1
Volumetric flow rate - Normalised	Nm^3/hr (dry gas, 0°C)	174,192	174,192	174,192	-	50,535	50,535	-	154,664
- O_2 content for the Normalised gas flowrate	*%*	*15%*	*15%*	*15%*	-	*3%*	*3%*	-	*3%*
Exhaust gas mass flowrate	kg/hr	211,577	211,577	211,577	-	67,680	67,680	-	207,628
Exhaust gas density	kg/m^3 (0°C, 1 atm)	1.18	1.18	1.18	-	1.23	1.23	-	1.25
POLLUTANT EMISSIONS									
NO_X - Emission rate	kg/hr	17.89	17.89	17.89	-	12.25	12.25	-	37.49
NO_X – Concentration	ppmv	50	50	50	-	118	118	-	118
NO_X - O_2 content relating to the maximum in-stack concentration	*%*	*15%*	*15%*	*15%*	-	*3%*	*3%*	-	*3%*
SO_2 - Emission rate	kg/hr	0.23	0.23	0.23	-	2.11	2.11	-	30.75
SO_2 - Concentration	mg/Nm^3	1.34	1.34	1.34	-	41.65	41.65	-	198.81
SO_2 - O_2 content relating to the maximum in-stack concentration	*%*	*15%*	*15%*	*15%*	-	*3%*	*3%*	-	*3%*
CO - Emission rate	kg/hr	5.44	5.44	5.44	-	0.05	0.05	-	0.15
CO - Concentration	mg/Nm^3	31	31	31	-	1.0	1.0	-	1.0
CO - O_2 content relating to the maximum in-stack concentration	*%*	*15%*	*15%*	*15%*	-	*3%*	*3%*	-	*3%*
TOTAL VOCS - Emission rate	kg/hr	8.71	8.71	8.71	-	0.34	0.34	-	0.49
TOTAL VOCS - Concentration	mg/Nm^3	50	50	50	-	6.80	6.80	-	3.17
TOTAL VOCS - O_2 content relating to maximum in-stack concentration	*%*	*15%*	*15%*	*15%*	-	*3%*	*3%*	-	*3%*
Benzene	kg/hr	0.0017	0.0017	0.0017		0.0002	0.0002		0.0003
Toluene	kg/hr	0.0016	0.0016	0.0016		0.0002	0.0002		0.0003
Xylene	kg/hr	0.00044	0.00044	0.00044		0.00011	0.00011		0.00016
Ethylbenzene	kg/hr	0.000044	0.000044	0.000044		0.000005	0.000005		0.000007

Table A.2 Stack and Emission Data - MP/LP+Acid Gas Injection - MP Mode with Acid Gas Injection, Additional Compression and Thermal Oxidizer on Standby

Parameter	Units	PGT1	PGT2	PGT3	PGT4	HB1	HB2	HB3
Description	-	Power Gas Turbine 1	Power Gas Turbine 2	Power Gas Turbine 3	Power Gas Turbine 4	Heating Boiler 1	Heating Boiler 2	Heating Boiler 3
Capacity	MW	22.37	22.37	22.37	22.37	40.0	40.0	40.0
Operational load		100%	100%	100%	standby	100%	100%	standby
Fuel		HP Fuel Gas	HP Fuel Gas	HP Fuel Gas	-	LP Fuel Gas	LP Fuel Gas	-
Fuel gas consumption	m^3/hr (20°C, 1 atm)	5,404	5,404	5,404	-	3,906	3,906	-
	kg/hr	4,029	4,029	4,029	-	3,470	3,470	-
	kmol/hr	228.6	228.6	228.6	-	165.2	165.2	-
Sulfur content of fuel gas combusted	% (mol)	0.0016%	0.0016%	0.0016%	-	0.0199%	0.0199%	-
Sulfur in	kg/hr	0.117	0.117	0.117	-	1.054	1.054	-
Stack Parameters								
Easting	m, UTM	300,636	300,651	300,620	300,605	300,715	300,705	300,695
Northing	m, UTM	9,186,600	9,186,580	9,186,621	9,186,641	9,186,666	9,186,658	9,186,650
Stack height	m	20	20	20	20	40	40	40
Ground Elevation	m (amsl)	35	35	35	35	35	35	35
Diameter	m	3.36	3.36	3.36	3.36	2.15	2.15	2.15
Temperature	°C	250	250	250	-	165	165	-
Velocity	m/s	10.8	10.8	10.8	-	6.7	6.7	-
Volumetric flow rate - Actual	Am^3/hr	343,932	343,932	343,932	-	87,961	87,961	-
- O_2 content for the actual gas flowrate	*%*	15%	15%	15%	-	7%	7%	-
- H_2O content for the actual gas flowrate	*%(vol)*	3%	3%	3%	-	8%	8%	-
Volumetric flow rate - Normalised	Nm^3/hr (dry gas, 0°C)	174,192	174,192	174,192	-	50,535	50,535	-

Parameter	Units	PGT1	PGT2	PGT3	PGT4	HB1	HB2	HB3
- O_2 content for the Normalised gas flowrate	*%*	15%	15%	15%	-	3%	3%	-
Exhaust gas mass flowrate	kg/hr	211,577	211,577	211,577	-	67,680	67,680	-
Exhaust gas density	kg/m^3 (0°C, 1 atm)	1.18	1.18	1.18	-	1.23	1.23	-
Pollutant Emissions								
NO_X - Emission rate	kg/hr	17.89	17.89	17.89	-	12.25	12.25	-
NO_X – Concentration	ppmv	50	50	50	-	118	118	-
NO_X - O_2 content relating to the maximum in-stack concentration	*%*	15%	15%	15%	-	3%	3%	-
SO_2 - Emission rate	kg/hr	0.23	0.23	0.23	-	2.11	2.11	-
SO_2 - Concentration	mg/Nm^3	1.34	1.34	1.34	-	41.65	41.65	-
SO_2 - O_2 content relating to the maximum in-stack concentration	*%*	15%	15%	15%	-	3%	3%	-
CO - Emission rate	kg/hr	5.44	5.44	5.44	-	0.05	0.05	-
CO - Concentration	mg/Nm^3	31.3	31.3	31.3	-	1.0	1.0	-
CO - O_2 content relating to the maximum in-stack concentration	*%*	15%	15%	15%	-	3%	3%	-
TOTAL VOCS - Emission rate	kg/hr	8.71	8.71	8.71	-	0.344	0.344	-
TOTAL VOCS - Concentration	mg/Nm^3	50	50	50	-	6.80	6.80	-
TOTAL VOCS - O_2 content relating to the maximum in-stack concentration	*%*	15%	15%	15%	-	3%	3%	-
Benzene	kg/hr	0.0017	0.0017	0.0017		0.0002	0.0002	
Toluene	kg/hr	0.0016	0.0016	0.0016		0.0002	0.0002	
Xylene	kg/hr	0.00044	0.00044	0.00044		0.00011	0.00011	
Ethylbenzene	kg/hr	0.000044	0.000044	0.000044		0.000005	0.000005	

Table A.2 (Continued)

Parameter	Units	TO1		MPC1	MPC2	MPC3	MPC4	MPC5
Description	-	Thermal Oxidizer		MP Compressor Turbine 1	MP Compressor Turbine 2	MP Compressor Turbine 3	MP Compressor Turbine 4	MP Compressor Turbine 5
Capacity	MW	-		22.37	22.37	22.37	22.37	22.37
Operational load		standby		100%	100%	100%	100%	100%
Fuel		LP Fuel Gas	Acid	HP Fuel Gas	HP Fuel Gas	HP Fuel Gas	HP Fuel Gas	HP Fuel Gas
Fuel gas consumption	m^3/hr (20°C, 1 atm)	558	0	4,464	4,464	4,464	4,464	4,464
	kg/hr	444	-	3,328	3,328	3,328	3,328	3,328
	kmol/hr	23.6	-	188.8	188.8	188.8	188.8	188.8
Sulfur content of fuel gas combusted	% (mol)	0.0199%	-	0.0016%	0.0016%	0.0016%	0.0016%	0.0016%
Sulfur in	kg/hr	0.151	-	0.117	0.117	0.117	0.117	0.117
Stack Parameters								
Easting	m, UTM	300,715		300,926	300,919	300,911	300,872	300,857
Northing	m, UTM	9,186,871		9,186,676	9,186,670	9,186,664	9,186,634	9,186,622
Stack height	m	50		20	20	20	20	20
Ground Elevation	m (amsl)	35		35	35	35	35	35
Diameter	m	3.0		3.36	3.36	3.36	3.36	3.36
Temperature	°C	853		250	250	250	250	250
Velocity	m/s	1.2		10.8	10.8	10.8	10.8	10.8
Volumetric flow rate - Actual	Am^3/hr	29,772		343,932	343,932	343,932	343,932	343,932
- O_2 content for the actual gas flowrate	*%*	5%		15%	15%	15%	15%	15%
- H_2O content for the actual gas flowrate	*%(vol)*	7%		3%	3%	3%	3%	3%
Volumetric flow rate - Normalised	Nm^3/hr (dry gas, 0°C)	6,719		174,192	174,192	174,192	174,192	174,192

Parameter	Units	TO1	MPC1	MPC2	MPC3	MPC4	MPC5
- O_2 content for the Normalised gas flowrate	*%*	3%	15%	15%	15%	15%	15%
Exhaust gas mass flowrate	kg/hr	9,020	211,577	211,577	211,577	211,577	211,577
Exhaust gas density	kg/m^3 (0°C, 1 atm)	1.25	1.18	1.18	1.18	1.18	1.18
Pollutant Emissions							
NO_X - Emission rate	kg/hr	1.63	17.89	17.89	17.89	17.89	17.89
NO_X – Concentration	ppmv	118	50	50	50	50	50
NO_X - O_2 content relating to the maximum in-stack concentration	*%*	3%	15%	15%	15%	15%	15%
SO_2 - Emission rate	kg/hr	0.30	0.23	0.23	0.23	0.23	0.23
SO_2 - Concentration	mg/Nm^3	44.75	1.34	1.34	1.34	1.34	1.34
SO_2 - O_2 content relating to the maximum in-stack concentration	*%*	3%	15%	15%	15%	15%	15%
CO - Emission rate	kg/hr	**0.01**	**5.44**	**5.44**	**5.44**	**5.44**	**5.44**
CO - Concentration	mg/Nm^3	1.0	31.3	31.3	31.3	31.3	31.3
CO - O_2 content relating to the maximum in-stack concentration	*%*	3%	15%	15%	15%	15%	15%
TOTAL VOCS - Emission rate	kg/hr	**0.05**	**8.71**	**8.71**	**8.71**	**8.71**	**8.71**
TOTAL VOCS - Concentration	mg/Nm^3	7.31	50	50	50	50	50
TOTAL VOCS - O_2 content relating to the maximum in-stack concentration	*%*	3%	15%	15%	15%	15%	15%
Benzene	kg/hr	0.00003	0.0017	0.0017	0.0017	0.0017	0.0017
Toluene	kg/hr	0.00003	0.0016	0.0016	0.0016	0.0016	0.0016
Xylene	kg/hr	0.00002	0.00044	0.00044	0.00044	0.00044	0.00044
Ethylbenzene	kg/hr	0.000001	0.000044	0.000044	0.000044	0.000044	0.000044

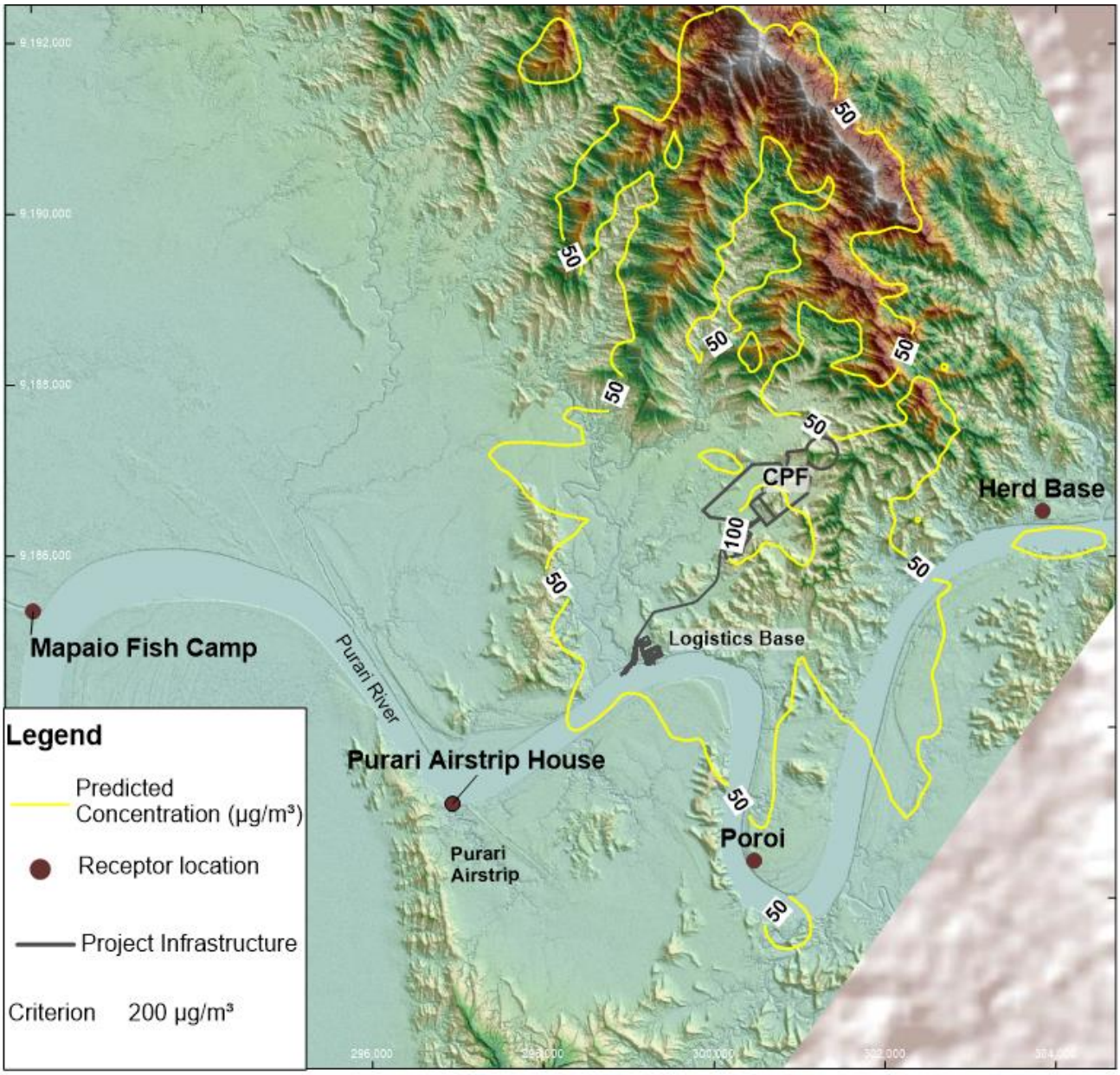
APPENDIX B

Contour Plots

Contour Plots:

High pressure mode without acid gas injection, but with sulfur recovery and thermal oxidizer

Pollutant	Averaging Period
NO_2	1-hour
	Annual
SO_2	10-minutes
	1-hour
	24-hours
CO	1-hr
	8-hr
Benzene	1-hour
	Annual
Toluene	1-hour
	Annual
Xylene	1-hour
	Annual
Ethylbenzene	1-hour
	Annual



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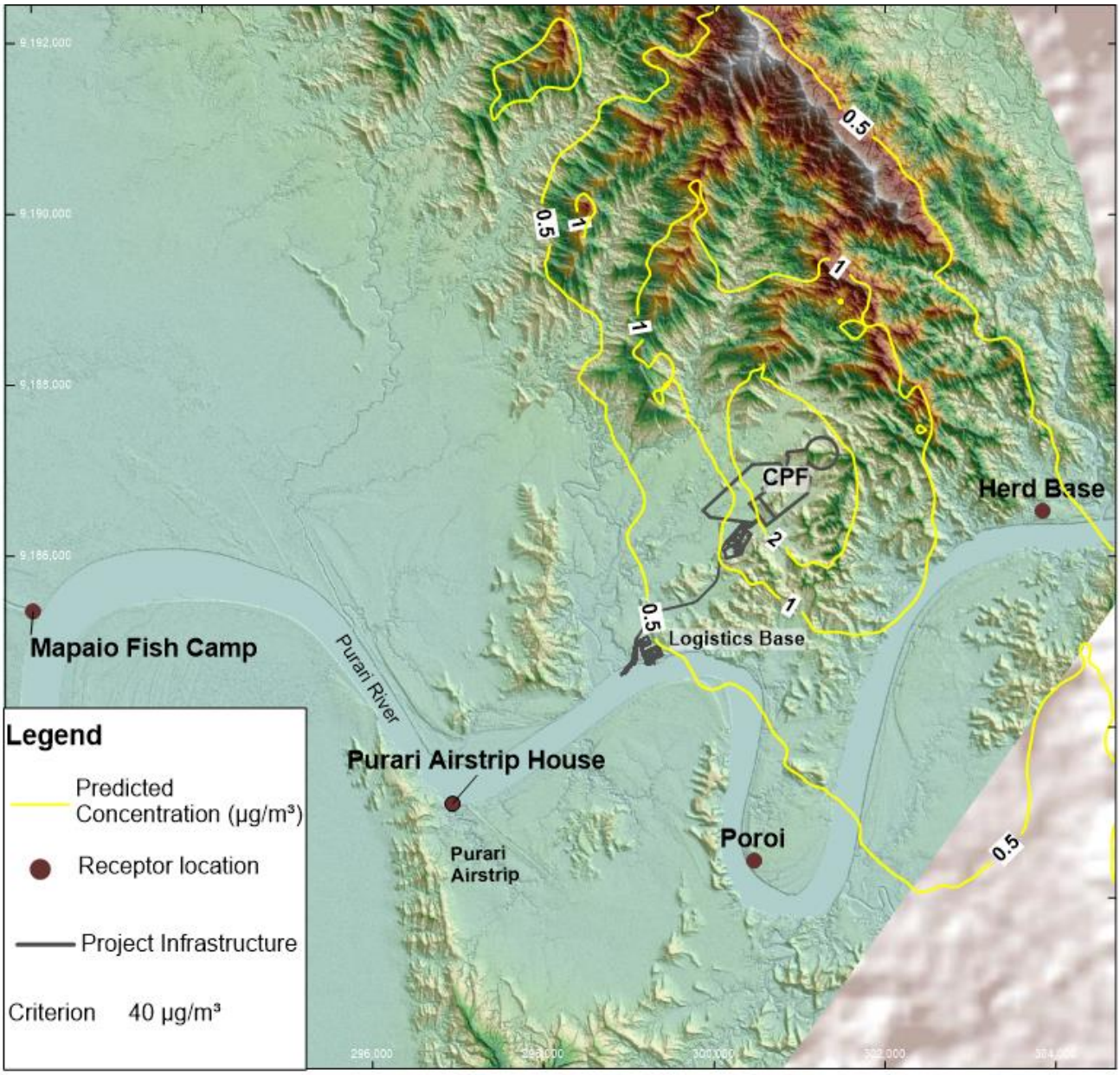
TOTAL

Proposed CPF
Air Quality Impact Assessment

HP/Incineration

Pollutant	NO_2	Averaging Period	1-Hour	Unit	µg/m³



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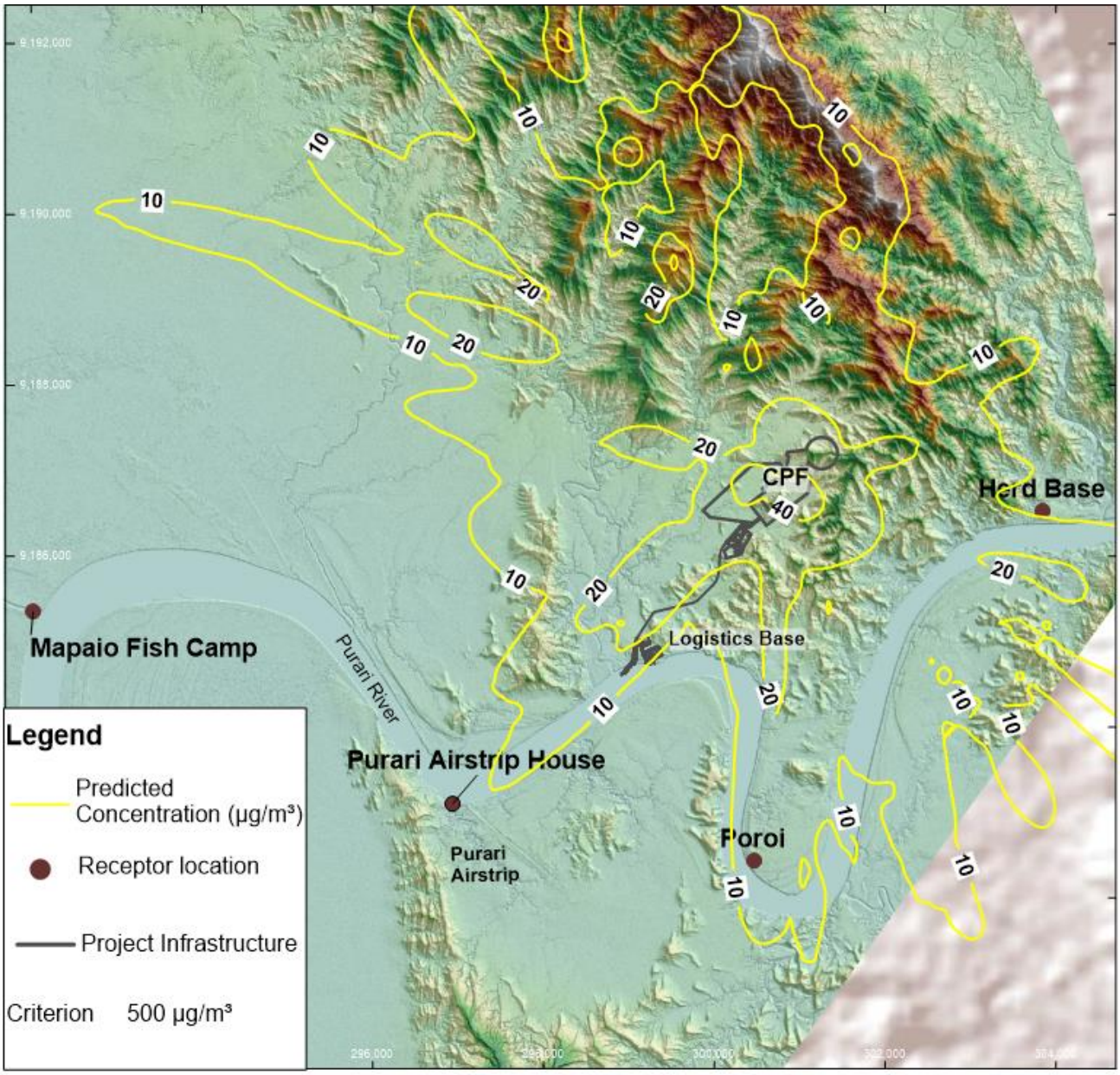
HP/Incineration

Pollutant	NO_2	Averaging Period	Annual	Unit	µg/m³



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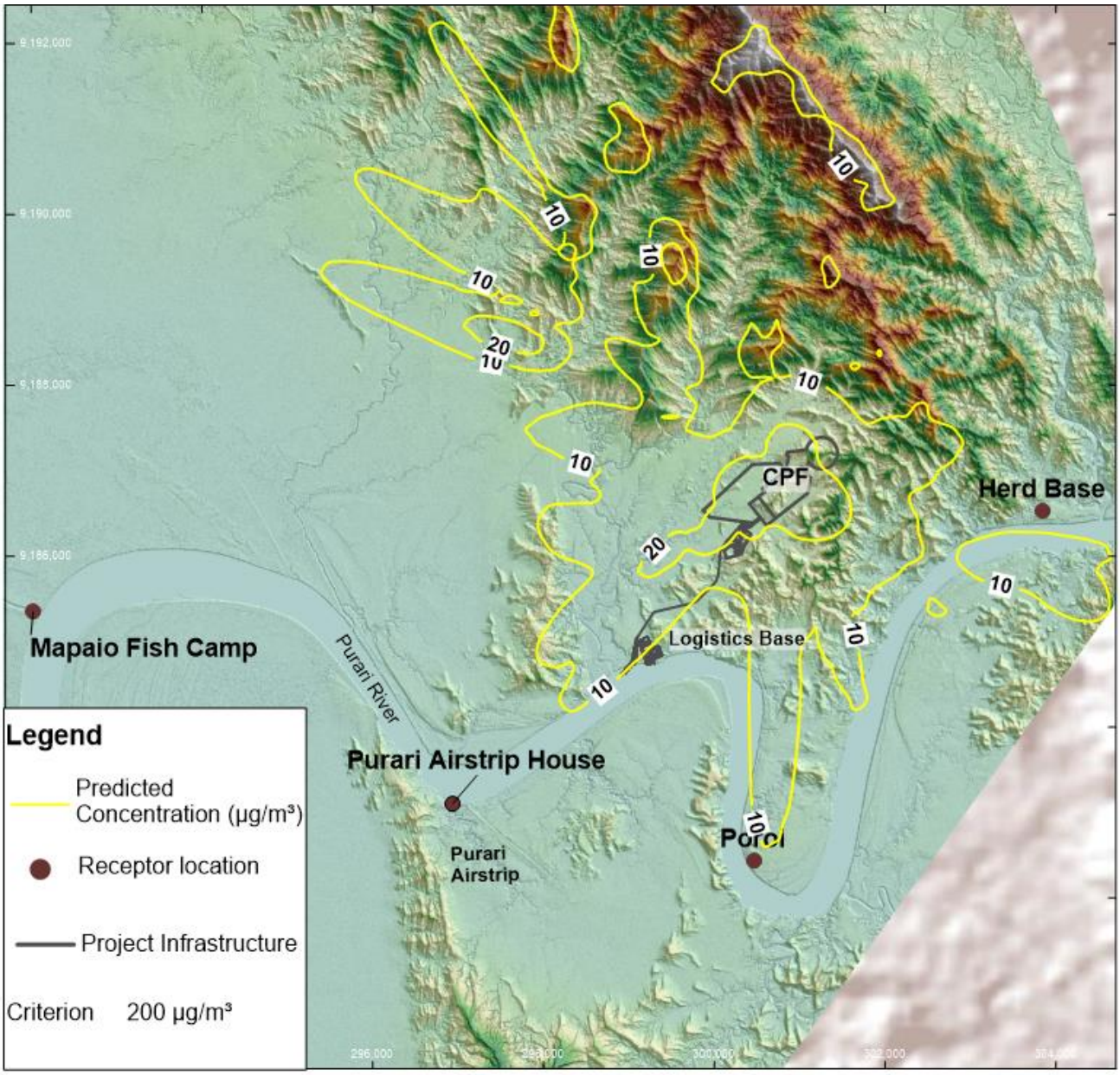
HP/Incineration

Pollutant	SO_2	Averaging Period	10-Minute	Unit	µg/m³



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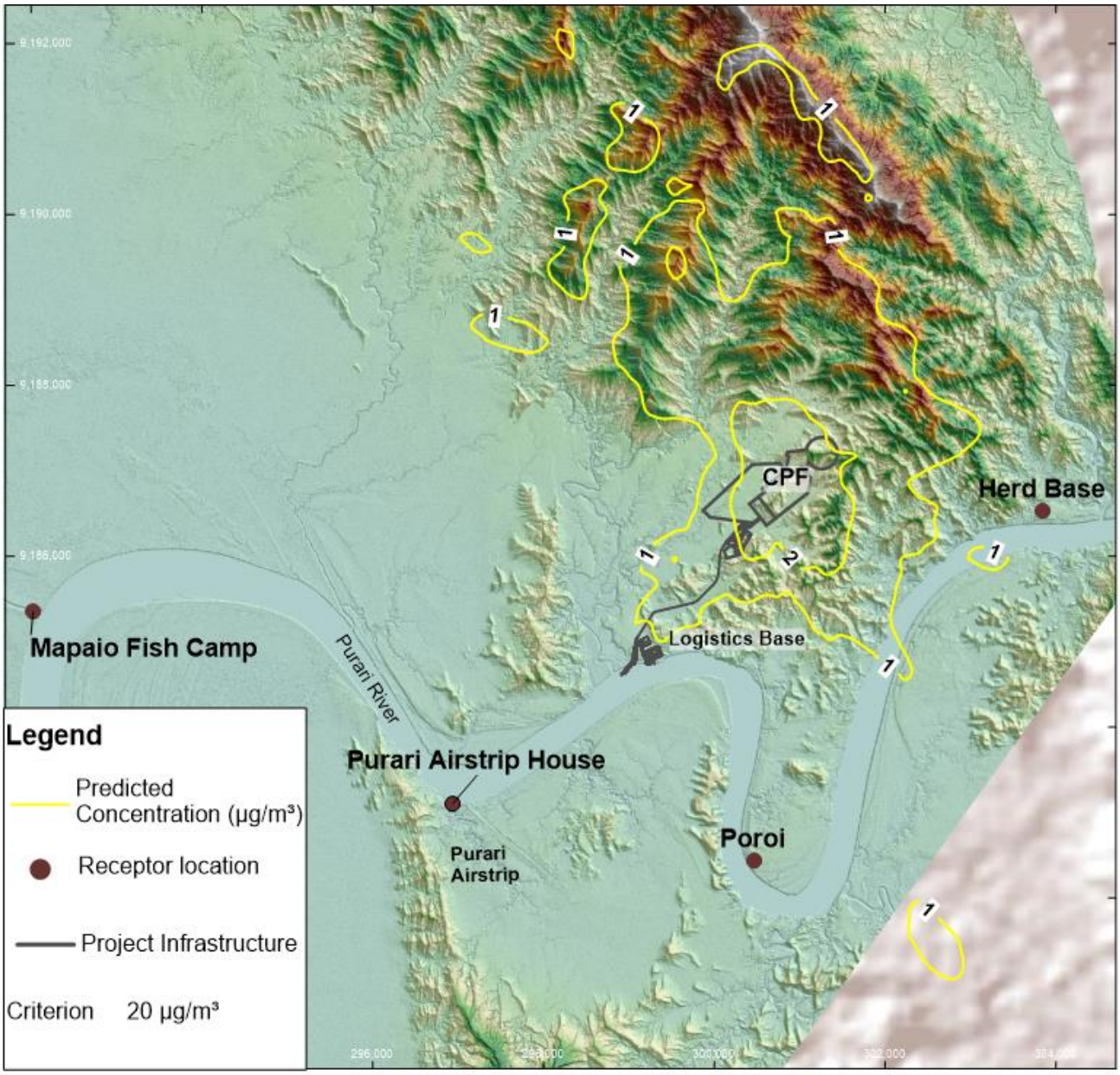
Air Quality Impact Assessment

HP/Incineration

Pollutant	SO_2	Averaging Period	1-Hour	Unit	µg/m³



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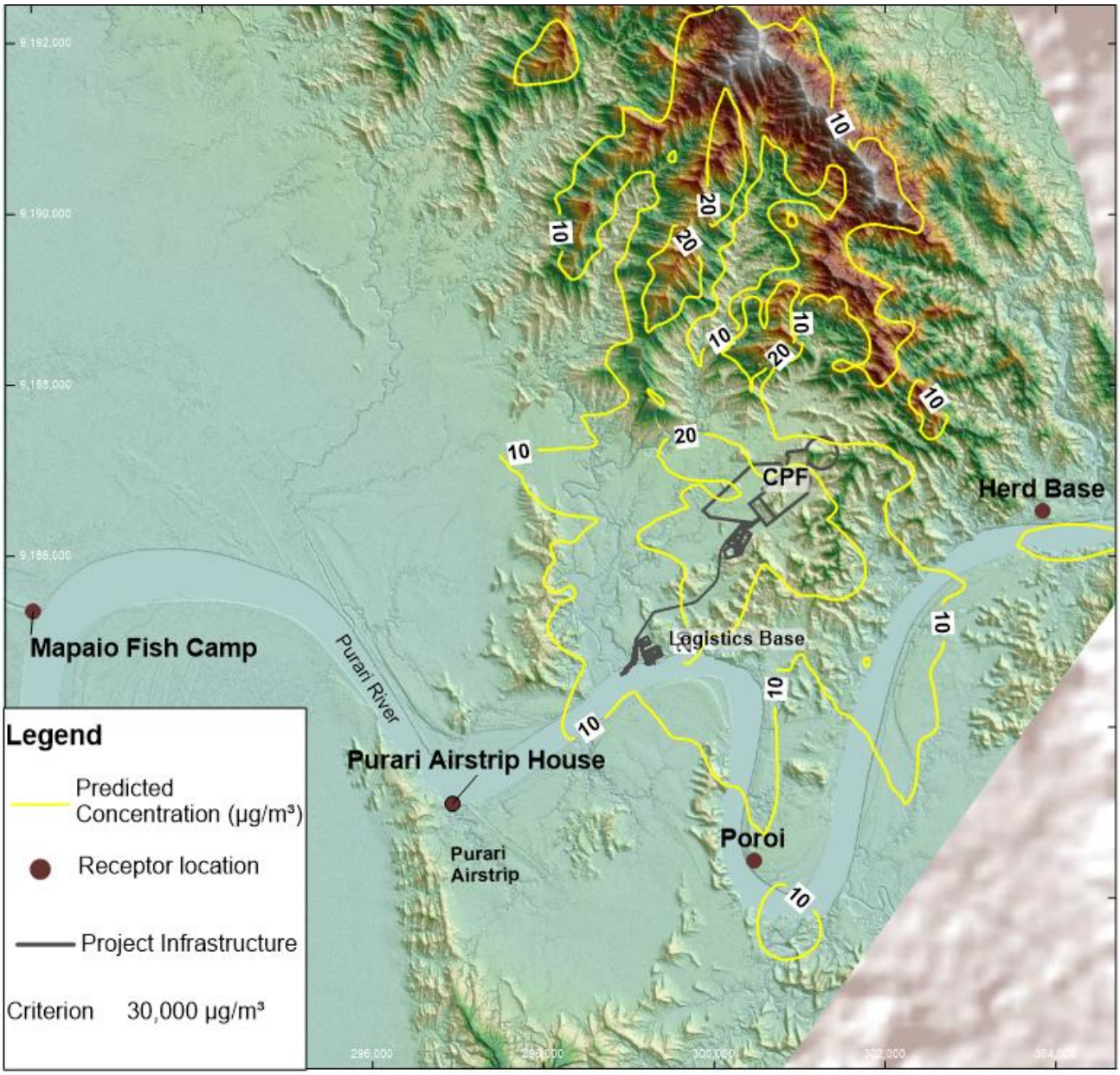
HP/Incineration

Pollutant	SO_2	Averaging Period	24-Hour	Unit	µg/m³



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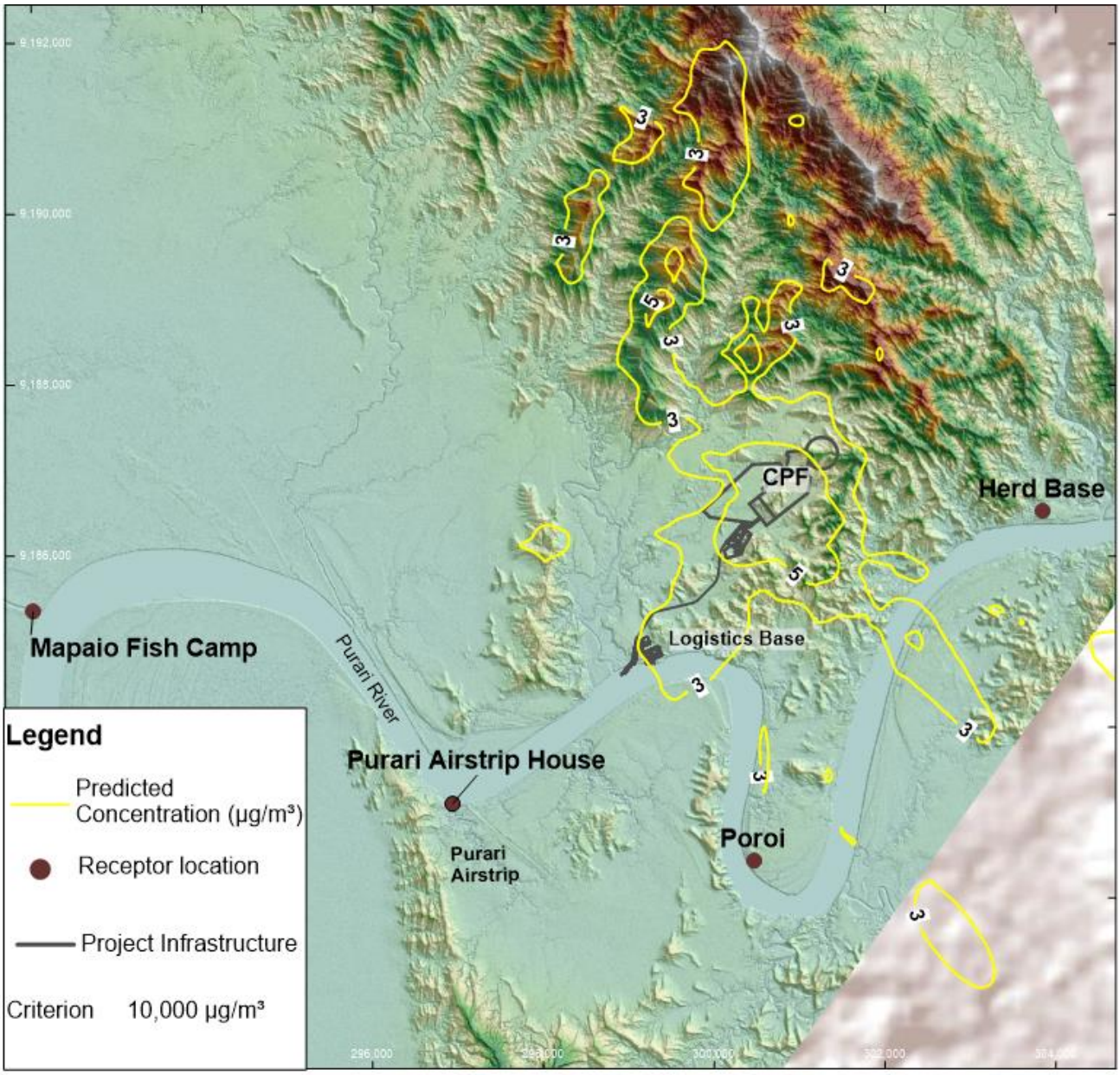
HP/Incineration

Pollutant	CO	Averaging Period	1-Hour	Unit	µg/m³



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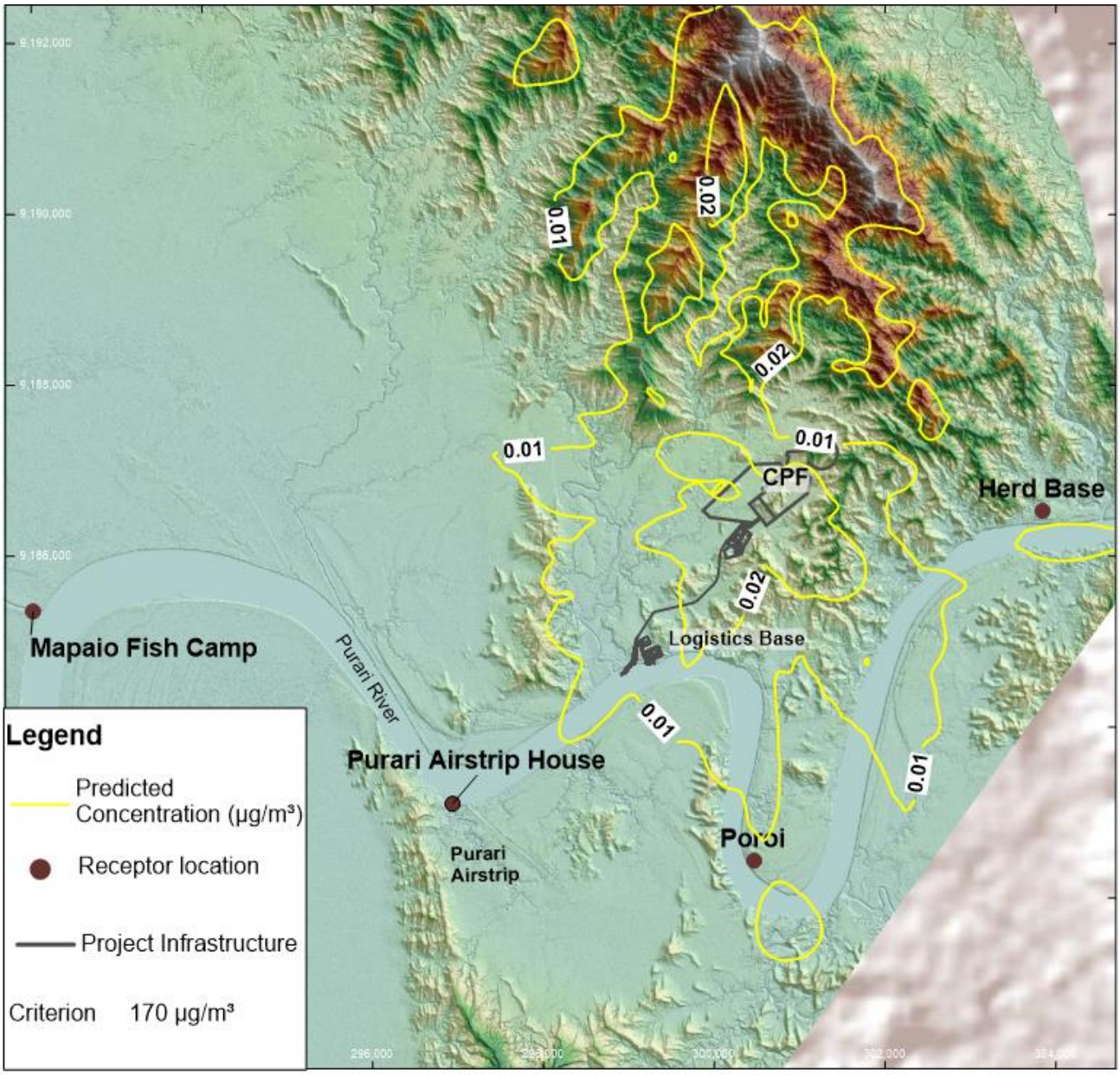
HP/Incineration

Pollutant	CO	Averaging Period	8-Hour	Unit	µg/m³



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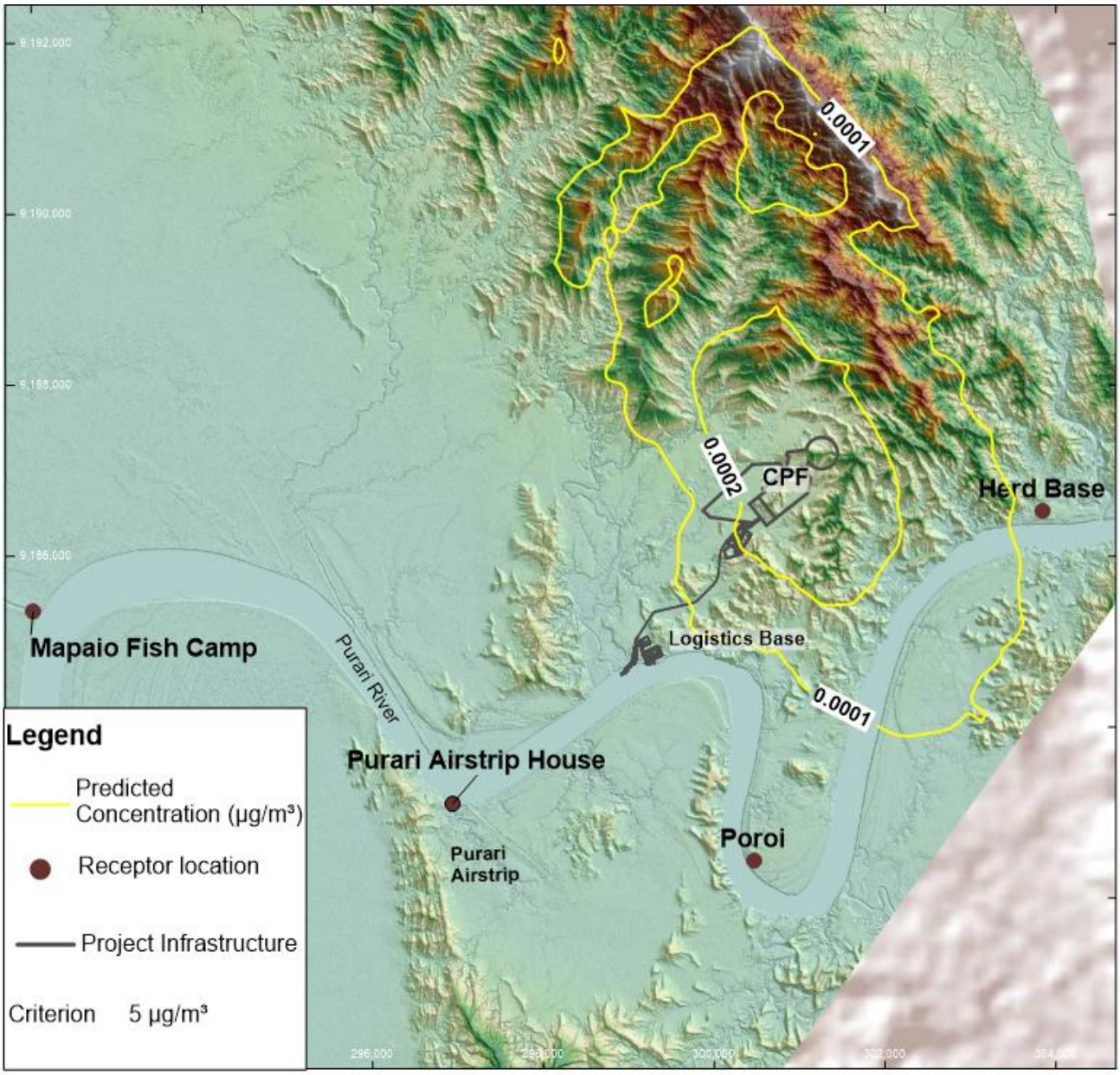
HP/Incineration

Pollutant	Benzene	Averaging Period	1-Hour	Unit	µg/m³



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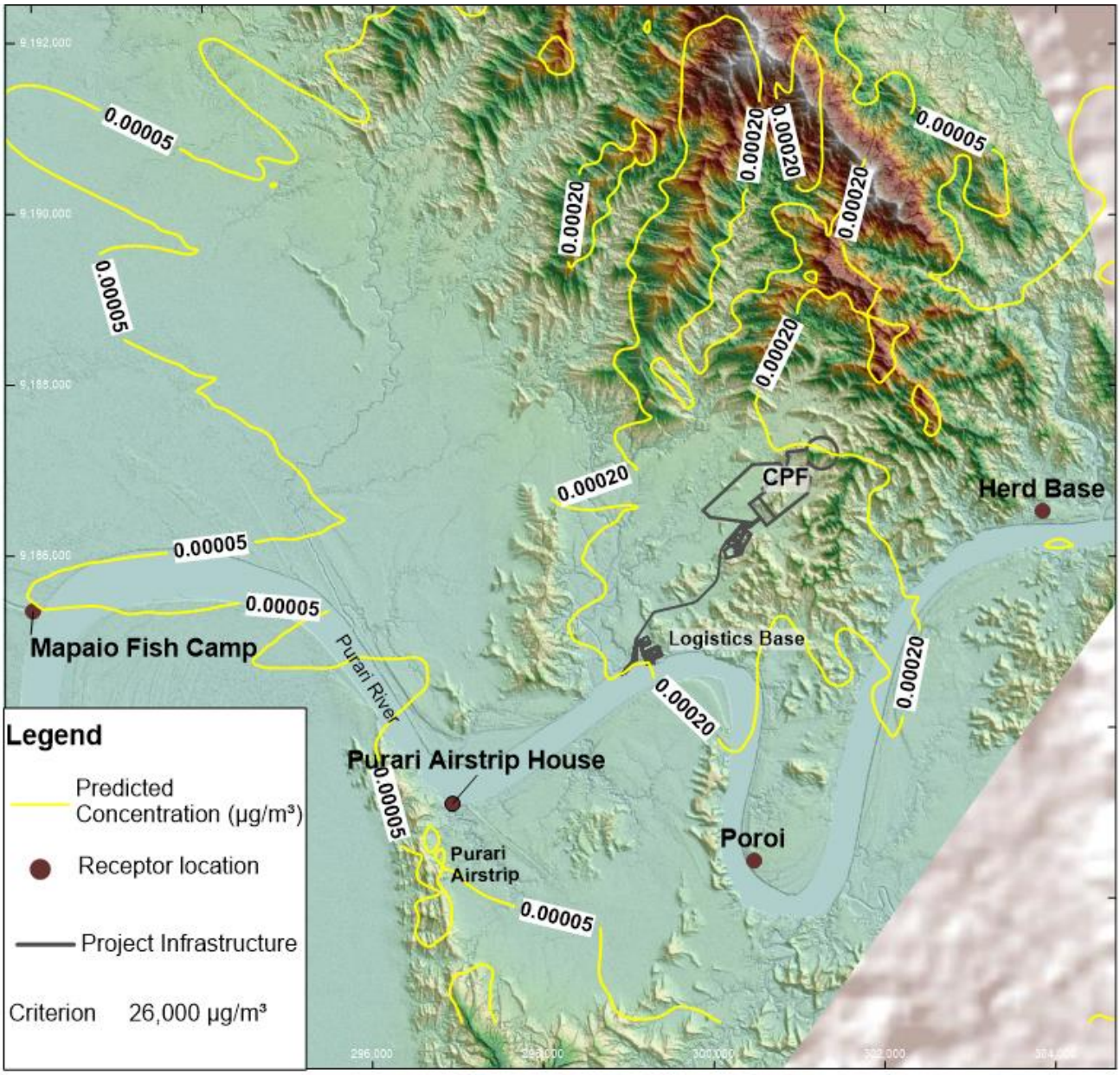
Proposed CPF Air Quality Impact Assessment

HP/Incineration

Pollutant	Benzene	Averaging Period	Annual	Unit	µg/m³



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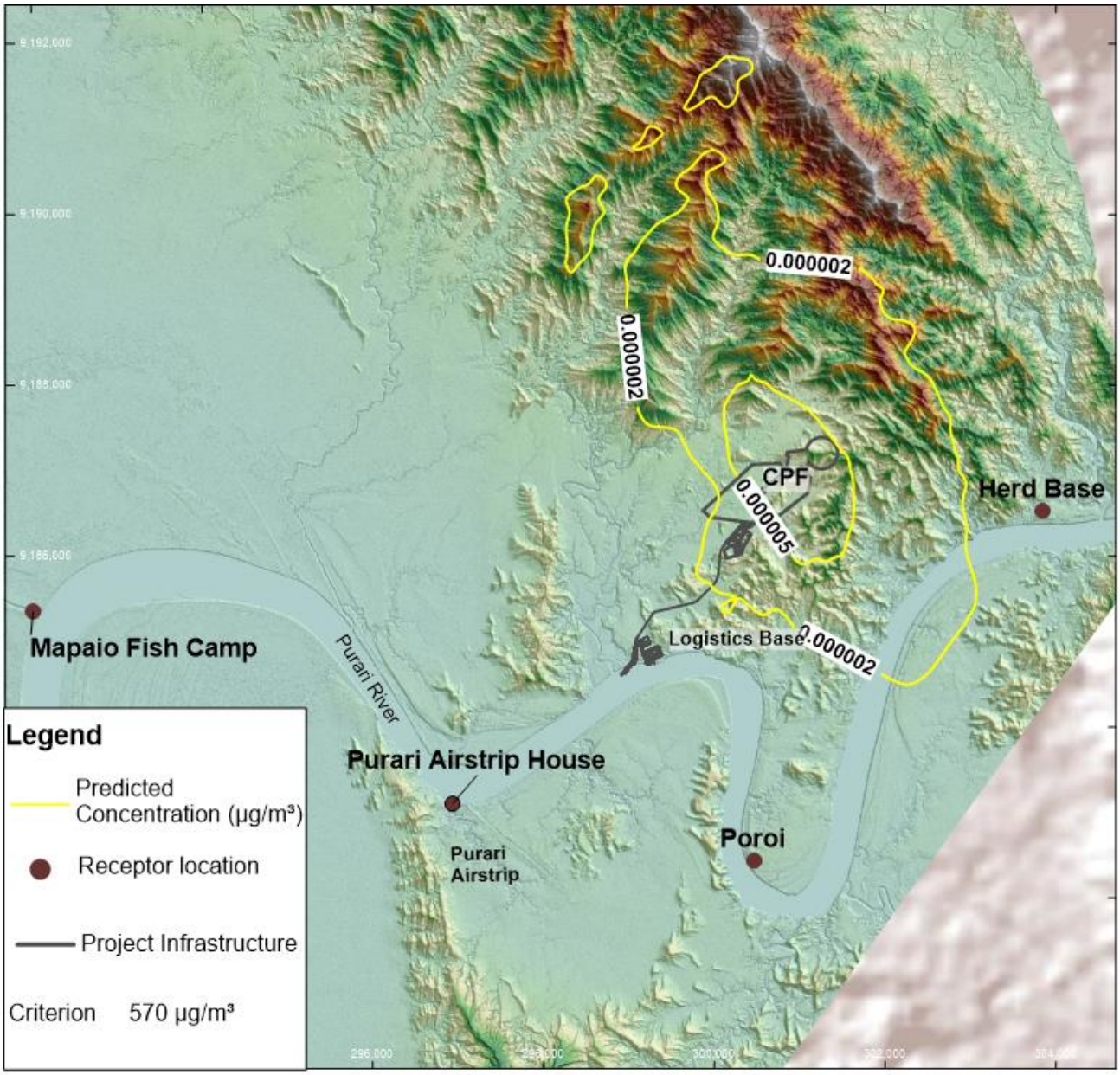
Air Quality Impact Assessment

HP/Incineration

Pollutant	Ethylbenzene	Averaging Period	1-Hour	Unit	µg/m³



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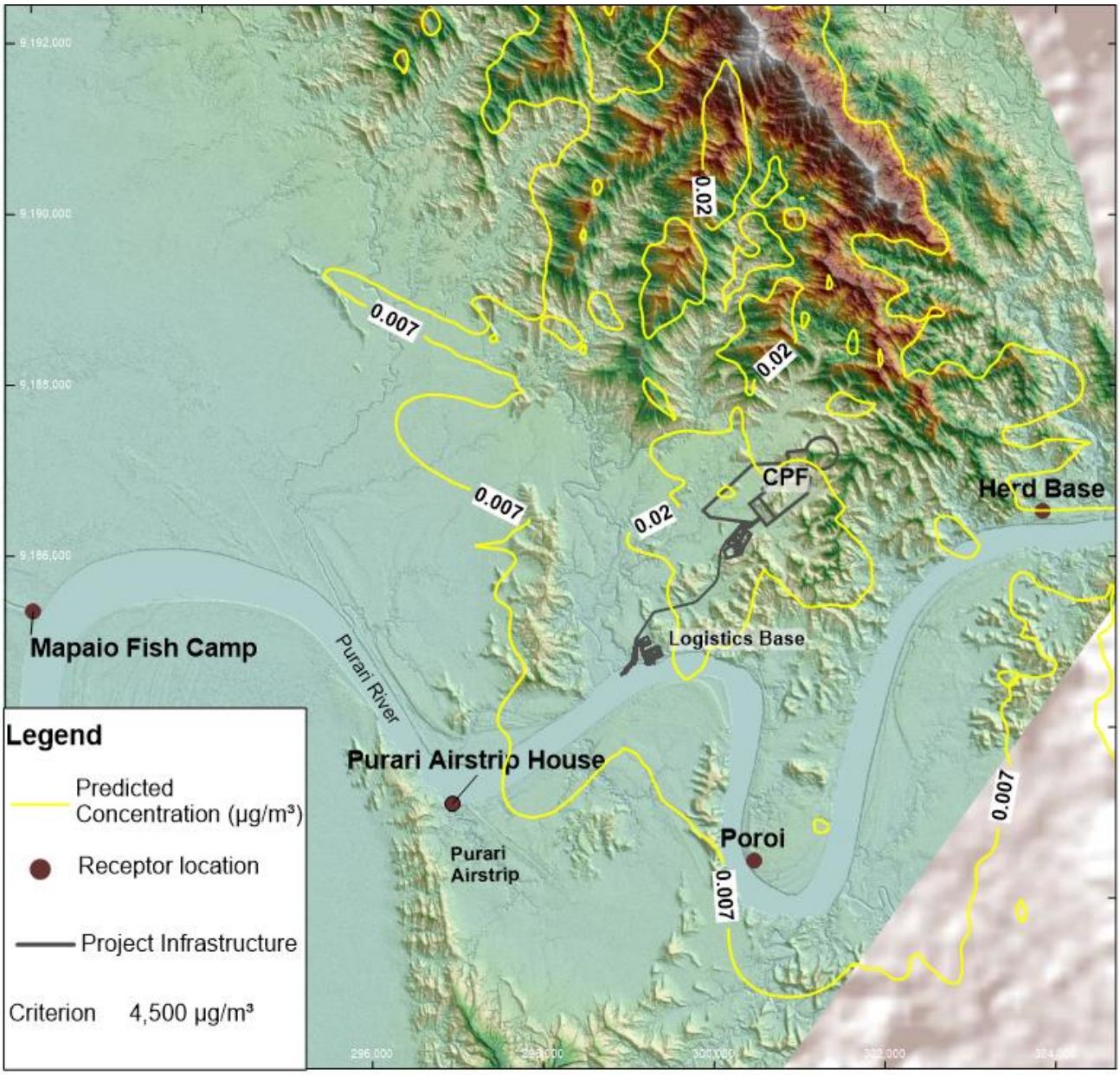
Air Quality Impact Assessment

HP/Incineration

Pollutant	Ethylbenzene	Averaging Period	Annual	Unit	µg/m³



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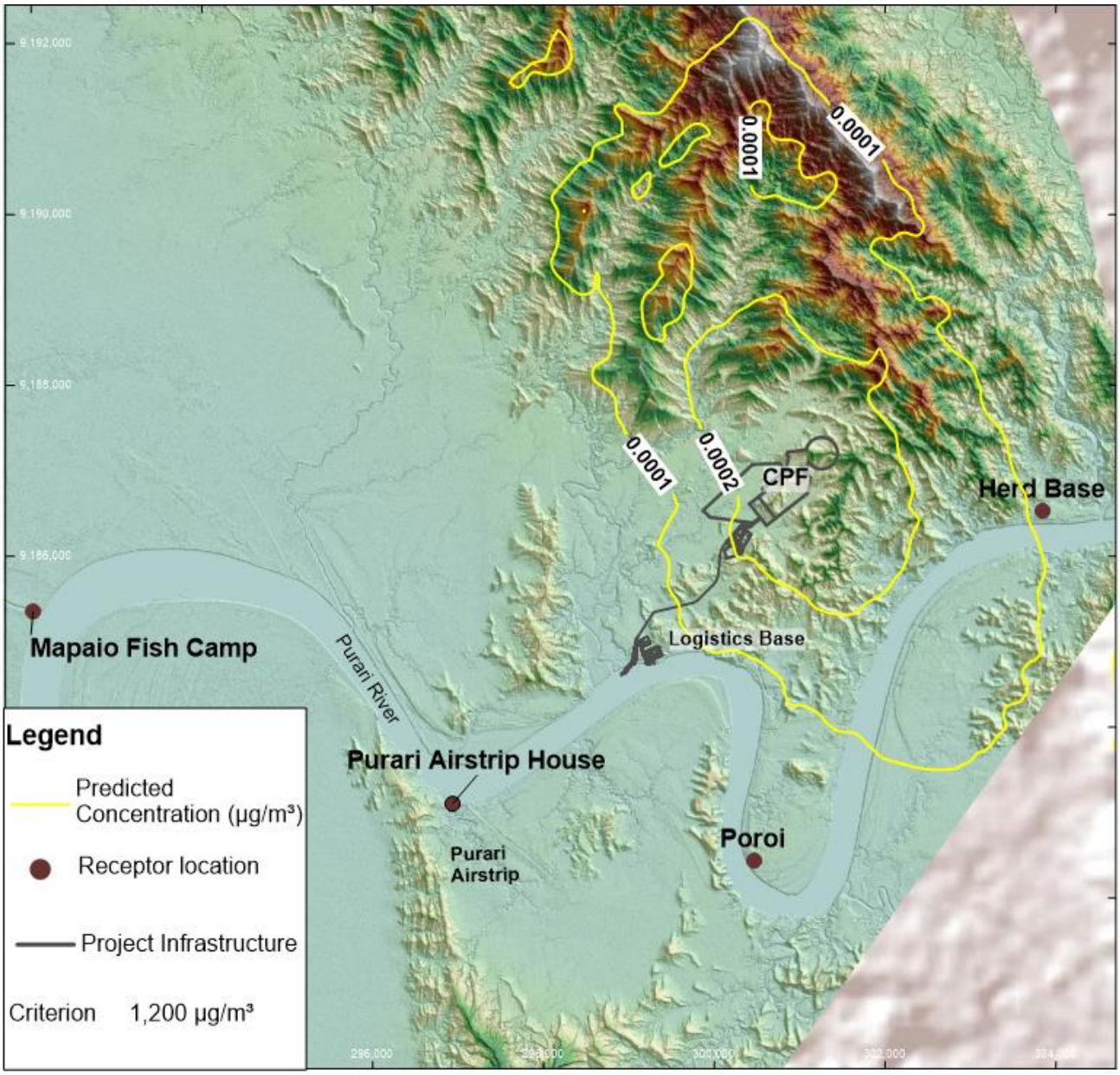
HP/Incineration

Pollutant	Toluene	Averaging Period	1-Hour	Unit	µg/m³



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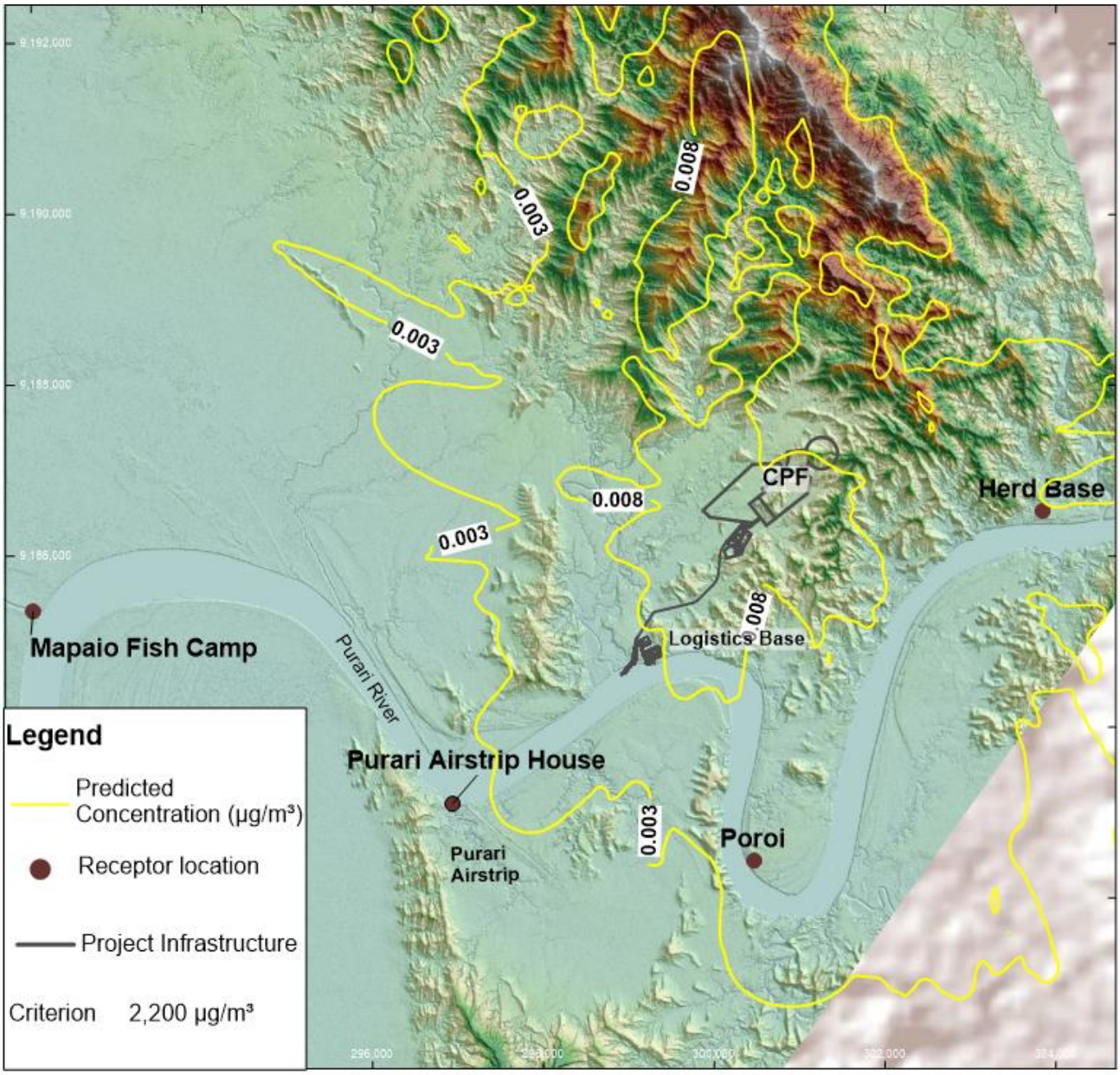
Proposed CPF
Air Quality Impact Assessment

HP/Incineration

Pollutant	Toluene	Averaging Period	Annual	Unit	µg/m³



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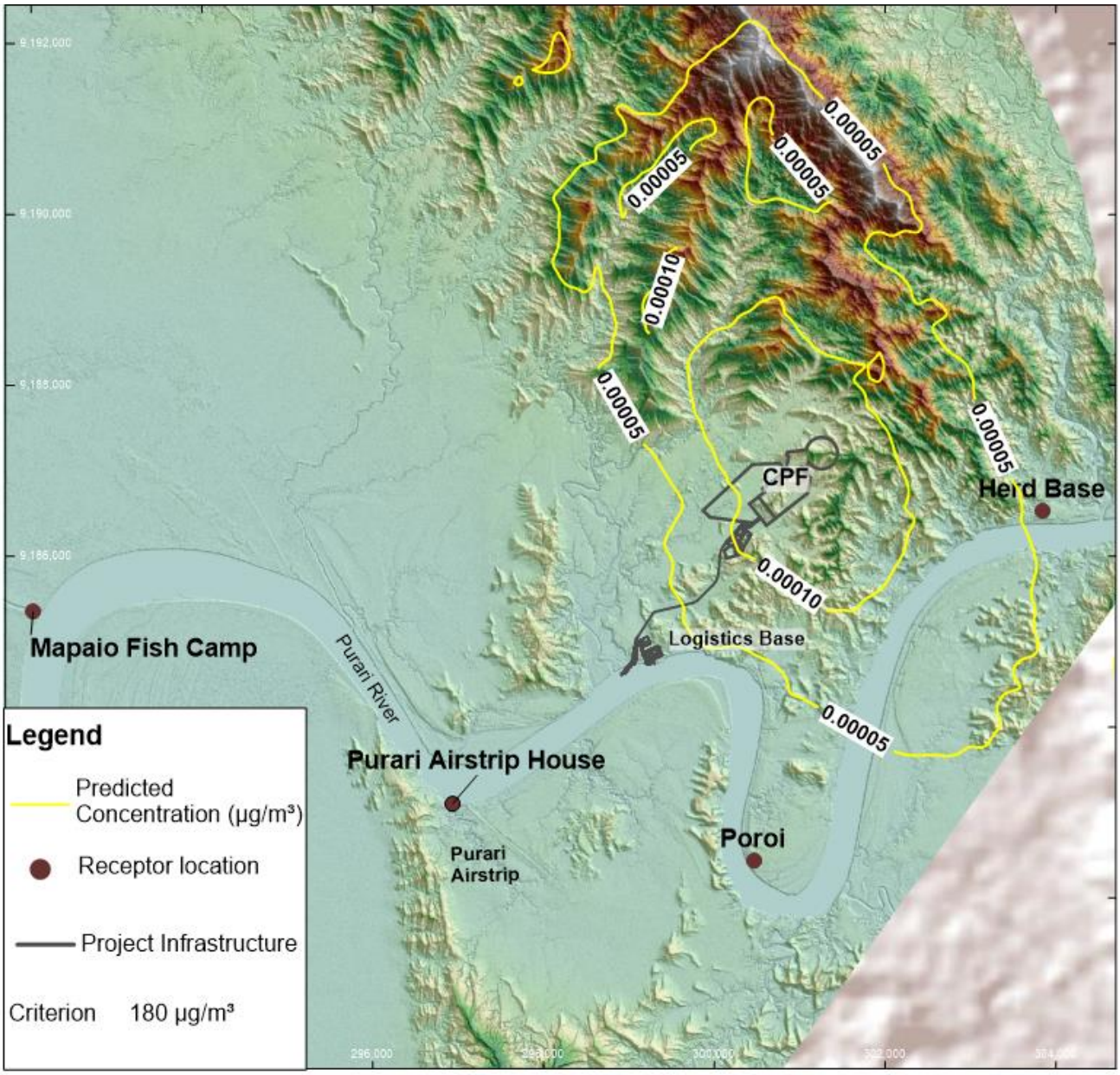
Air Quality Impact Assessment

HP/Incineration

Pollutant	Xylene	Averaging Period	1-Hour	Unit	µg/m³



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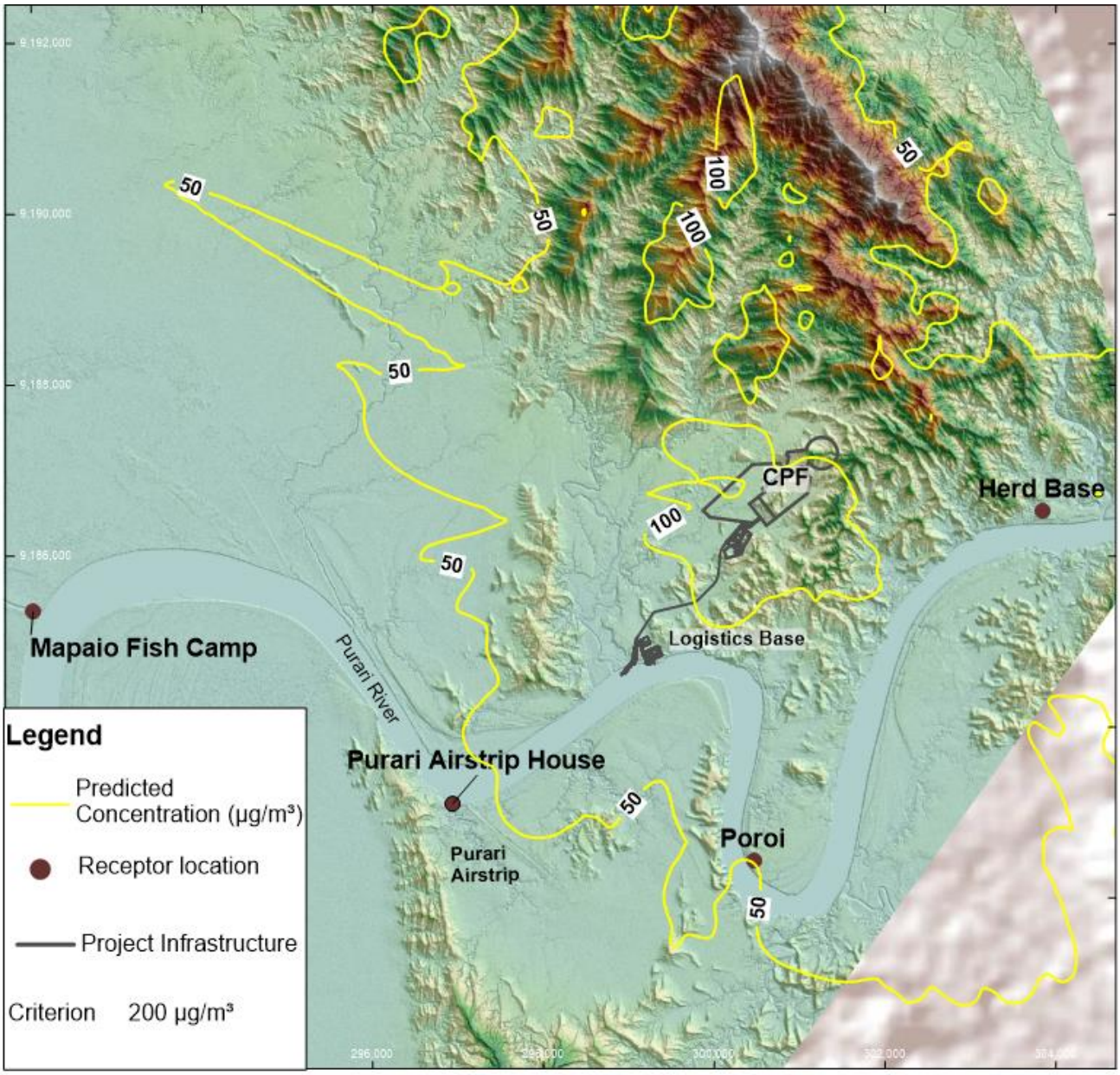
Proposed CPF Air Quality Impact Assessment

HP/Incineration

Pollutant	Xylene	Averaging Period	Annual	Unit	µg/m³

Contour Plots:
Acid gas injection and additional export gas compression

Pollutant	Averaging Period
NO_2	1-hour
	Annual
SO_2	10-minutes
	1-hour
	24-hours
CO	1-hr
	8-hr
Benzene	1-hour
	Annual
Toluene	1-hour
	Annual
Xylene	1-hour
	Annual
Ethylbenzene	1-hour
	Annual



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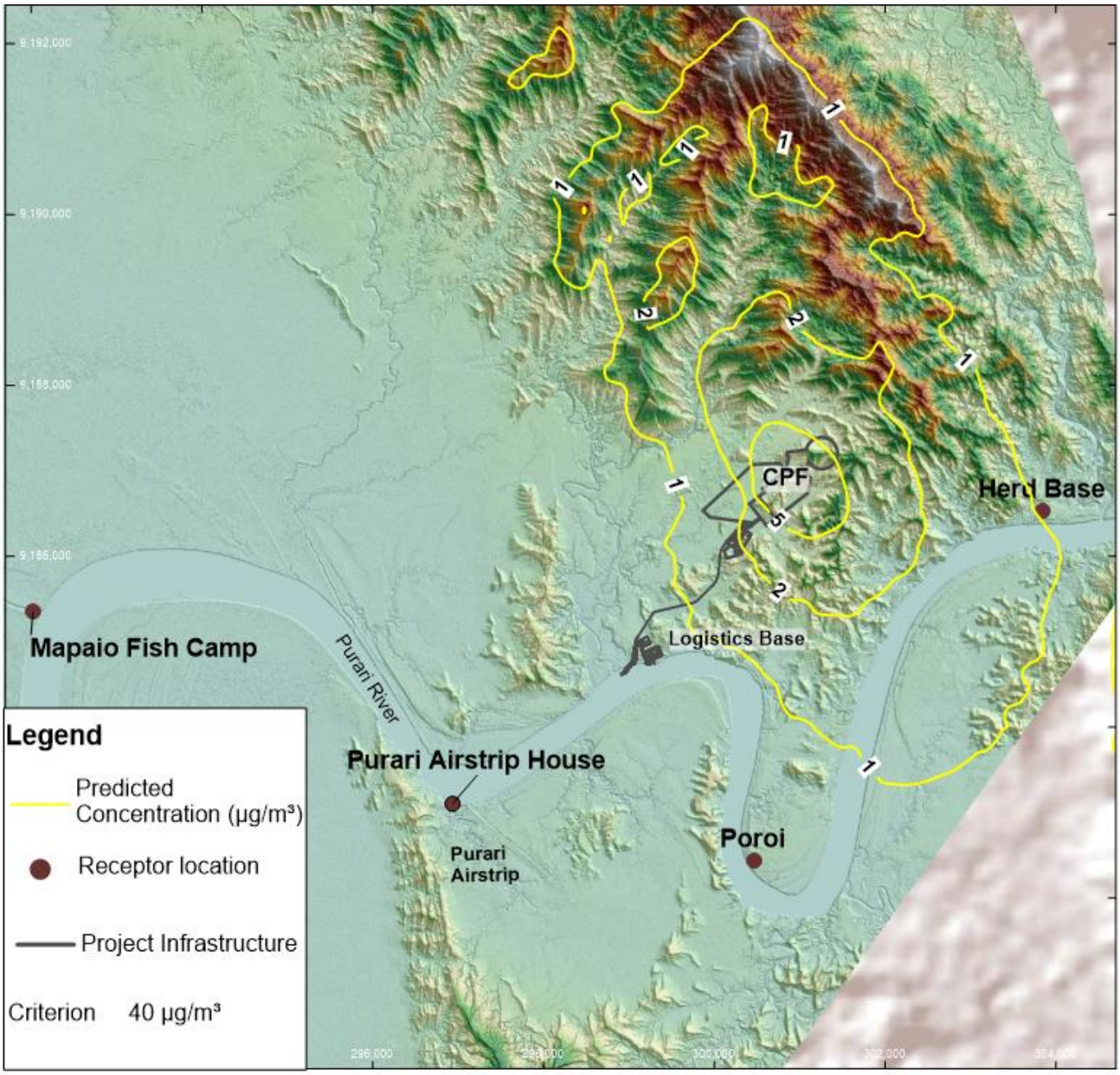
Proposed CPF Air Quality Impact Assessment

MP/LP and Acid Gas Injection

Pollutant	NO_2	Averaging Period	1-Hour	Unit	µg/m³



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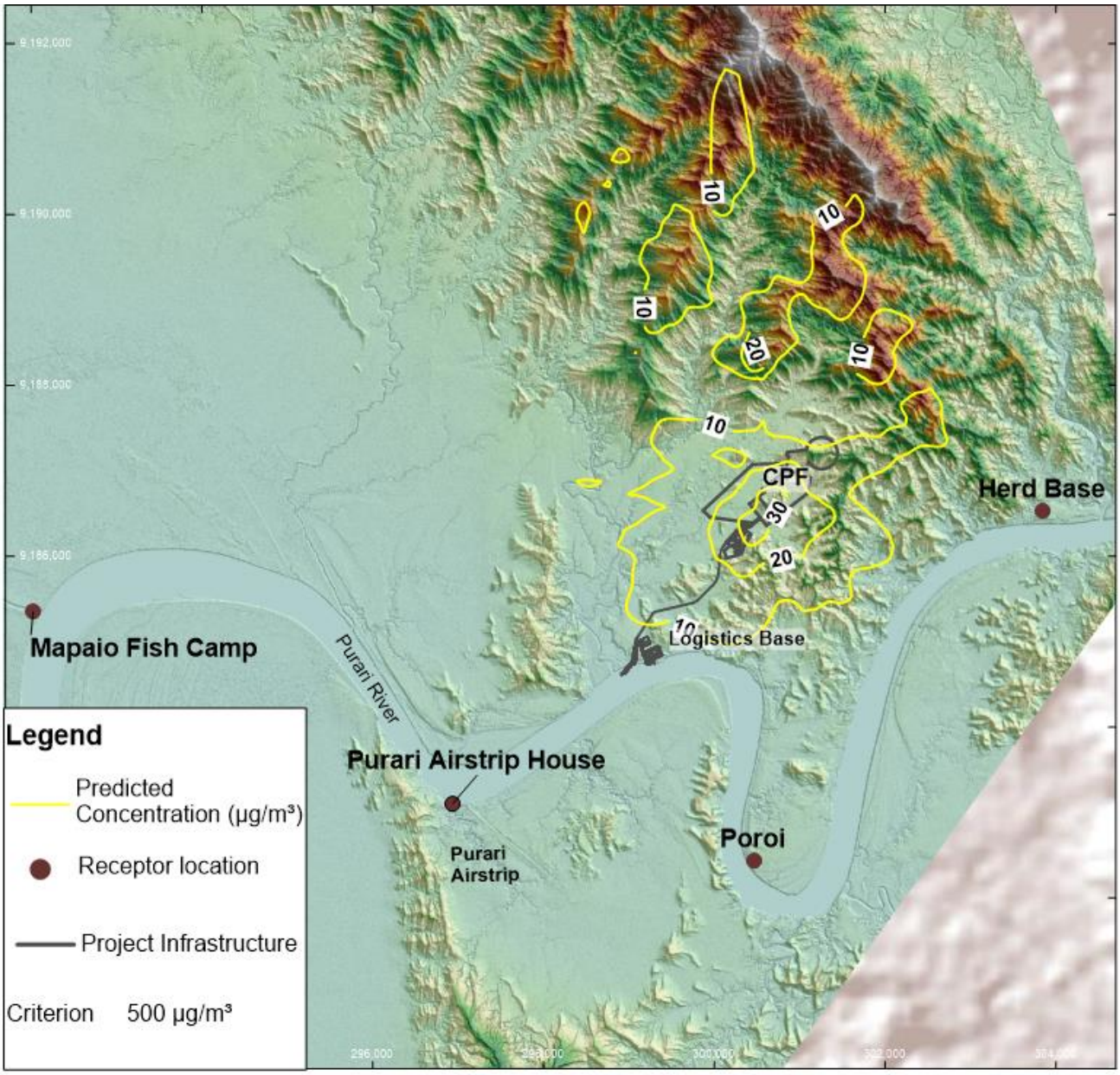
Air Quality Impact Assessment

MP/LP and Acid Gas Injection

Pollutant	NO_2	Averaging Period	Annual	Unit	µg/m³



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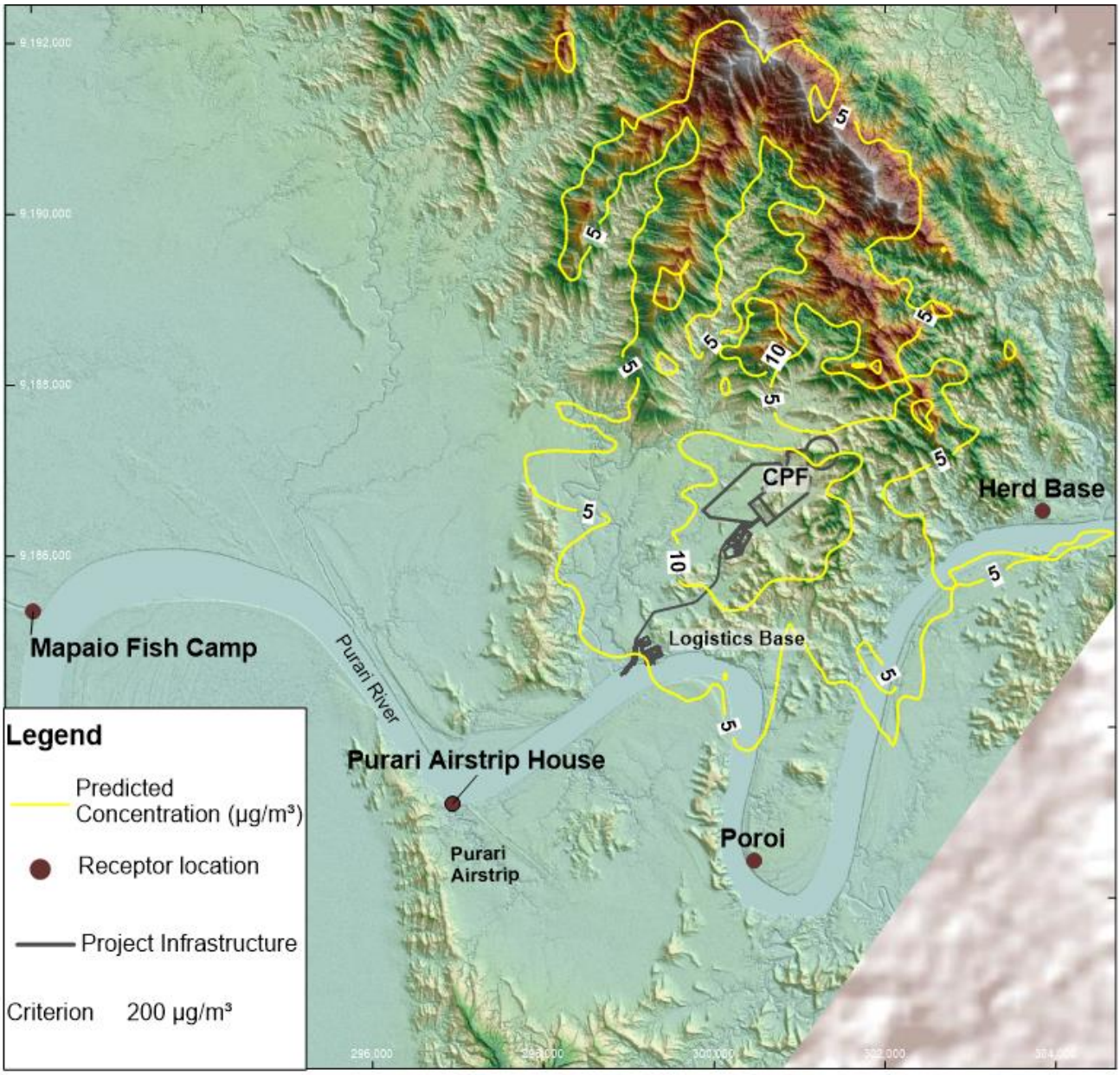
MP/LP and Acid Gas Injection

Pollutant	SO_2	Averaging Period	10-Minute	Unit	µg/m³



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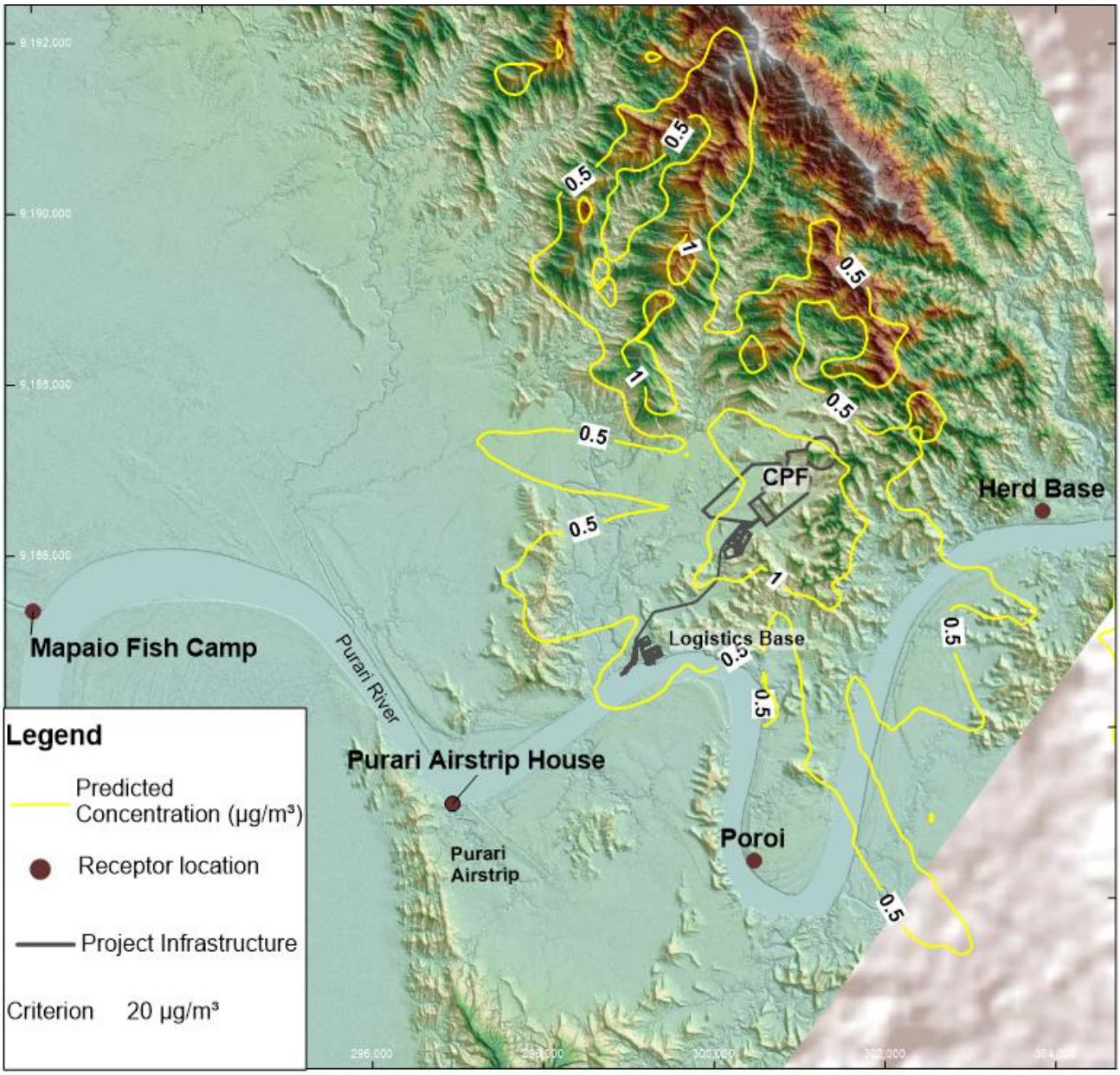
MP/LP and Acid Gas Injection

Pollutant	SO_2	Averaging Period	1-Hour	Unit	µg/m³



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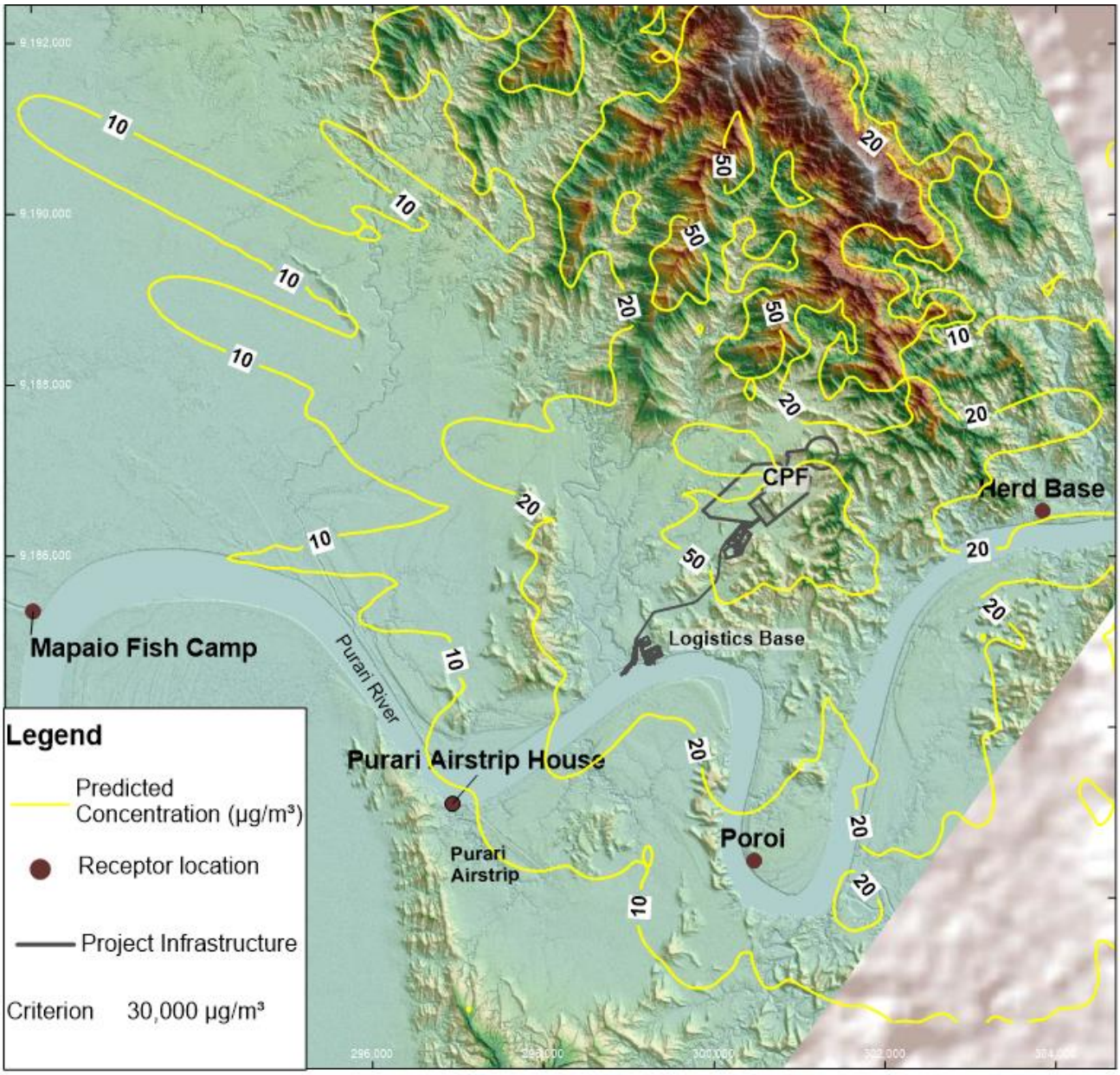
Date:	13/08/2019

TOTAL

Proposed CPF Air Quality Impact Assessment

MP/LP and Acid Gas Injection

Pollutant	SO_2	Averaging Period	24-Hour	Unit	µg/m³



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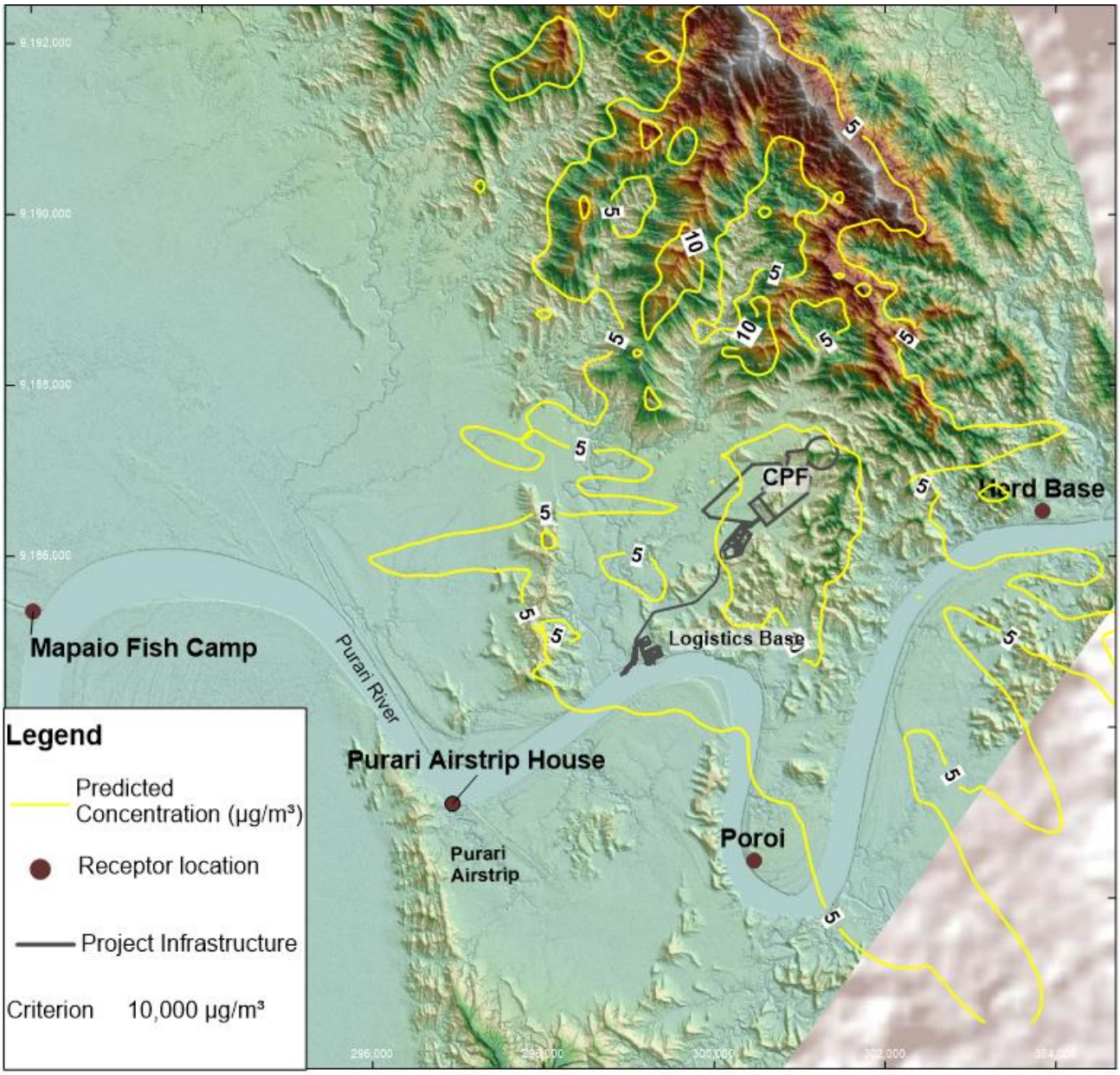
MP/LP and Acid Gas Injection

Pollutant	CO	Averaging Period	1-Hour	Unit	µg/m³



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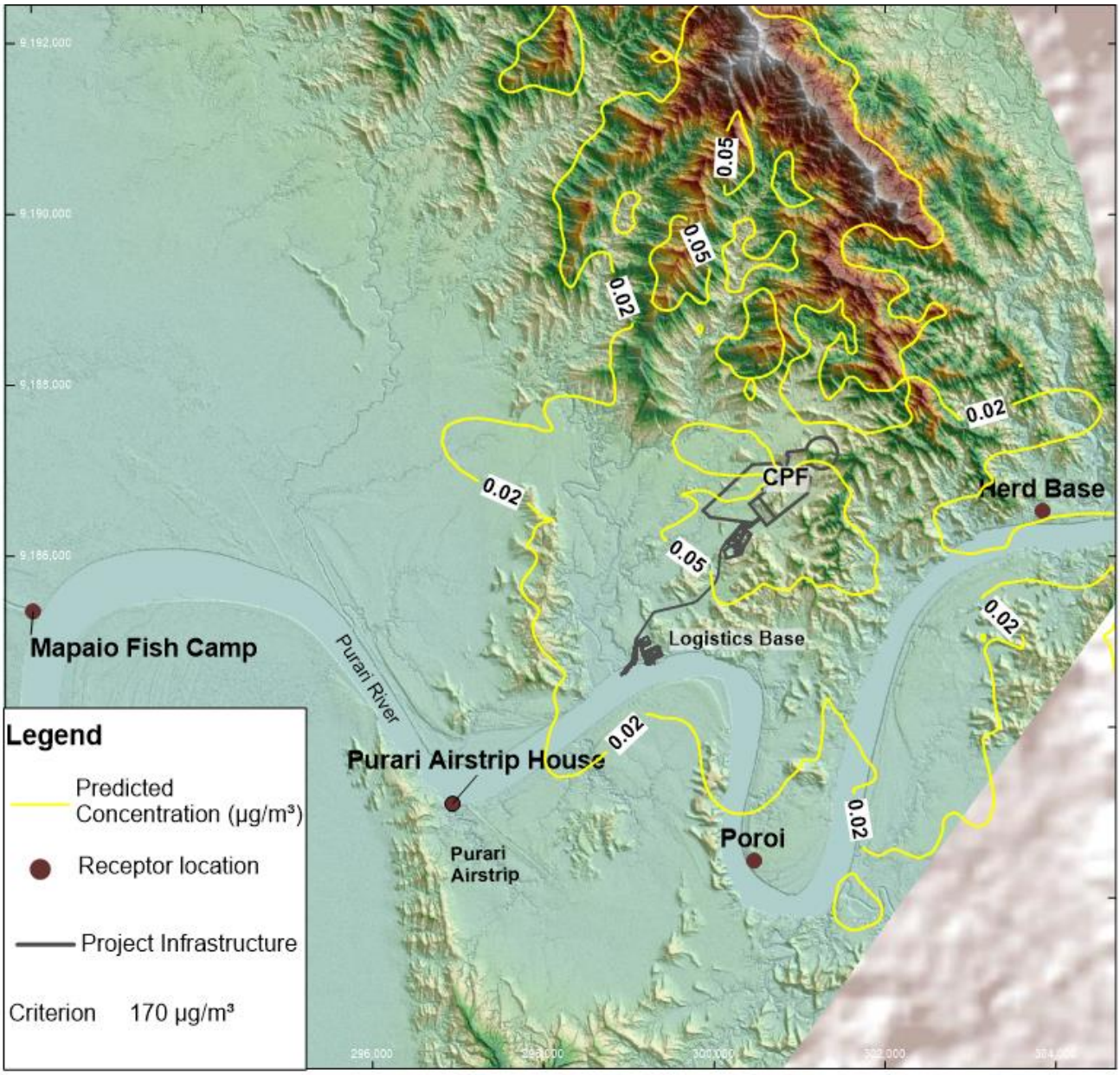
MP/LP and Acid Gas Injection

Pollutant	CO	Averaging Period	8-Hour	Unit	µg/m³



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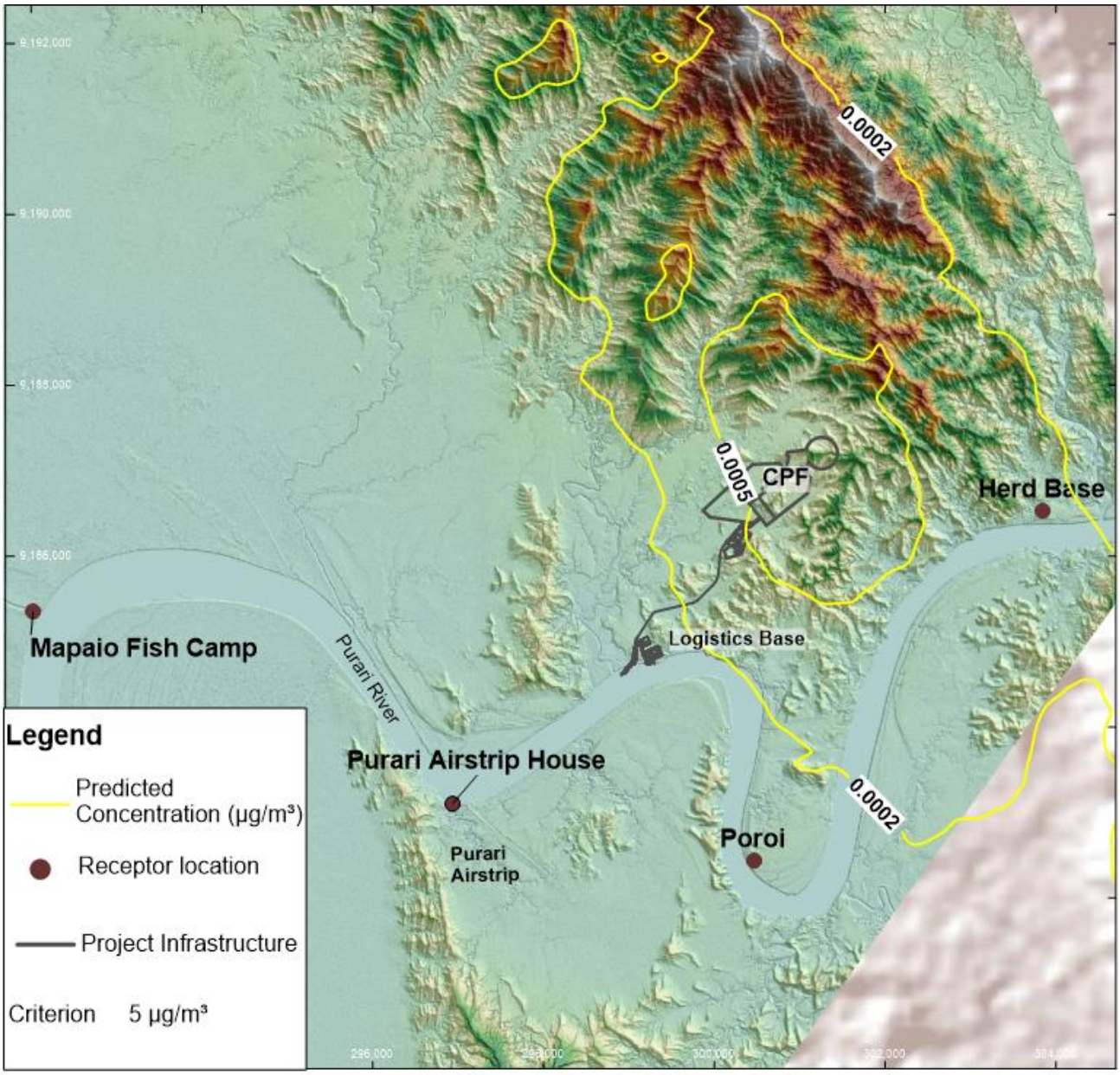
MP/LP and Acid Gas Injection

Pollutant	Benzene	Averaging Period	1-Hour	Unit	µg/m³



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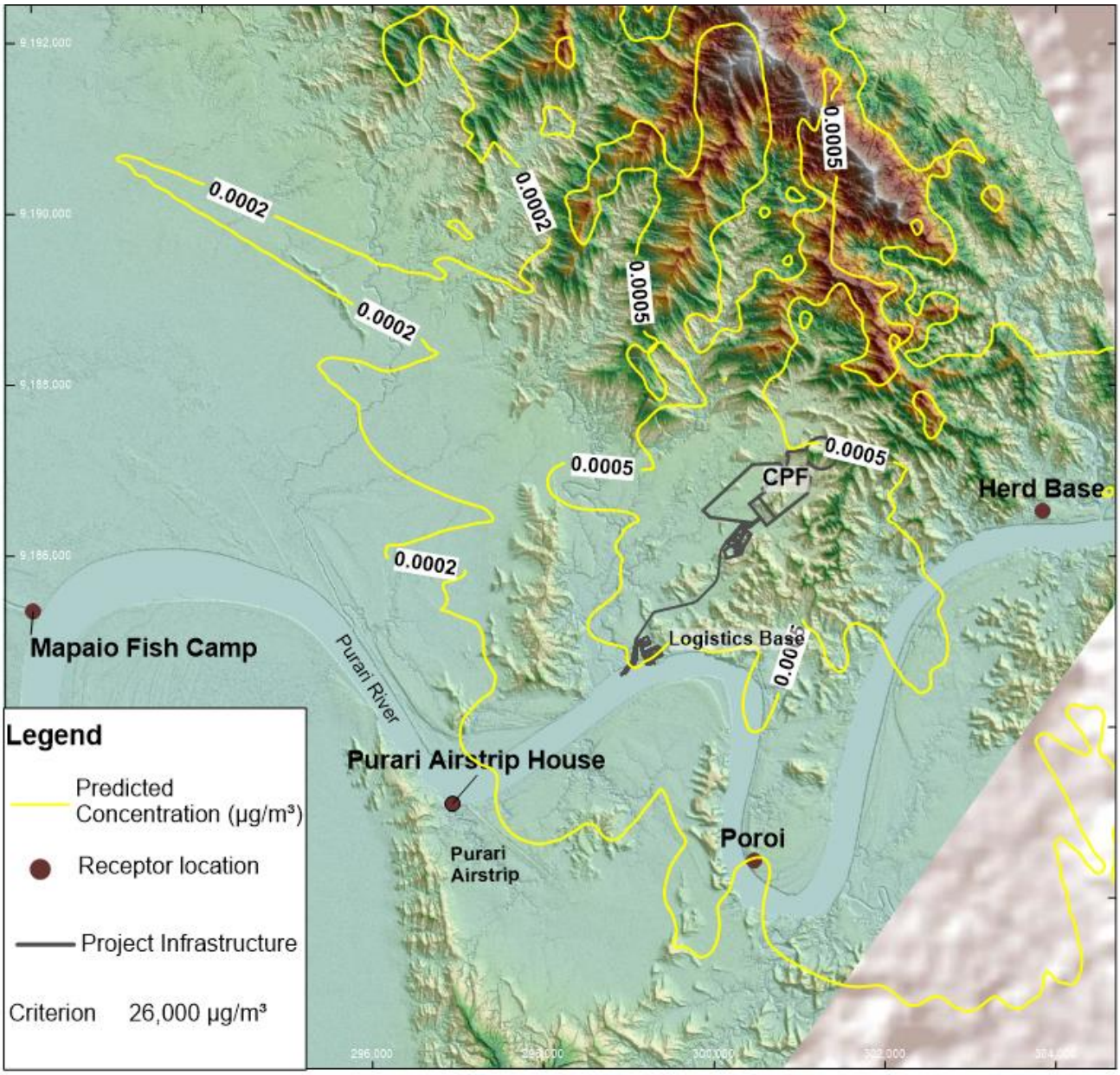
MP/LP and Acid Gas Injection

Pollutant	Benzene	Averaging Period	Annual	Unit	µg/m³



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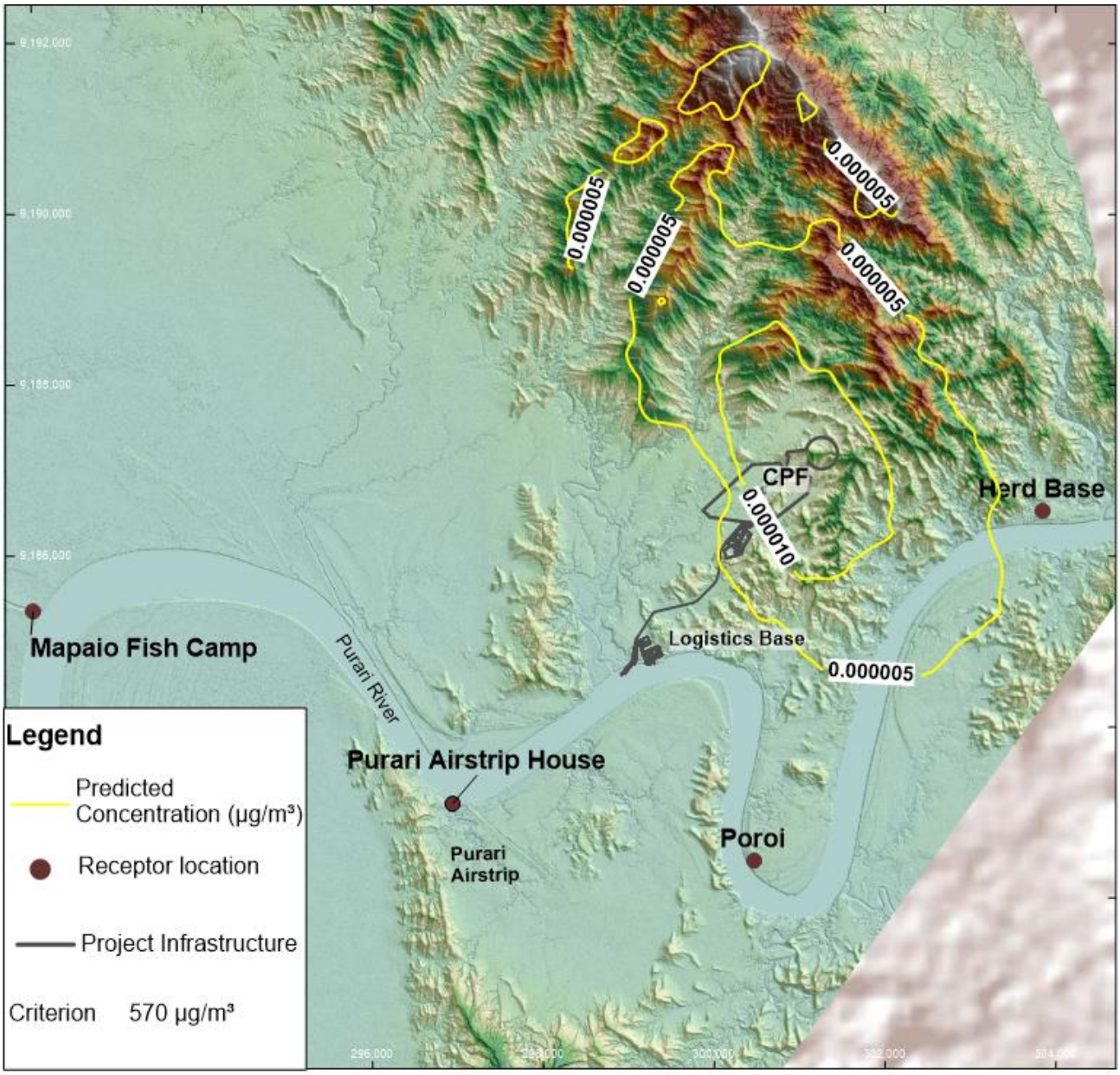
MP/LP and Acid Gas Injection

Pollutant	Ethylbenzene	Averaging Period	1-Hour	Unit	µg/m³



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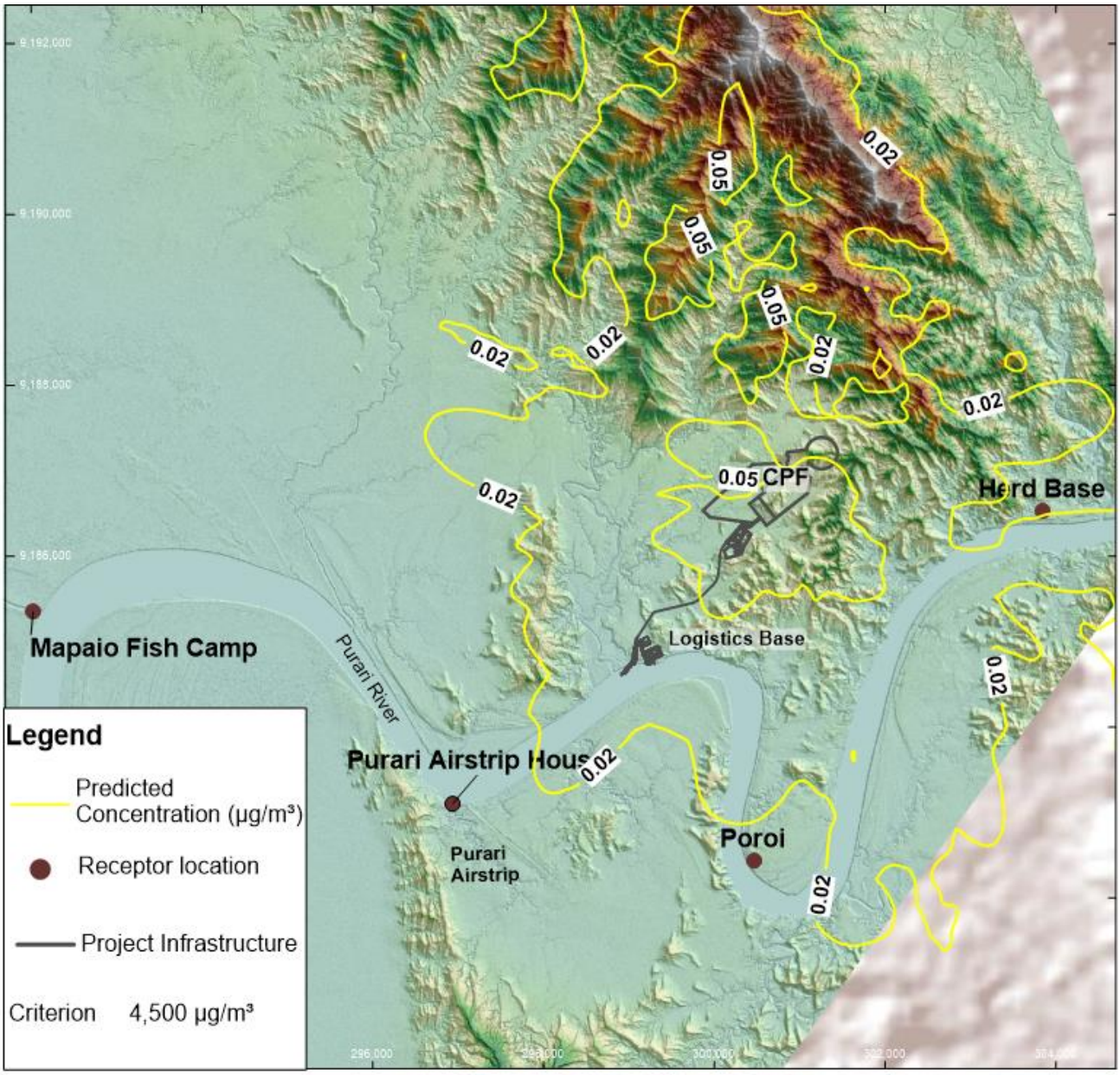
MP/LP and Acid Gas Injection

Pollutant	Ethylbenzene	Averaging Period	Annual	Unit	µg/m³



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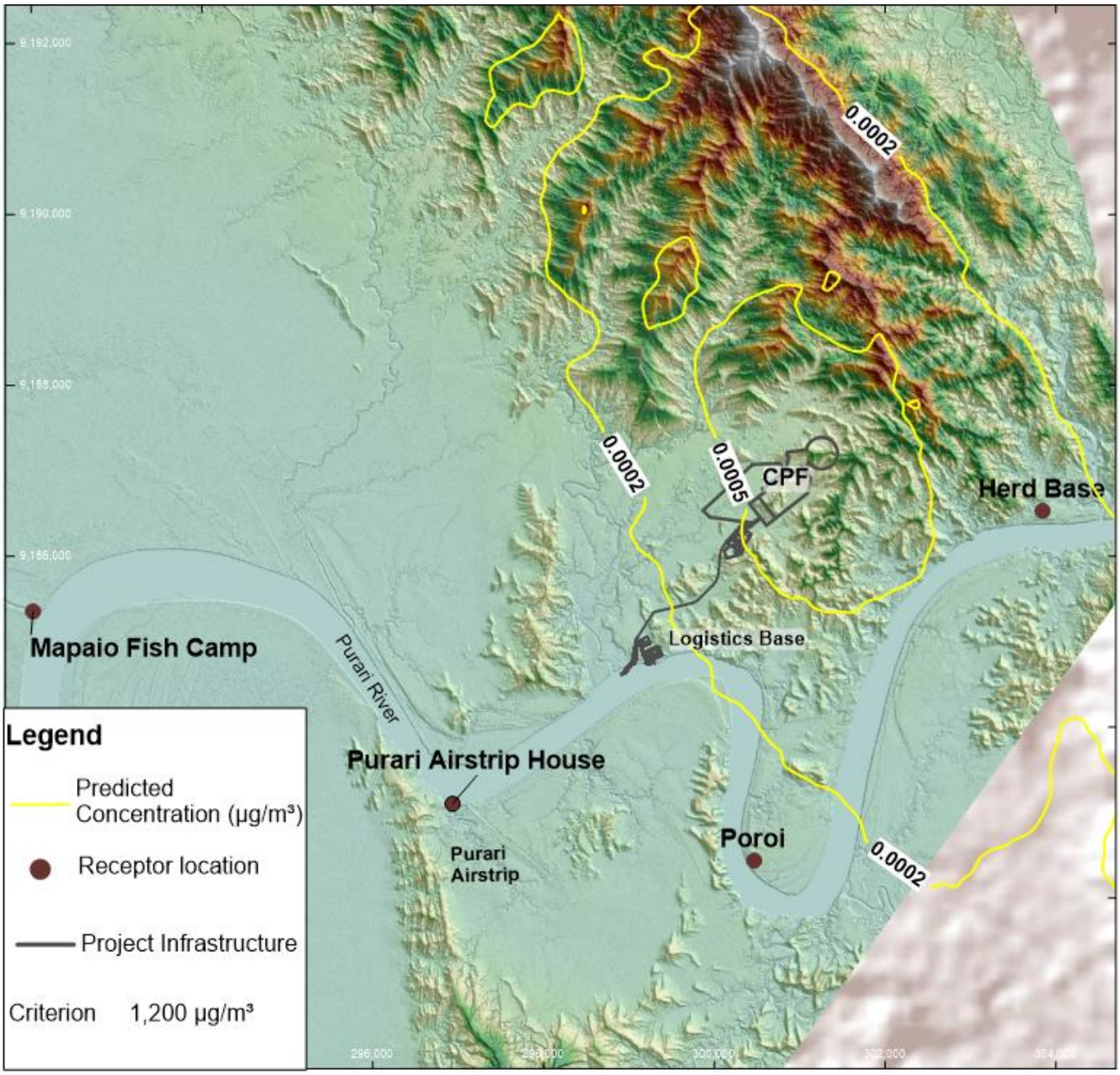
MP/LP and Acid Gas Injection

Pollutant	Toluene	Averaging Period	1-Hour	Unit	µg/m³



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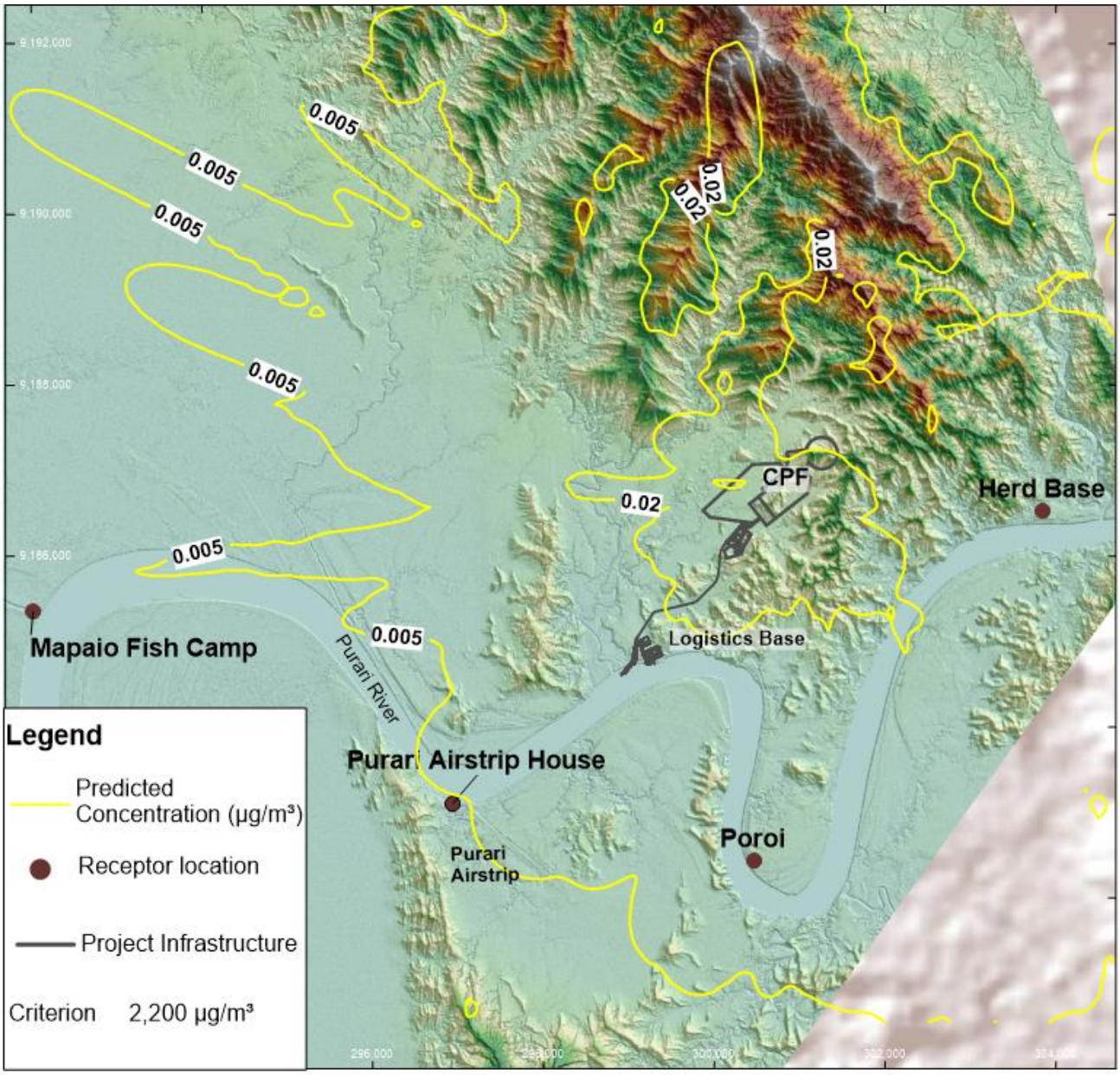
MP/LP and Acid Gas Injection

Pollutant	Toluene	Averaging Period	Annual	Unit	µg/m³



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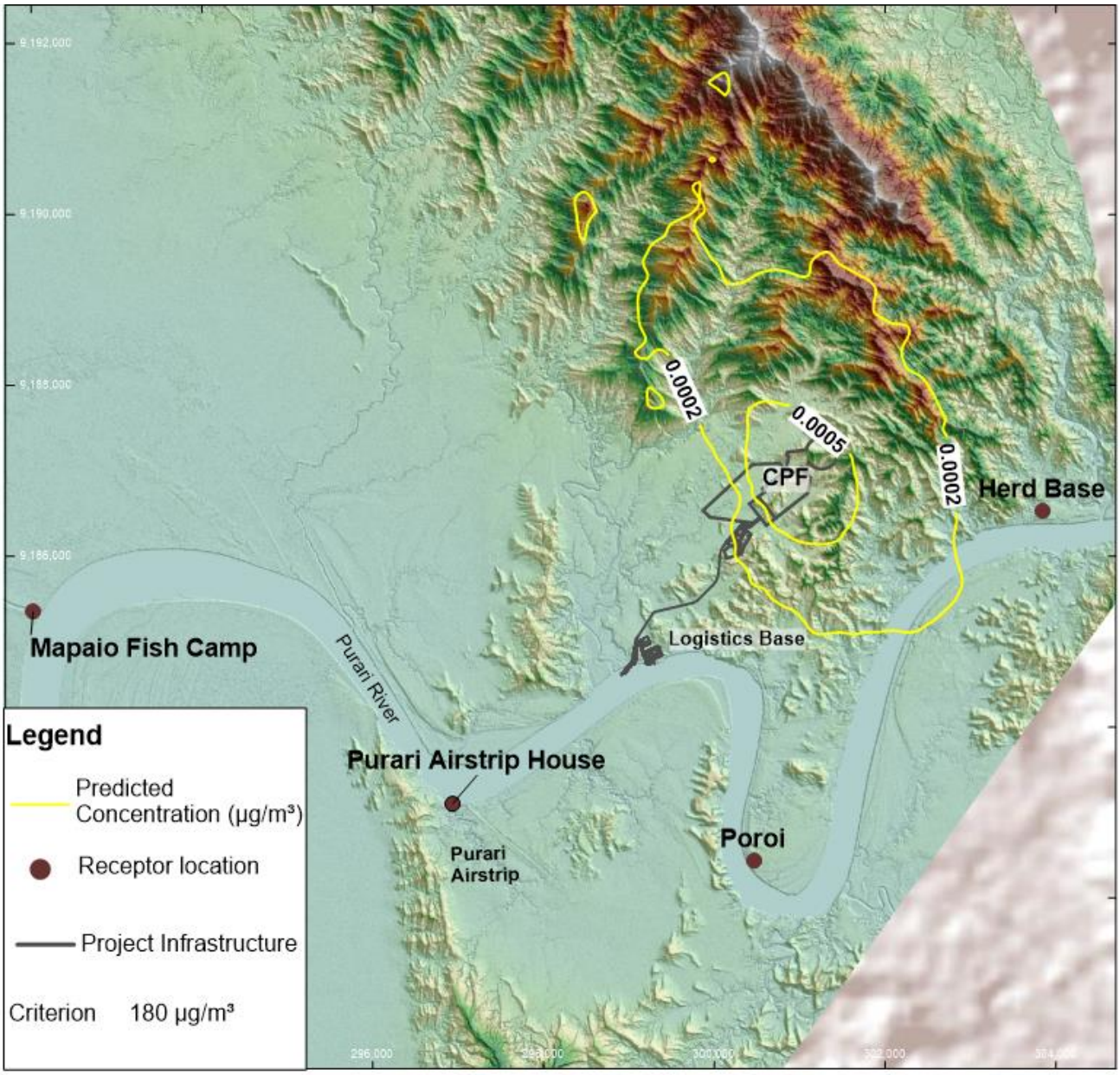
MP/LP and Acid Gas Injection

Pollutant	Xylene	Averaging Period	1-Hour	Unit	µg/m³



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MP/LP and Acid Gas Injection

Pollutant	Xylene	Averaging Period	Annual	Unit	µg/m³

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