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1.0 INTRODUCTION

The RAPID Refinery Cracker Complex was originally designed to produce diesel that meet the EURO 5 specifications and MOGAS (motor gasoline) that meet EURO 4 specifications. To upgrade and meet the EURO 5 MOGAS specifications, the Refinery and Cracker Complex has been expanded to include additional units as listed below:

1. 2nd Stage Cracked Naphtha Hydrotreating (CNHT 2) Unit
2. Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME) Unit
3. Isomerization Unit
4. Additional Storage Tanks which consist of:

    i. Two Tertiary-Armyl-Methyl-Ether (TAME) storage tanks
    ii. Two Isomerate storage tanks
    iii. One Medium Cracked Naphtha (MCN) storage tank

Besides that, there will be new olefin storage tankages located in the current refinery tank farms which consists of:

1. Four mounded bullets for Butadiene Storage
2. One Ethylene Tank
3. Four spheres for Propylene Storage

Details of the additional units are described in **Volume 1, Chapter 2**. This additional information report conducted studies to assess the impacts from these new process units and tank farms in the Refinery and Cracker Complex.

2.0 STUDY APPROACH AND METHODOLOGY.

The air dispersion study in this Addendum report was conducted in accordance with the United States Environmental Protection Agency (USEPA) Guideline on Air Quality Models (GAQM; as incorporated in Appendix W of 40 CFR Part 51) with AERMOD dispersion model.

The approach and methodology for this study are further detailed out in **Volume 1**, **Chapter 3**

2.1 Scope of Study

In this Additional Information study, the scope of work focuses on the updated and latest available information of the Refinery & Cracker Complex. Among the scope of works are;

a) Identify new and update existing sources of air emissions in the Refinery and Cracker Complex;
b) To assess the impacts of these changes by modelling using the same AERMOD model.
c) To assess the latest generated results with the regulatory and/or guideline limits to determine the acceptance level. In the event of breaches of limits and/or guideline values, modifications of project design and/or process parameters for the contributing packages and its units within the Refinery and Cracker Complex will be proposed as mitigation measures;
d) To propose mitigation measures to ensure that the residual impacts after implementation of the mitigation measures do not pose short- and long-term adverse impacts to the physical and human environment

2.2 Applicable Regulatory Framework

Compliance to the ambient ground level concentration shall be referred to the Malaysian Ambient Air Quality Standards, 2013 (Standard 2020) (Table 2-1).

Table 2-1: Emission Concentration Limit and Malaysian Ambient Air Quality Standards 2013 (Standard 2020)

No.	Pollutant	MAAQG	MAAQS 2013 (Standard 2020)
1.	Sum of NO and NO_2 expressed as NO_2 • 1 hour • 24 hour	320 µg/m^3 75 µg/m^3	280 µg/m^3 70 µg/m^3
2.	Sum of SO_2 and SO_3 expressed as SO_2 • 1 hour • 24 hour	350 µg/m^3 105 µg/m^3	250 µg/m^3 80 µg/m^3
3.	CO • 1 hour • 8 hour	35,000 µg/m^3 10,000 µg/m^3	30,000 µg/m^3 10,000 µg/m^3
4.	TSP • 24 hour • Annual	260 µg/m^3 90 µg/m^3	- -
5.	PM_{10} • 24 hour • Annual	150 µg/m^3 50 µg/m^3	100 µg/m^3 40 µg/m^3
6.	$PM_{2.5}$ • 24 hour • Annual	-	35 µg/m^3 15 µg/m^3

Note: The previous Malaysian Ambient Air Quality Guidelines (MAAQG) is shown for comparison purposes. The Malaysian Ambient Air Quality Standard (MAAQS 2013) was introduced in the second quarter of 2015

Hydrogen Chloride, Ammonia, Mercury, Hydrogen Sulphide and VOCs are identified to be present in the emission sources and modelled for the dispersion. Since these pollutants do not have compliance limits under the Malaysian Ambient Air Quality Standards 2013 (Standard 2020), these parameters will be assessed under Health Impact Assessment (**Volume 2, Appendix 2**).

The regulatory compliance for stack emissions limit shall be designed to meet the emission limit as specified in the Clean Air Regulation (CAR) 2014 that is applicable for the refinery and cracker operation. Table 2-2 shows the emission limits applicable for refineries. However, for the EURO 5 MOGAS and Olefin Storage Tankages, the emissions do not fall under any of the source types. Nevertheless, the fugitive emission from both of the units are to be minimized in accordance to the DOE Malaysia’s guidance document entitled “*Best Available Techniques Guidance Document on Storage and Handling of Petroleum Products*”.

Table 2-2: Clean Air Regulation 2014 - Oil and Gas Industries: Refineries (All Sizes); Natural Gas Processing and Storage; Storage and Handling of Petroleum Products.

SOURCE	POLLUTANT	LIMIT VALUE	MONITORING
Claus plant	Sulphur	Recovery > 95%	periodic
Catalytic cracking	Total PM	40 mglm^3	continuous
	Sum of $S0_2$ and $S0_3$, expressed as $S0_2$	1200 mglm^3	continuous
Calcination	Total PM	40 mglm^3	continuous

Notes:
1. Gases and vapors of organic substances such as hydrogen and hydrogen sulphide which escape from pressure relief fittings and blow-down systems shall be fed into a gas collecting system.
2. The collected gases shall be combusted in process furnaces if this is feasible. If this is not feasible, the gases shall be fed into a flare.
3. Waste gases continually produced by processing systems and waste gases occurring during the regeneration of catalysts, inspections and cleaning operations shall be fed into a post-combustion facility, or equivalent measures to reduce emissions shall be applied.
4. Gaseous and vaporous organic compounds shall be indicated as total organic carbon.
5. Fugitive emissions of volatile organic substances shall be minimized according to the respective Best Available Techniques Economically Achievable Guidance Document.
6. For compliance check a "Leakage Detection and Repair Program" shall be implemented as outlined in the Guidance Document on Leak Detection and Repair Program for Oil and Gas Industries in a manner as specified and approved by the Director General.

2.3 Identification of Sensitive Receptors

The identified sensitive receptors are shown in **Volume 1**, **Chapter 3** and **Chapter 4**.

2.4 Sources of Air Emission

Sources of air emissions captured in this Additional Information report includes the following

a) Emission sources from the EURO 5 MOGAS Units and Olefins Storage Tankages
b) Emission Sources from the Refinery Cracker Complex
c) Emission Sources from RAPID Complex which include the Petrochemical Complex, Utilities and Pengerang Cogeneration Plant.

The list of emission sources are tabulated in Table 2-3. The data from other RAPID components and the model set up for the emission sources are assumed to be the same and remain unchanged in the air dispersion model setup.

Table 2-3: List of Air Emission Sources Identified for RAPID Complex

No.	Process Unit	Source ID	Description
A.	**Refinery Cracker Complex**		
1.	Residue Fluidised Catalytic Cracking	RFCC1	Flue Gas Vent
2.		RFCC2	Flue Gas Vent
3.	Crude Distillation Unit	CDU1	Crude Heater
4.		CDU2	Crude Heater
5.	Atmospheric Residue Desulphurization Unit	ARDS1	Reactor Heater
6.		ARDS2	Reactor Heater
7.		ARDS3	Fractionator Feed Heater
8.		ARDS4	Reactor Heater
9.		ARDS5	Reactor Heater
10.		ARDS6	Fractionator Feed Heater
11.	Diesel Hydrotreating Unit	DHT1	Heater
12.	Kerosene Hydrotreating Unit	KHT1	Heater
13.	Cracked Naphtha Hydrotreating Unit	CNHT1	Heater
14.		CNHT2 (source from EURO5 MOGAS unit)	Heater
15.	Naphtha Hydrotreating Unit	NHT1	Heater
16.	Continuous Catalytic Reformer	CCR1	Heater
17.		CCR2	Heater
18.		CCR3	Heater
19.		CCR4	Heater
20.		CCR5	Vent
21.	Hydrogen Production Unit	HPU1	Heater
22.		HPU2	Heater
23.		HPU3	Heater
24.		HPU4	Degasifier Vent
25.		HPU5	Degasifier Vent
26.		HPU6	Degasifier Vent
27.		HPU7	CO_2 stripper vent
28.	Acid Flare System	AF1	Acid Flare
29.	Refinery Flare System	RF1	Main Flare
30.	Sulphur Recovery Unit	SRU1	Wet Scrubber
31.		SRU2	Wet Scrubber
32.		SRU3	Wet Scrubber
33.	Sulphur Solidification Units	SSU1	Flue Gas Vent
34.		SSU2	Flue Gas Vent
35.		SSU3	Flue Gas Vent
36.		SSU4	Flue Gas Vent
37.		SSU5	Flue Gas Vent
38.	Steam Cracker Complex	SCC1	Cracking Heater (normal)
39.		SCC2	Cracking Heater (normal)
40.		SCC3	Cracking Heater (normal)
41.		SCC4	Cracking Heater (normal)
42.		SCC5	Cracking Heater (normal)
43.		SCC6	Cracking Heater (decoking)
44.		PGH1	PGH Second Stage Reactor Vent
45.		SCCF1	Flare
46.	Refinery Tank Farm	RTFF1	Flare
47.	Olefin Storage	CF1	Cold Flare
B.	**Petrochemical Complex**		
1.	EOEG Thermal Oxidiser	TOX1	Thermal Oxidiser
2.	Polymer Tank Farm Thermal Oxidiser	TOX4	Thermal Oxidiser
3.	SCC Tank Farm Thermal Oxidiser	TOX6	Thermal Oxidiser
4.	PP Regenerative Thermal Oxidiser	TOX7	Thermal Oxidiser
5.	C4-INA Boiler	BOILER1	Boiler
6.	Petrochemical Common Flare	PCF1	Flare
7.	C4-INA Flare	C4-INA Flare	Flare
C.	**Pengerang Cogeneration Plant (PCP)**		
1.	HRSG Main Stack	PCP1	Vent
2.	HRSG Main Stack	PCP2	Vent
3.	HRSG Main Stack	PCP3	Vent
4.	HRSG Main Stack	PCP4	Vent
D.	**Utilities**		
1.	Boilers HP Stack	Utilities1	Vent
2.	Boilers HP Stack	Utilities2	Vent
3.	Boilers HHP Stack	Utilities3	Vent

2.5 Modelling Scenarios

Modelling was conducted for cumulative emissions from all process units in the Refinery and Cracker Complex and cumulative emissions from the Refinery and Cracker Complex and all RAPID components. Three operating condition scenarios, namely normal, abnormal and emergency operating condition were assessed.

2.5.1 Normal Operating Condition Scenario

- Normal Scenario is based on normal operating conditions with emissions meeting or below stipulate emission limits from all sources;
- Data input is based on design data input for continuous emissions when plants are in operation with normal design conditions.
- RAPID Complex design philosophy ensures that VOCs and acid gases containing toxic pollutants are combusted at the thermal oxidizers or acid flare to ensure only traces of these pollutants are released into the atmosphere and meeting compliance and health limit. All vents during the emergency conditions (pressure built up/fire/power failure event) are routed to the flare system.

2.5.2 Abnormal Operating Condition Scenario

- Abnormal scenario is based on only one emission control failure event at a time or based on the worst-case pollutant load released from a selected failure event.
- During abnormal operation of Refinery Cracker Complex process units, waste gasses are release to the atmosphere and this is expected to be temporary, thus modelling shall be modelled for 1 hour averaging time for all parameters.

2.5.3 Emergency Operating Condition Scenario

- Emergency scenario is based on full load of the refinery flare in the event of total failure of all emission controls in the refinery and all untreated emissions are directed to the refinery flare. There is no venting of untreated gaseous pollutants.
- Operating philosophy for all RAPID facilities shall be that during fire and power failure cases, all vented emissions shall be routed to the flare system.
- For the selection of the emergency air dispersion modeling scenario shall be one flare failure at a time and selection of the worst-case scenario will be from the highest flare load. The highest flare load shall be the refinery flare.
- Study had been made by considering Refinery flare in the event where there is general electrical power failure where the load is coming from refinery flare and acid flare load.
- Model data input for refinery flare stack are as below:

Height: 92 meters
Diameter: 2.13 meters
Exit Velocity: 20 m/s (default value)
Exit Temperature: 1000 ºC (default value)
Volume flow rate: 21,503,453 Nm^3/hr.
Pollutant Emission Rate (g/s):

- PM_{10}: 608.3
- $PM_{2.5}$: 365.0
- NO_2: 492.9
- CO: 2682.2
- SO_2: 6366.0
- NMVOC: 5397.2
- H_2S: 69.3

During emergency operation of Refinery Cracker Complex, the waste gasses are flared and this is expected to be temporary, thus the modelling shall be modelled for 1 hour averaging time for all parameters. This assumption represents the most conservative estimation of emergency operation.

Other RAPID components remain as in normal operating condition when other RAPID components are included in the cumulative emissions modelling assessment.

2.5.4 Model Setup

AERMOD Version 15181 was used in this Additional Information study. AERMOD is a refined dispersion model for simple and complex terrain for receptors within 50 km of a modelled source. AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal planes. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf).

Additionally, in the CBL, AERMOD treats “plume lofting,” whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the planetary boundary layer (PBL) before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. For sources in both the CBL and the SBL, AERMOD treats the enhancement of lateral dispersion resulting from plume meander.

AERMOD incorporates current concepts about flow and dispersion in complex terrain. Where appropriate, the plume is modelled as either impacting and/or following the terrain, thus AERMOD removes the need for defining complex terrain regimes. All terrain is handled in a consistent and continuous manner while considering the dividing streamline concept in stably stratified conditions.

2.5.5 Modelling Input Data

The inputs in the model set up include the followings:

- Emission sources
- Emission rate
- Meteorological data
- Local terrain and receptor grid
- Sensitive receptor locations.

For this study, five years of hourly meteorological data (surface and upper air data) for the years 2010 to 2014 generated by the Mesoscale Meteorological Model (MM5) was used in the modelling.

The effect of terrain on dispersion was accounted in the study.

A multi-tier receptor grid extending up to 15 km from the RAPID boundary embedded with 11 sensitive receptors was used for this modelling exercise. The sensitive receptors with its coordinates are listed in **Volume 1, Chapter 3 and Chapter 4.**

2.5.6 Emission Sources and Characteristics

Tabulated below in **Table 2-4 – Table 2-6** are the source characteristics of the Refinery and Cracker Complex and other RAPID components emission sources used in the dispersion modelling.

Table 2-4: Inventory of Current Air Pollution Sources and Emission Characteristics for the RAPID Refinery Cracker Complex (Normal Operation)

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^0C)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)								
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S
1	RFCC1	Flue Gas Stack	109	4.5	14.58	60.55	683,313	407078.30	151599.36	1.5	0.460	46.4	32.0	25.0	-	-	-	-
2	RFCC2	Flue Gas Stack	109	4.5	14.58	60.55	683,313	407308.57	151599.36	1.5	0.460	46.4	32.0	25.0	-	-	-	-
3	CDU1	Crude Heater	67	2.87	12.27	201	164,621	407293.38	151114.65	0.089	0.089	2.9	1.0	0.572	-	-	-	-
4	CDU2	Crude Heater	67	2.87	12.27	201	164,621	407293.38	151066.95	0.089	0.089	2.9	1.0	0.572	-	-	-	-
5	ARDS1	Reactor Heater	61.5	1.15	12.51	164	29,229	407136.48	151467.32	0.019	0.019	0.389	0.2	0.100	-	-	-	-
6	ARDS2	Reactor Heater	61.5	1.15	12.51	164	29,229	407019.64	151466.58	0.019	0.019	0.389	0.2	0.100	-	-	-	-
7	ARDS3	Fractionator Feed Heater	50	0.65	8.64	178	6,249	407022.33	151249.38	0.008	0.008	0.169	0.1	0.044	-	-	-	-
8	ARDS4	Reactor Heater	61.5	1.15	8.68	164	20,280	406963.68	151466.59	0.019	0.019	0.389	0.2	0.100	-	-	-	-
9	ARDS5	Reactor Heater	61.5	1.15	8.68	164	20,280	407192.46	151467.33	0.019	0.019	0.389	0.2	0.100	-	-	-	-
10	ARDS6	Fractionator Feed Heater	50	0.65	8.64	178	6,249	407200.33	151249.39	0.008	0.008	0.169	0.1	0.044	-	-	-	-
11	DHT1	Diesel Hydrotreating (DHT)	47.6	1.68	7.62	254	31,509	407623.24	151616.53	0.016	0.010	1.4	-	0.200	-	0.069	-	-
12	KHT1	Kerosene Hydrotreating (KHT)	39.85	0.88	13	325	12,998	407626.81	151726.48	0.007	0.004	0.060	-	0.086	-	0.029	-	-
13	CNHT1	Cracked Naphtha Hydrotreating (CNHT)	51	0.66	15	348	8,124	407626.81	151831.96	0.004	0.003	0.350	-	0.052	-	0.018	-	-
14	CNHT2	Cracked Naphtha Hydrotreating (CNHT) – EURO5 MOGAS unit	51	0.66	15	348	9,623	407717.05	151757.31	0.011	0.011	0.744	0.117	0.031	-	0.022	-	-
15	NHT1	Naphtha Hydrotreating (NHT)	38.3	0.88	12	315	12,203	407593.93	151892.74	0.006	0.004	0.517	-	0.078	-	0.027	-	-
16	CCR1	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-
17	CCR2	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-
18	CCR3	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^0C)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)								
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S
19	CCR4	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-
20	CCR5	Continuous Catalytic Reformer (CCR)	23.2	0.64	0.46	44	344	407661.00	151948.88	-	-	-	-	-	-	-	-	-
21	HPU1	Hydrogen Production (HPU)	45	2.75	20.1	150	277,435	407510.45	151421.28	-	-	4.8	2.5	0.260	-	0.586	-	-
22	HPU2	Hydrogen Production (HPU)	45	2.75	20.1	150	277,435	407605.62	151421.21	-	-	4.8	2.5	0.260	-	0.586	-	-
23	HPU3	Hydrogen Production (HPU)	45	2.75	20.1	150	277,435	407707.59	151421.15	-	-	4.8	2.5	0.260	-	0.586	-	-
24	HPU4	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407476.60	151491.27	-	-	-	0.527	-	0.002	-	-	-
25	HPU5	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407571.68	151491.21	-	-	-	0.527	-	0.002	-	0.045	-
26	HPU6	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407667.65	151491.15	-	-	-	0.527	-	0.002	-	0.045	-
28	HPU7	Hydrogen Production (HPU) CO2 stripper vent	22.2	0.25	22	50	3,286	407621.66	151342.13	-	-	-	1.4	-	-	-	0.045	-
29	SRU1	SRU Unit 1	105	2.5	8.38	74.3	116,419	407213.08	152216.63	-	-	10.3	2.3	3.4	-	-	-	0.167
30	SRU2	SRU Unit 2	105	2.5	8.38	74.3	116,419	407312.43	152216.63	-	-	10.3	2.3	3.4	-	-	-	0.167
31	SRU3	SRU Unit 3	105	2.5	8.38	74.3	116,419	407417.96	152216.63	-	-	10.3	2.3	3.4	-	-	-	0.167
32	SSU1	SSU Unit 1	12.1	0.39	15.32	80	5,096	407711.37	152231.87	-	-	-	-	0.083	-	-	-	-
33	SSU2	SSU Unit 2	12.1	0.39	15.32	80	5,096	407711.37	152217.22	-	-	-	-	0.083	-	-	-	-
34	SSU3	SSU Unit 3	12.1	0.39	15.32	80	5,096	407711.37	152201.93	-	-	-	-	0.083	-	-	-	-
35	SSU4	SSU Unit 4	12.1	0.39	15.32	80	5,096	407711.37	152190.08	-	-	-	-	0.083	-	-	-	-
36	SSU5	SSU Unit 5	12.1	0.39	15.32	80	5,096	407711.37	152178.23	-	-	-	-	0.083	-	-	-	-
37	SCC1	Cracking Heater (normal)	59.2	3.3	10.1	112.85	220,067	406166.00	151560.20	0.145	0.116	8.6	2.6	-	-	-	-	-
38	SCC2	Cracking Heater (normal)	59.2	3.3	10.1	112.85	220,067	406166.00	151541.20	0.145	0.116	8.6	2.6	-	-	-	-	-

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^{0}C)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)								
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S
39	SCC3	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406166.00	151522.00	0.147	0.117	8.7	2.6	-	-	-	-	-
40	SCC4	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406166.00	151502.50	0.147	0.117	8.7	2.6	-	-	-	-	-
41	SCC5	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406165.90	151483.10	0.147	0.117	8.7	2.6	-	-	-	-	-
42	SCC6	Cracking Heater (decoking)	59.2	3.3	11.1	299.85	162,926	406165.90	151463.70	1.8	1.8	7.5	1.8	-	-	-	-	-

Table 2-5: Inventory of Emission Sources Form Other RAPID Complex Components

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (C)	UTM Coordinate (Zone 48 N) (m)		UTM Coordinate (Zone 48 N) (m)								
							X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S
A. Petrochemical Complex																	
1	TOX1	EOEG Thermal Oxidiser	30	1	8	200	405246.36	151618.80	0.126	0.072	1.0	3.2	-	-	-	-	-
2	TOX4	Polymer Tank Farm Thermal Oxidiser	45	1	8	200	405747.31	150913.71	0.136	0.078	1.0	3.4	-	-	-	-	-
3	TOX6	SCC Tank Farm Thermal Oxidiser	45	1	8	200	406021.25	151809.11	0.136	0.078	1.0	3.4	-	-	-	-	-
4	TOX7	PP Regenerative Thermal Oxidiser	45	1	8	200	406028.56	150538.71	0.136	0.078	1.0	3.4	-	-	-	-	-
5	BOILER1	C4 INA Boiler	25	1.3	9.84	150	406034.75	151157.79	0.316	0.180	2.4	8.0	-	-	-	-	-
6	FLARE1	C4 INA Flare	100	0.6	20 Note2	1000 Note2	406072.84	151145.05	-	-	19.6	106.8	-	-	-	-	-
7	PCF1	Petrochemical Common Flare	125	1.5	20 Note2	1000 Note2	406036.41	152179.97	-	-	0.083	0.483	-	-	-	-	-
B. Pengerang Cogeneration Plant (PCP)																	
1	PCP1	HRSG Main Stack	40	8.5	51.48	680	408283.40	152056.60	2.2	2.2	43.5	27.4	1.1	-	-	-	-
2	PCP2	HRSG Main Stack	40	8.5	51.48	680	408239.58	152056.60	2.2	2.2	43.5	27.4	1.1	-	-	-	-
3	PCP3	HRSG Main Stack	40	8.5	51.48	680	408102.58	152056.60	2.2	2.2	43.5	27.4	1.1	-	-	-	-
4	PCP4	HRSG Main Stack	40	8.5	51.48	680	408054.81	152056.60	2.2	2.2	43.5	27.4	1.1	-	-	-	-
C. Utilities																	
1	Utilities1	Boilers HP	68	2.5	8.82	270	406503.95	151668.69	0.081	0.081	5.0	0.811	0.203	-	-	-	-
2	Utilities2	Boilers HP	68	2.5	8.82	270	406544.47	151669.23	0.081	0.081	5.0	0.811	0.203	-	-	-	-
3	Utilities3	Boilers HHP	83	3.5	12.69	144	406464.34	151668.7	0.297	0.297	5.0	3.0	0.747	-	-	-	-

Note:
Note1: Effective flare calculation
Note2: Default value

Table 2-6: Inventory of Current Air Pollution Sources and Emission Characteristics for the RAPID Refinery Cracker Complex (Abnormal Operation)

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^0C)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)									
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S	UHC*
1	RFCC1	Flue Gas Stack Note1	109	4.5	18.23	289.94	596,455	407078.30	151599.36	22.4	7.010	41.9	27.9	700	-	-	-	-	-
2	RFCC2	Flue Gas Stack	109	4.5	14.58	60.55	683,313	407308.57	151599.36	1.5	0.460	46.4	32.0	25.0	-	-	-	-	-
3	CDU1	Crude Heater	67	2.87	12.27	201	164,621	407293.38	151114.65	0.089	0.089	2.9	1.0	0.572	-	-	-	-	-
4	CDU2	Crude Heater	67	2.87	12.27	201	164,621	407293.38	151066.95	0.089	0.089	2.9	1.0	0.572	-	-	-	-	-
5	ARDS1	Reactor Heater	61.5	1.15	12.51	164	29,229	407136.48	151467.32	0.019	0.019	0.389	0.2	0.100	-	-	-	-	-
6	ARDS2	Reactor Heater	61.5	1.15	12.51	164	29,229	407019.64	151466.58	0.019	0.019	0.389	0.2	0.100	-	-	-	-	-
7	ARDS3	Fractionator Feed Heater	50	0.65	8.64	178	6,249	407022.33	151249.38	0.008	0.008	0.169	0.1	0.044	-	-	-	-	-
8	ARDS4	Reactor Heater	61.5	1.15	8.68	164	20,280	406963.68	151466.59	0.019	0.019	0.389	0.2	0.100	-	-	-	-	-
9	ARDS5	Reactor Heater	61.5	1.15	8.68	164	20,280	407192.46	151467.33	0.019	0.019	0.389	0.2	0.100	-	-	-	-	-
10	ARDS6	Fractionator Feed Heater	50	0.65	8.64	178	6,249	407200.33	151249.39	0.008	0.008	0.169	0.1	0.044	-	-	-	-	-
11	DHT1	Diesel Hydrotreating (DHT) Note1	47.6	1.68	11.7	508	32,649	407623.24	151616.53	0.017	0.01	1.5	-	0.209	-	0.071	-	-	-
12	KHT1	Kerosene Hydrotreating (KHT)	39.85	0.88	13	325	12,998	407626.81	151726.48	0.007	0.004	0.060	-	0.086	-	0.029	-	-	-
13	CNHT1	Cracked Naphtha Hydrotreating (CNHT)	51	0.66	15	348	8,124	407626.81	151831.96	0.004	0.003	0.350	-	0.052	-	0.018	-	-	-
14	CNHT2	Cracked Naphtha Hydrotreating (CNHT) – EURO5 MOGAS unit	51	0.66	15	348	9,623	407717.05	151757.31	0.011	0.011	0.744	0.117	0.031	-	0.022	-	-	-
15	NHT1	Naphtha Hydrotreating (NHT)	38.3	0.88	12	315	12,203	407593.93	151892.74	0.006	0.004	0.517	-	0.078	-	0.027	-	-	-
16	CCR1	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-	-
17	CCR2	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-	-
18	CCR3	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-	-

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^oC)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)									
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S	UHC*
19	CCR4	Continuous Catalytic Reformer (CCR)	66	1.95	7.5	174.7	52,051	407661.00	151956.00	0.025	0.015	3.3	-	0.311	-	0.107	-	-	-
20	CCR5	Continuous Catalytic Reformer (CCR)	23.2	0.64	0.46	44	344	407661.00	151948.88	-	-	-	-	-	-	-	-	-	-
21	HPU1	Hydrogen Production (HPU) Note1	45	2.75	10.3	150	142,168	407510.45	151421.28	-	-	9.2	2.2	0.299	-	0.586	-	-	-
22	HPU2	Hydrogen Production (HPU) Note1	45	2.75	10.3	150	142,168	407605.62	151421.21	-	-	9.2	2.2	0.299	-	0.586	-	-	-
23	HPU3	Hydrogen Production (HPU) Note1	45	2.75	10.3	150	142,168	407707.59	151421.15	-	-	9.2	2.2	0.299	-	0.586	-	-	-
24	HPU4	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407476.60	151491.27	-	-	-	0.527	-	0.002	-	-	-	-
25	HPU5	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407571.68	151491.21	-	-	-	0.527	-	0.002	-	0.045	-	-
26	HPU6	Hydrogen Production (HPU) Degasifier Vent	21.2	0.08	10.224	40	161	407667.65	151491.15	-	-	-	0.527	-	0.002	-	0.045	-	-
27	HPU7	Hydrogen Production (HPU) CO2 stripper vent	22.2	0.25	22	50	3,286	407621.66	151342.13	-	-	-	1.4	-	-	-	0.045	-	-
28	AF1	Acid Flare System Note1	92	1.83	20	1000	40,630	406610.19	152213.44	0.497	0.298	0.214	1.2	6.0	-	1.9	-	-	-
29	SRU1	SRU Unit 1 Note1	105	2.5	10.7	352	82,618	407213.08	152216.63	-	-	14.6	3.2	4.9	-	-	-	0.222	-
30	SRU2	SRU Unit 2	105	2.5	8.38	74.3	116,419	407312.43	152216.63	-	-	10.3	2.3	3.4	-	-	-	0.167	-
31	SRU3	SRU Unit 3	105	2.5	8.38	74.3	116,419	407417.96	152216.63	-	-	10.3	2.3	3.4	-	-	-	0.167	-
32	SSU1	SSU Unit 1	12.1	0.39	15.32	80	5,096	407711.37	152231.87	-	-	-	-	0.083	-	-	-	-	-
33	SSU2	SSU Unit 2	12.1	0.39	15.32	80	5,096	407711.37	152217.22	-	-	-	-	0.083	-	-	-	-	-
34	SSU3	SSU Unit 3	12.1	0.39	15.32	80	5,096	407711.37	152201.93	-	-	-	-	0.083	-	-	-	-	-
35	SSU4	SSU Unit 4	12.1	0.39	15.32	80	5,096	407711.37	152190.08	-	-	-	-	0.083	-	-	-	-	-
36	SSU5	SSU Unit 5	12.1	0.39	15.32	80	5,096	407711.37	152178.23	-	-	-	-	0.083	-	-	-	-	-

No	Source ID	Description	Stack Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (^{0}C)	Volume Flow Rate (Nm^3/hr)	UTM Coordinate (Zone 48 N) (m)		Emission Rate (g/s)									
								X	Y	PM_{10}	$PM_{2.5}$	NO_2	CO	SO_2	NH_3	NMVOC	Methanol	H_2S	UHC*
37	SCC1	Cracking Heater (normal)	59.2	3.3	10.1	112.85	220,067	406166.00	151560.20	0.145	0.116	8.6	2.6	-	-	-	-	-	-
38	SCC2	Cracking Heater (normal)	59.2	3.3	10.1	112.85	220,067	406166.00	151541.20	0.145	0.116	8.6	2.6	-	-	-	-	-	-
39	SCC3	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406166.00	151522.00	0.147	0.117	8.7	2.6	-	-	-	-	-	-
40	SCC4	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406166.00	151502.50	0.147	0.117	8.7	2.6	-	-	-	-	-	-
41	SCC5	Cracking Heater (normal)	59.2	3.3	10	105.85	221,913	406165.90	151483.10	0.147	0.117	8.7	2.6	-	-	-	-	-	-
42	SCC6	Cracking Heater (decoking)	59.2	3.3	11.1	299.85	162,926	406165.90	151463.70	1.8	1.8	7.5	1.8	-	-	-	-	-	-
43	SCCF1	SCC Flare Note1	150	2.2	0.241	1000	708	406000.00	152230.00	2.2	2.8	1.4	5.6	-	-	-	-	-	-
44	PGH1	PGH Second Stage Reactor Note1	34.4	0.976	33.7	479.85	32925	405905.00	151635.00	-	-	-	-	39.2	-	-	-	-	-
45	RTFF1	Refinery Tank Farm Flare Note1	24	0.4572	20	1000	2536	406831.06	149597.35	-	-	35.0	-	733.0	-	-	-	8.0	72.0
46	CF1	Olefin Storage Cold Flare Note1	24	0.4572	20	1000	2536	406893.14	149657.04	-	-	5.7	30.8	-	-	-	-	-	-

Note:
Note1: Abnormal operation
UHC*: unburnt hydrocarbon

2.6 Model Output

The following iso-contours were generated in accordance with MAAQS, 2013 requirements and other reference values as shown in **Table 2-7** below.

Table 2-7: Modelling Parameters and Averaging Times

Parameter	Averaging Time
TSP	Maximum 24-hour and annual average incremental concentration
PM_{10}	Maximum 24-hour and annual average incremental concentration
$PM_{2.5}$	Maximum 24-hour and annual average incremental concentration
NO_2	Maximum 1-hour and 24-hour average incremental concentration
CO	Maximum 1-hour and 8-hour average incremental concentration
SO_2	Maximum 1-hour and 24-hour average incremental concentration
NH_3	Maximum 1-hour, 8-hour and 24-hour average incremental concentration
H_2S	Maximum 1-hour, 8-hour and 24-hour average incremental concentration
VOC	Maximum 1-hour, 8-hour and 24-hour average incremental concentration

When there is non-compliance of NO_2 to the MAAQS, 2013 (2020) limit for cumulative emissions, the multi-tier approach as recommended by the United States Environmental Protection Agency (USEPA, 2011) will be adopted. The multi-tier approach is elaborated as follows:

Tier 1: Assumes full conversion of NO to NO_2 and if the predicted concentration exceeds the regulatory NO_2 guideline, the Tier 2 approach will be used.

Tier 2: Applies the ambient ratio of NO_2/ NOx (nitrogen oxides) to Tier 1 results with the use of 0.80 as a default ambient ratio for the 1-hour average NO_2 standard without additional justification; and

Tier 3: Is a detailed screening method selected on a case-by-case basis. Detailed screening technique such as the OLM (Ozone Limiting Method) and PVMRM (Plume Volume Molar Ratio Method) options within AERMOD default in-stack ratio of NO_2/NOx with 0.50 in the absence of more appropriate source-specific information on in-stack ratios. For OLM, the default background ozone level of 40 ppb was selected. The refined Tier 3 modelling has also been set up to model for results within the 98th percentile in accordance to the USEPA NAAQS 1-hour NO_2 modelling procedure.

The 24 hours average NO_2 GLC is not available for Tier 3 when performing refined modelling (with percentiles) due to the limitation of the modelling setup.

It is to be emphasised that the prescribed standard for 1-hour averaging time for NO_2 in the MAAQS 2013 (2020) is more stringent than the previous superseded MAAQG i.e. from 320 µg/ m^3 to 280 µg/m^3. Hence, the prescribed standard for this current additional information study is more stringent in relation to the RAPID DEIA 2012 assessment.

3.0 MODELLING RESULTS

Modelling was conducted for cumulative emission from the Refinery and Cracker Complex and cumulative emissions for the whole RAPID Complex for the three scenarios described above. The results of the modelling are presented below.

3.1 Emission from the new EURO 5 MOGAS Units and Olefin Storage Tank

a) Normal

- For normal operating conditions, modelling findings indicate all pollutants emitted from EURO5 MOGAS expansion meets the Malaysia Ambient Air Quality Standards (MAAQS) Standard 2020 at all identified sensitive receptor locations. Vent is routed from the CHNT2 heater unit to atmosphere from this emission source;
- There is no continuous emission source from Olefin Storage tankages as vent is routed to either the Cold Flare or routed to the Refinery Tank Farm Flare. The cold flare system is a

compression system that is dedicated to collect vents from pressurized ethylene storage system to be released intermittently. Hence, this dispersion will be considered under abnormal and emergency scenario.

b) Abnormal

- No abnormal emission modeling conducted for EURO 5 MOGAS unit. Vent is routed to CHNT2 Unit to be treated before discharged to atmosphere from this emission source;
- During abnormal operation, the emission source from Olefin Storage tankages as vent is routed to Cold Flare located within the Olefin Storage Tank boundary. The predicted GLCs of CO is below the required respective MAAQS (Standard 2020) at all receptors for the maximum 1 hour average concentration while the predicted maximum GLC of NO_2 exceeds the stipulated limit but it is located within the RAPID Complex.

Table 3-1 Predicted Incremental GLC and Cumulative GLC for EURO 5 MOGAS Unit (Normal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
	EURO 5 MOGAS Pollutant: **PM_{10}** 24 hrs Average Limit: 100 μg/m^3	Tg. Pengelih	24	0.034 (Bukit Pengerang)	0.0012	24.0
		Pengelih Naval Base	24		0.0339	24.0
		Kg. Pengerang	36		0.0019	36.0
		Kg. Sg. Kapal	25		0.0068	25.0
		Taman Rengit Jaya	38		0.0050	38.0
		Kg. Sg. Buntu	28		0.0039	28.0
		Kg. Bukit Buloh	31		0.0017	31.0
		Kg. Sg. Rengit	20		0.0014	20.0
		Kg. Bukit Gelugor	22		0.0015	22.0
		Kg. Lepau	35		0.0017	35.0
		Kg. Pasir Gogok	20		0.0011	20.0
	EURO 5 MOGAS Pollutant: **PM_{10}** Annual Average Limit: 40 μg/m^3	Tg. Pengelih	NM	0.004 (Within RAPID)	0.00003	NA
		Pengelih Naval Base	NM		0.00050	NA
		Kg. Pengerang	NM		0.00004	NA
		Kg. Sg. Kapal	NM		0.00034	NA
		Taman Rengit Jaya	NM		0.00032	NA
		Kg. Sg. Buntu	NM		0.00026	NA
		Kg. Bukit Buloh	NM		0.00014	NA
		Kg. Sg. Rengit	NM		0.00009	NA
		Kg. Bukit Gelugor	NM		0.00007	NA
		Kg. Lepau	NM		0.00011	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Pasir Gogok	NM		0.00004	NA
	EURO 5 MOGAS Pollutant: **PM$_{2.5}$** 24 hrs Average Limit: 35 µg/m^3	Tg. Pengelih	NM	0.034 (Bukit Pengerang)	0.0012	NA
		Pengelih Naval Base	NM		0.0339	NA
		Kg. Pengerang	NM		0.0019	NA
		Kg. Sg. Kapal	NM		0.0068	NA
		Taman Rengit Jaya	NM		0.0050	NA
		Kg. Sg. Buntu	NM		0.0039	NA
		Kg. Bukit Buloh	NM		0.0017	NA
		Kg. Sg. Rengit	NM		0.0014	NA
		Kg. Bukit Gelugor	NM		0.0015	NA
		Kg. Lepau	NM		0.0017	NA
		Kg. Pasir Gogok	NM		0.0011	NA
	EURO 5 MOGAS Pollutant: **PM$_{2.5}$** Annual Average Limit: 15 µg/m^3	Tg. Pengelih	NM	0.004 (Within RAPID)	0.00003	NA
		Pengelih Naval Base	NM		0.00050	NA
		Kg. Pengerang	NM		0.00004	NA
		Kg. Sg. Kapal	NM		0.00034	NA
		Taman Rengit Jaya	NM		0.00032	NA
		Kg. Sg. Buntu	NM		0.00026	NA
		Kg. Bukit Buloh	NM		0.00014	NA
		Kg. Sg. Rengit	NM		0.00009	NA
		Kg. Bukit Gelugor	NM		0.00007	NA
		Kg. Lepau	NM		0.00011	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Pasir Gogok	NM		0.00004	NA
	EURO 5 MOGAS Pollutant: **NO_2 Tier1** 1 hr Average Limit: 280 µg/m^3	Tg. Pengelih	<5	25.8 (Bukit Pengerang)	0.824	5.8
		Pengelih Naval Base	<5		25.8	30.8
		Kg. Pengerang	<5		1.2	6.2
		Kg. Sg. Kapal	<5		1.7	6.7
		Taman Rengit Jaya	<5		2.0	7.0
		Kg. Sg. Buntu	<5		1.8	6.8
		Kg. Bukit Buloh	<5		1.8	6.8
		Kg. Sg. Rengit	ND		1.6	1.6
		Kg. Bukit Gelugor	<5		1.6	6.6
		Kg. Lepau	<5		1.9	6.9
		Kg. Pasir Gogok	ND		1.1	1.1
	EURO 5 MOGAS Pollutant: **NO_2 Tier1** 24 hrs Average Limit: 70 µg/m^3	Tg. Pengelih	NM	2.3 (Bukit Pengerang)	0.083	NA
		Pengelih Naval Base	NM		2.3	NA
		Kg. Pengerang	NM		0.125	NA
		Kg. Sg. Kapal	NM		0.454	NA
		Taman Rengit Jaya	NM		0.333	NA
		Kg. Sg. Buntu	NM		0.262	NA
		Kg. Bukit Buloh	NM		0.111	NA
		Kg. Sg. Rengit	NM		0.092	NA
		Kg. Bukit Gelugor	NM		0.102	NA
		Kg. Lepau	NM		0.115	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Pasir Gogok	NM		0.072	NA
	EURO 5 MOGAS Pollutant: **SO_2** 1 hr Average Limit: 250 µg/m^3	Tg. Pengelih	<5	1.1 (Bukit Pengerang)	0.034	5.0
		Pengelih Naval Base	<5		1.076	6.1
		Kg. Pengerang	<5		0.051	5.1
		Kg. Sg. Kapal	<5		0.071	5.1
		Taman Rengit Jaya	<5		0.082	5.1
		Kg. Sg. Buntu	<5		0.076	5.1
		Kg. Bukit Buloh	<5		0.076	5.1
		Kg. Sg. Rengit	ND		0.067	0.1
		Kg. Bukit Gelugor	<5		0.066	5.1
		Kg. Lepau	<5		0.078	5.1
		Kg. Pasir Gogok	ND		0.046	0.0
	EURO 5 MOGAS Pollutant: **SO_2** 24 hrs Average Limit: 80 µg/m^3	Tg. Pengelih	NM	0.095 (Bukit Pengerang)	0.003	NA
		Pengelih Naval Base	NM		0.095	NA
		Kg. Pengerang	NM		0.005	NA
		Kg. Sg. Kapal	NM		0.019	NA
		Taman Rengit Jaya	NM		0.014	NA
		Kg. Sg. Buntu	NM		0.011	NA
		Kg. Bukit Buloh	NM		0.005	NA
		Kg. Sg. Rengit	NM		0.004	NA
		Kg. Bukit Gelugor	NM		0.004	NA
		Kg. Lepau	NM		0.005	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (μg/m³)	Receptor Incremental (μg/m³)	Cumulative GLC (μg/m³)
		Kg. Pasir Gogok	NM		0.003	NA
	EURO 5 MOGAS Pollutant: **CO** 1 hr Average Limit: 30,000 μg/m³	Tg. Pengelih	NM	4.1 (Bukit Pengerang)	0.130	NA
		Pengelih Naval Base	NM		4.1	NA
		Kg. Pengerang	NM		0.193	NA
		Kg. Sg. Kapal	NM		0.270	NA
		Taman Rengit Jaya	NM		0.308	NA
		Kg. Sg. Buntu	NM		0.288	NA
		Kg. Bukit Buloh	NM		0.286	NA
		Kg. Sg. Rengit	NM		0.254	NA
		Kg. Bukit Gelugor	NM		0.250	NA
		Kg. Lepau	NM		0.296	NA
		Kg. Pasir Gogok	NM		0.172	NA
	EURO 5 MOGAS Pollutant: **CO** 8 hrs Average Limit: 10,000 μg/m³	Tg. Pengelih	<100	1.1 (Bukit Pengerang)	0.032	100.0
		Pengelih Naval Base	<100		1.1	101.1
		Kg. Pengerang	<100		0.050	100.1
		Kg. Sg. Kapal	<100		0.148	100.1
		Taman Rengit Jaya	<100		0.116	100.1
		Kg. Sg. Buntu	<100		0.090	100.1
		Kg. Bukit Buloh	<100		0.044	100.0
		Kg. Sg. Rengit	ND		0.035	0.0
		Kg. Bukit Gelugor	<100		0.031	100.0
		Kg. Lepau	<100		0.052	100.1
		Kg. Pasir Gogok	ND		0.023	0.0

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	EURO 5 MOGAS Pollutant: **NMVOC** 1 hr Average Limit: NA	Tg. Pengelih	NM	0.764 (Bukit Pengerang)	0.024	NA
		Pengelih Naval Base	NM		0.764	NA
		Kg. Pengerang	NM		0.036	NA
		Kg. Sg. Kapal	NM		0.051	NA
		Taman Rengit Jaya	NM		0.058	NA
		Kg. Sg. Buntu	NM		0.054	NA
		Kg. Bukit Buloh	NM		0.054	NA
		Kg. Sg. Rengit	NM		0.048	NA
		Kg. Bukit Gelugor	NM		0.047	NA
		Kg. Lepau	NM		0.056	NA
		Kg. Pasir Gogok	NM		0.032	NA
	EURO 5 MOGAS Pollutant: **NMVOC** 8 hrs Average Limit: NA	Tg. Pengelih	NM	0.201 (Bukit Pengerang)	0.006	NA
		Pengelih Naval Base	NM		0.201	NA
		Kg. Pengerang	NM		0.009	NA
		Kg. Sg. Kapal	NM		0.028	NA
		Taman Rengit Jaya	NM		0.022	NA
		Kg. Sg. Buntu	NM		0.017	NA
		Kg. Bukit Buloh	NM		0.008	NA
		Kg. Sg. Rengit	NM		0.007	NA
		Kg. Bukit Gelugor	NM		0.006	NA
		Kg. Lepau	NM		0.010	NA
		Kg. Pasir Gogok	NM		0.004	NA
	EURO 5 MOGAS	Tg. Pengelih	NM	0.067	0.002	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	Pollutant: **NMVOC** 24 hrs Average Limit: NA	Pengelih Naval Base	NM	(Bukit Pengerang)	0.067	NA
		Kg. Pengerang	NM		0.004	NA
		Kg. Sg. Kapal	NM		0.013	NA
		Taman Rengit Jaya	NM		0.010	NA
		Kg. Sg. Buntu	NM		0.008	NA
		Kg. Bukit Buloh	NM		0.003	NA
		Kg. Sg. Rengit	NM		0.003	NA
		Kg. Bukit Gelugor	NM		0.003	NA
		Kg. Lepau	NM		0.003	NA
		Kg. Pasir Gogok	NM		0.002	NA

Table 3-2 Predicted Incremental GLC and Cumulative GLC for Olefin Storage Tank (Abnormal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
	Olefin Storage Tank Pollutant: **NO_2 Tier1** 1 hr Average Limit: 280 μg/m^3	Tg. Pengelih	<5	308.1 (Within RAPID)	9.7	14.7
		Pengelih Naval Base	<5		128.7	133.7
		Kg. Pengerang	<5		12.0	17.0
		Kg. Sg. Kapal	<5		30.0	35.0
		Taman Rengit Jaya	<5		25.4	30.4
		Kg. Sg. Buntu	<5		21.5	26.5
		Kg. Bukit Buloh	<5		38.6	43.6
		Kg. Sg. Rengit	ND		16.2	16.2
		Kg. Bukit Gelugor	<5		13.5	18.5
		Kg. Lepau	<5		24.4	29.4
		Kg. Pasir Gogok	ND		14.1	14.1
	Olefin Storage Tank Pollutant: **CO** 1 hr Average Limit: 30,000 μg/m^3	Tg. Pengelih	NM	1814.0 (Western RAPID Boundary)	99.1	NA
		Pengelih Naval Base	NM		714.3	NA
		Kg. Pengerang	NM		112.1	NA
		Kg. Sg. Kapal	NM		172.8	NA
		Taman Rengit Jaya	NM		160.9	NA
		Kg. Sg. Buntu	NM		132.1	NA
		Kg. Bukit Buloh	NM		222.2	NA
		Kg. Sg. Rengit	NM		111.3	NA
		Kg. Bukit Gelugor	NM		87.7	NA
		Kg. Lepau	NM		147.5	NA
		Kg. Pasir Gogok	NM		84.8	NA

3.2 Cumulative Refinery and Cracker Complex

a) Normal

- For normal operating conditions, the max ground level concentration (GLC) for all criteria pollutants are below the MAAQS Standard 2020 except for NO_2 where the GLC limit is exceeded at Bukit Pelali (1-hour average) and Bukit Pengerang (24-hour average) as shown in Table 3-7. However, with regard to sensitive receptors, all pollutants meet the Malaysia Ambient Air Quality Standards (MAAQS) Standard 2020 at these identified sensitive receptor locations.
- The NO_2 Tier 1 and NO_2 Tier 3 1-hour average GLC of 791.5 µg/m^3 (Bukit Pelali) and 483.1 µg/m^3 (Bukit Pelali) respectively exceeded the 1 hour averaging limit of 280 µg/m^3. With percentile analysis of the modelling results of NO_2, it is found that approximately 0.4 percentile or translated into a probability to occur at 7 days in every 5 years operating period that the NO_2 standard limit is exceeded.
- The NO_2 Tier 1 24-hour average GLC of 98.2 µg/m^3 (Bukit Pengerang) exceeded the 24 hours averaging limit of 70 µg/m^3. With percentile analysis of NO_2, approximately 0.2 percentile or translated into a probability to occur at 4 days in every 5 years operating period that the standard limit is exceeded.
- NO_2 emission contribution for each source in the Refinery Cracker Complex by percentage is tabulated in Table 3-3 and Table 3-4 shows the NO_2 contribution for each Refinery Cracker Complex source to the maximum GLC.
- Predicted concentrations of ammonia (NH_3), methanol, NMVOC and hydrogen sulphide (H_2S) are further assessed in the health impact assessment.

Table 3-3: NO_2 Emission Contribution from Sources in the Refinery and Cracker Complex

No.	Process Unit	Source ID	Total of NO_2 emission (g/s)	Total of NO_2 emission load (Kg/hr)	Percentage (%)
1.	Residue Fluidised Catalytic Cracking	RFCC1	46.4	167.0	22
2.		RFCC2	46.4	167.0	22
3.	Crude Distillation Unit	CDU1	2.9	10.5	1
4.		CDU2	2.9	10.5	1
5.	Atmospheric Residue Desulphurization Unit	ARDS1	0.389	1.4	<1
6.		ARDS2	0.389	1.4	<1
7.		ARDS3	0.169	0.6	<1
8.		ARDS4	0.389	1.4	<1
9.		ARDS5	0.389	1.4	<1
10.		ARDS6	0.169	0.6	<1
11.	Diesel Hydrotreating Unit	DHT1	1.4	5.0	1
12.	Kerosene Hydrotreating Unit	KHT1	0.060	0.2	<1
13.	Cracked Naphtha Hydrotreating Unit	CNHT1	0.350	1.3	<1
14.		CNHT2	0.744	2.7	<1
15.	Naphtha Hydrotreating Unit	NHT1	0.517	1.9	<1
16.	Continuous Catalytic Reformer	CCR1	3.3	12.0	2
17.		CCR2	3.3	12.0	2
18.		CCR3	3.3	12.0	2
19.		CCR4	3.3	12.0	2
20.		CCR5	-	-	0
21.	Hydrogen Production Unit	HPU1	4.8	17.4	2
22.		HPU2	4.8	17.4	2
23.		HPU3	4.8	17.4	2
24.		HPU4	-	-	0
25.		HPU5	-	-	0
26.		HPU6	-	-	0
27.		HPU7	-	-	0
28.	Sulphur Recovery Unit	SRU1	10.3	37.1	5
29.		SRU2	10.3	37.1	5
30.		SRU3	10.3	37.1	5
31.	Sulphur Solidification Units	SSU1	-	-	0
32.		SSU2	-	-	0
33.		SSU3	-	-	0
34.		SSU4	-	-	0
35.		SSU5	-	-	0

No.	Process Unit	Source ID	Total of NO_2 emission (g/s)	Total of NO_2 emission load (Kg/hr)	Percentage (%)
36.	Steam Cracker Complex	SCC1	8.6	30.9	4
37.		SCC2	8.6	30.9	4
38.		SCC3	8.7	31.2	4
39.		SCC4	8.7	31.2	4
40.		SCC5	8.7	31.2	4
41.		SCC6	7.5	27.0	4
TOTAL			**212.9**	**766.5**	**100**

Table 3-4: NO_2 Contribution to the Maximum GLC

Pollutant	Process Unit	Maximum Concentration (µg/m^3)	Location
NO_2 Tier 1 - 1 hour	RFCC, LTU and PRU	134.3	Within RAPID
	CDU, ARDS, HCDU and FOS	85.9	Bukit Pelali
	DHT, KHT, CNHT, CCR and HPU	691.9 Note1	Bukit Pelali
	SRU and SSU	72.9	Within RAPID
	SCC	470.7	Bukit Pelali
	Refinery Tank Farm	-	-
	Olefin Storage Tankages	-	-
	EURO5 MOGAS	25.8	Bukit Pengerang
NO_2 Tier 1 - 24 hours	RFCC, LTU and PRU	24.6	Within RAPID
	CDU, ARDS, HCDU and FOS	8.4	Bukit Pelali
	DHT, KHT, CNHT, CCR and HPU	55.2 Note1	Bukit Pengerang
	SRU and SSU	15.6	Within RAPID
	SCC	50.5	Bukit Pengerang
	Refinery Tank Farm	-	-
	Olefin Storage Tankages	-	-
	EURO5 MOGAS	-	-
NO_2 Tier 3 - 1	RFCC, LTU and PRU	89.1	Within RAPID

Pollutant	Process Unit	Maximum Concentration ($\mu g/m^3$)	Location
hour	CDU, ARDS, HCDU and FOS	60.7	Bukit Pelali
	DHT, KHT, CNHT, CCR and HPU	396.4 Note1	Bukit Pelali
	SRU and SSU	60.3	Within RAPID
	SCC	243.7	Bukit Pelali
	Refinery Tank Farm	-	-
	Olefin Storage Tankages	-	-
	EURO5 MOGAS	-	-

Note:
Note1: Highest concentration

b) Abnormal

- During abnormal operation, the predicted GLCs of CO is below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration. However, predicted SO_2 concentrations exceed the MAAQS Standard 2020 at all receptors and the NO_2 limit is exceeded at Pengelih Naval Base and Kg Bukit Buloh (**Table 3-8**). With particulate matter PM10 and PM2.5, the predicted 1-hour average concentration is even lower than its 24-hour average limit.
- During abnormal operation, predicted NMVOC, H_2S and UHC concentrations are significantly higher (**Table 3-8**) and these are assessed in the health impact assessment.
- Analysis of source contribution of SO_2 emissions during abnormal operation scenario showed that the Refinery Tank Farm emits the highest rate of SO_2. (**Table 3-5**).
- Source apportionment of the predicted highest maximum 1-hour average ground level concentration of SO_2 during abnormal operation scenario also showed that the main contributor is the Refinery Tank Farm (**Table 3-6**).

Table 3-5: SO_2 Emission Contribution from Sources in the Refinery and Cracker Complex during Abnormal Operation

No.	Process Unit	Source ID	Total of SO_2 emission (g/s)	Total of SO_2 emission load (Kg/hr)	Percentage (%)
1.	Residue Fluidised Catalytic Cracking	RFCC1 Note1	700.0	2,520.0	46
2.		RFCC2	25.0	90	2
3.	Crude Distillation Unit	CDU1	0.572	2.1	<1
4.		CDU2	0.572	2.1	<1
5.	Atmospheric Residue Desulphurization Unit	ARDS1	0.100	0.4	<1
6.		ARDS2	0.100	0.4	<1
7.		ARDS3	0.044	0.2	<1
8.		ARDS4	0.100	0.4	<1
9.		ARDS5	0.100	0.4	<1
10.		ARDS6	0.044	0.2	<1
11.	Diesel Hydrotreating Unit	DHT1 Note1	0.209	0.8	<1
12.	Kerosene Hydrotreating Unit	KHT1	0.086	0.3	<1
13.	Cracked Naphtha Hydrotreating Unit	CNHT1	0.052	0.2	<1
14.		CNHT2	0.031	0.11	<1
15.	Naphtha Hydrotreating Unit	NHT1	0.078	0.3	<1
16.	Continuous Catalytic Reformer	CCR1	0.311	1.1	<1
17.		CCR2	0.311	1.1	<1
18.		CCR3	0.311	1.1	<1
19.		CCR4	0.311	1.1	<1
20.		CCR5	-	-	-
21.	Hydrogen Production Unit	HPU1	0.229	0.8	<1
22.		HPU2	0.229	0.8	<1
23.		HPU3	0.229	0.8	<1
24.		HPU4	-	-	-
25.		HPU5	-	-	-
26.		HPU6	-	-	-
27.		HPU7	-	-	-
28.	Flare System	AF1 Note1	6.0	21.4	<1
29.	Sulphur Recovery Unit	SRU1 Note1	4.9	17.5	<1
30.		SRU2	3.4	12.4	<1
31.		SRU3	3.4	12.4	<1
32.	Sulphur Solidification	SSU1	0.083	0.3	<1

No.	Process Unit	Source ID	Total of SO_2 emission (g/s)	Total of SO_2 emission load (Kg/hr)	Percentage (%)
33.	Units	SSU2	0.083	0.3	<1
34.		SSU3	0.083	0.3	<1
35.		SSU4	0.083	0.3	<1
36.		SSU5	0.083	0.3	<1
37.	Steam Cracker Complex	SCC1	-	-	-
38.		SCC2	-	-	-
39.		SCC3	-	-	-
40.		SCC4	-	-	-
41.		SCC5	-	-	-
42.		SCC6	-	-	-
43.		PGH1 Note1	39.2	141.1	3
44.		SCCF1 Note1	-	-	-
45.	Refinery Tank Farm	RTFF1 Note1	733.0	2,638.8	48
46.	Olefin Storage	CF1 Note1	-	-	-
TOTAL			**1,519.3**	**5,463.6**	**100**

Note:
Note1: Abnormal operation

Table 3-6: SO_2 Contribution to the Maximum GLC during Abnormal Operation

Pollutant	Process Unit	Maximum Concentration (µg/m^3)	Location
SO_2 - 1 hour (Abnormal)	RFCC, LTU and PRU	295.1	Eastern Boundary of RAPID
	CDU, ARDS, HCDU and FOS	-	-
	DHT, KHT, CNHT, CCR and HPU	60.5	Bukit Pelali
	SRU and SSU	55.1	Bukit Pelali
	SCC	905.4	Bukit Pelali
	Refinery Tank Farm	40,582.8 Note1	Within RAPID
	Olefin Storage Tankages	-	-

Note:
Note1: Highest SO_2 concentration contribution

c) Emergency

- During emergency operation, the predicted GLCs of CO, SO_2 and NO_2 are below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration. (**Table 3-9**). With PM_{10} and $PM_{2.5}$, the predicted 1-hour average concentration is even lower than its 24-hour average limit.
- Predicted NMVOC are lower and H_2S concentrations are insignificant compared to the Arizona Ambient Air Quality Guideline levels (**Table 3-9)**.

Table 3-7: Predicted Incremental GLC and Cumulative GLC for Refinery Cracker Complex (Normal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
1	**Refinery Cracker Complex** Pollutant: **PM_{10}** 24 hrs Average Limit: 100 μg/m^3	Tg. Pengelih	24	1.8 (Bukit Pengerang)	0.191	24.2
		Pengelih Naval Base	24		0.383	24.4
		Kg. Pengerang	36		0.217	36.2
		Kg. Sg. Kapal	25		0.389	25.4
		Taman Rengit Jaya	38		0.391	38.4
		Kg. Sg. Buntu	28		0.368	28.4
		Kg. Bukit Buloh	31		0.396	31.4
		Kg. Sg. Rengit	20		0.280	20.3
		Kg. Bukit Gelugor	22		0.237	22.2
		Kg. Lepau	35		0.441	35.4
		Kg. Pasir Gogok	20		0.262	20.3
2	**Refinery Cracker Complex** Pollutant: **PM_{10}** Annual Average Limit: 40 μg/m^3	Tg. Pengelih	NM	0.295 (Within RAPID)	0.012	NA
		Pengelih Naval Base	NM		0.020	NA
		Kg. Pengerang	NM		0.017	NA
		Kg. Sg. Kapal	NM		0.053	NA
		Taman Rengit Jaya	NM		0.048	NA
		Kg. Sg. Buntu	NM		0.037	NA
		Kg. Bukit Buloh	NM		0.038	NA
		Kg. Sg. Rengit	NM		0.027	NA
		Kg. Bukit Gelugor	NM		0.023	NA
		Kg. Lepau	NM		0.079	NA
		Kg. Pasir Gogok	NM		0.016	NA
3	**Refinery Cracker Complex** Pollutant: **$PM_{2.5}$** 24 hrs Average Limit: 35 μg/m^3	Tg. Pengelih	NM	1.6 (Bukit Pengerang)	0.135	NA
		Pengelih Naval Base	NM		0.344	NA
		Kg. Pengerang	NM		0.158	NA
		Kg. Sg. Kapal	NM		0.256	NA
		Taman Rengit Jaya	NM		0.265	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Sg. Buntu	NM		0.241	NA
		Kg. Bukit Buloh	NM		0.245	NA
		Kg. Sg. Rengit	NM		0.178	NA
		Kg. Bukit Gelugor	NM		0.151	NA
		Kg. Lepau	NM		0.341	NA
		Kg. Pasir Gogok	NM		0.159	NA
4	**Refinery Cracker Complex** Pollutant: **$PM_{2.5}$** Annual Average Limit: 15 µg/m^3	Tg. Pengelih	NM	0.214 (Within RAPID)	0.008	NA
		Pengelih Naval Base	NM		0.015	NA
		Kg. Pengerang	NM		0.011	NA
		Kg. Sg. Kapal	NM		0.032	NA
		Taman Rengit Jaya	NM		0.029	NA
		Kg. Sg. Buntu	NM		0.023	NA
		Kg. Bukit Buloh	NM		0.023	NA
		Kg. Sg. Rengit	NM		0.016	NA
		Kg. Bukit Gelugor	NM		0.014	NA
		Kg. Lepau	NM		0.056	NA
		Kg. Pasir Gogok	NM		0.011	NA
5	**Refinery Cracker Complex** Pollutant: **NO_2 Tier1** 1 hr Average Limit: 280 µg/m^3	Tg. Pengelih	<5	**791.5 (Bukit Pelali)**	67.2	72.2
		Pengelih Naval Base	<5		198.7	203.7
		Kg. Pengerang	<5		86.1	91.1
		Kg. Sg. Kapal	<5		165.0	170.0
		Taman Rengit Jaya	<5		123.9	128.9
		Kg. Sg. Buntu	<5		91.5	96.5
		Kg. Bukit Buloh	<5		163.8	168.8
		Kg. Sg. Rengit	ND		121.4	121.4
		Kg. Bukit Gelugor	<5		113.0	118.0
		Kg. Lepau	<5		146.2	151.2
		Kg. Pasir Gogok	ND		79.0	79.0
6	**Refinery Cracker**	Tg. Pengelih	NM	**98.2**	8.7	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
	Complex Pollutant: **NO_2** **Tier1** 24 hrs Average Limit: 70 µg/m³	Pengelih Naval Base	NM	**(Bukit Pengerang)**	28.1	NA
		Kg. Pengerang	NM		10.3	NA
		Kg. Sg. Kapal	NM		19.7	NA
		Taman Rengit Jaya	NM		19.6	NA
		Kg. Sg. Buntu	NM		17.0	NA
		Kg. Bukit Buloh	NM		13.8	NA
		Kg. Sg. Rengit	NM		9.5	NA
		Kg. Bukit Gelugor	NM		9.9	NA
		Kg. Lepau	NM		16.0	NA
		Kg. Pasir Gogok	NM		9.5	NA
7	**Refinery Cracker Complex** Pollutant: **NO_2** **Tier3** 1 hr Average Limit: 280 µg/m³	Tg. Pengelih	<5	**483.1 (Bukit Pelali)**	14.2	19.2
		Pengelih Naval Base	<5		122.1	127.1
		Kg. Pengerang	<5		20.4	25.4
		Kg. Sg. Kapal	<5		78.8	83.8
		Taman Rengit Jaya	<5		70.7	75.7
		Kg. Sg. Buntu	<5		62.7	67.7
		Kg. Bukit Buloh	<5		92.1	97.1
		Kg. Sg. Rengit	ND		68.5	68.5
		Kg. Bukit Gelugor	<5		63.9	68.9
		Kg. Lepau	<5		68.1	73.1
		Kg. Pasir Gogok	ND		32.0	32.0
8	**Refinery Cracker Complex** Pollutant: **NO_2 99.6 Percentile** 1 hr Average Limit: 280 µg/m³	Tg. Pengelih	<5	254.5 (Bukit Pelali)	12.3	17.3
		Pengelih Naval Base	<5		30.3	35.3
		Kg. Pengerang	<5		17.3	22.3
		Kg. Sg. Kapal	<5		56.2	61.2
		Taman Rengit Jaya	<5		52.8	57.8
		Kg. Sg. Buntu	<5		45.3	50.3
		Kg. Bukit Buloh	<5		60.5	65.5
		Kg. Sg. Rengit	ND		48.3	48.3
		Kg. Bukit Gelugor	<5		36.1	41.1

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Lepau	<5		50.8	55.8
		Kg. Pasir Gogok	ND		16.3	16.3
9	**Refinery Cracker Complex** Pollutant: **NO_2 99.8 Percentile** 24 hrs Average Limit: 70 µg/m³	Tg. Pengelih	NM	63.9 (Bukit Pelali)	3.6	NA
		Pengelih Naval Base	NM		21.7	NA
		Kg. Pengerang	NM		4.6	NA
		Kg. Sg. Kapal	NM		16.0	NA
		Taman Rengit Jaya	NM		14.8	NA
		Kg. Sg. Buntu	NM		12.2	NA
		Kg. Bukit Buloh	NM		11.4	NA
		Kg. Sg. Rengit	NM		8.7	NA
		Kg. Bukit Gelugor	NM		7.6	NA
		Kg. Lepau	NM		15.5	NA
		Kg. Pasir Gogok	NM		7.8	NA
10	**Refinery Cracker Complex** Pollutant: **SO_2** 1 hr Average Limit: 250 µg/m³	Tg. Pengelih	<5	95.6 (Within RAPID)	18.8	23.8
		Pengelih Naval Base	<5		30.2	35.2
		Kg. Pengerang	<5		20.2	25.2
		Kg. Sg. Kapal	<5		52.7	57.7
		Taman Rengit Jaya	<5		37.4	42.4
		Kg. Sg. Buntu	<5		29.1	34.1
		Kg. Bukit Buloh	<5		51.2	56.2
		Kg. Sg. Rengit	ND		36.9	36.9
		Kg. Bukit Gelugor	<5		33.4	38.4
		Kg. Lepau	<5		51.5	56.5
		Kg. Pasir Gogok	ND		23.9	23.9
11	**Refinery Cracker Complex** Pollutant: **SO_2** 24 hrs Average Limit: 80 µg/m³	Tg. Pengelih	NM	18.0 (Within RAPID)	2.2	NA
		Pengelih Naval Base	NM		4.5	NA
		Kg. Pengerang	NM		2.2	NA
		Kg. Sg. Kapal	NM		5.0	NA
		Taman Rengit Jaya	NM		4.8	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Sg. Buntu	NM		4.2	NA
		Kg. Bukit Buloh	NM		4.1	NA
		Kg. Sg. Rengit	NM		2.9	NA
		Kg. Bukit Gelugor	NM		2.7	NA
		Kg. Lepau	NM		5.7	NA
		Kg. Pasir Gogok	NM		3.3	NA
12	**Refinery Cracker Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 µg/m^3	Tg. Pengelih	NM	455.4 (Eastern side of RAPID)	31.4	NA
		Pengelih Naval Base	NM		74.6	NA
		Kg. Pengerang	NM		34.1	NA
		Kg. Sg. Kapal	NM		87.3	NA
		Taman Rengit Jaya	NM		77.8	NA
		Kg. Sg. Buntu	NM		44.1	NA
		Kg. Bukit Buloh	NM		455.4	NA
		Kg. Sg. Rengit	NM		54.8	NA
		Kg. Bukit Gelugor	NM		50.8	NA
		Kg. Lepau	NM		72.7	NA
		Kg. Pasir Gogok	NM		37.6	NA
13	**Refinery Cracker Complex** Pollutant: **CO** 8 hrs Average Limit: 10,000 µg/m^3	Tg. Pengelih	<100	204.8 (Within RAPID)	9.6	109.6
		Pengelih Naval Base	<100		26.5	126.5
		Kg. Pengerang	<100		8.5	108.5
		Kg. Sg. Kapal	<100		21.5	121.5
		Taman Rengit Jaya	<100		41.5	141.5
		Kg. Sg. Buntu	<100		20.6	120.6
		Kg. Bukit Buloh	<100		204.8	304.8
		Kg. Sg. Rengit	ND		11.5	11.5
		Kg. Bukit Gelugor	<100		9.9	109.9
		Kg. Lepau	<100		22.4	122.4
		Kg. Pasir Gogok	ND		10.6	10.6
14	**Refinery Cracker**	Tg. Pengelih	NM	1.6	0.088	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
	Complex Pollutant: **NH_3** 1 hr Average Limit: NA	Pengelih Naval Base	NM	Within RAPID	0.036	NA
		Kg. Pengerang	NM		0.099	NA
		Kg. Sg. Kapal	NM		0.189	NA
		Taman Rengit Jaya	NM		0.311	NA
		Kg. Sg. Buntu	NM		0.138	NA
		Kg. Bukit Buloh	NM		1.036	NA
		Kg. Sg. Rengit	NM		0.103	NA
		Kg. Bukit Gelugor	NM		0.091	NA
		Kg. Lepau	NM		0.130	NA
		Kg. Pasir Gogok	NM		0.067	NA
15	**Refinery Cracker Complex** Pollutant: **NH_3** 8 hrs Average Limit: NA	Tg. Pengelih	NM	0.828 Within RAPID	0.023	NA
		Pengelih Naval Base	NM		0.005	NA
		Kg. Pengerang	NM		0.025	NA
		Kg. Sg. Kapal	NM		0.066	NA
		Taman Rengit Jaya	NM		0.141	NA
		Kg. Sg. Buntu	NM		0.056	NA
		Kg. Bukit Buloh	NM		0.535	NA
		Kg. Sg. Rengit	NM		0.017	NA
		Kg. Bukit Gelugor	NM		0.019	NA
		Kg. Lepau	NM		0.025	NA
		Kg. Pasir Gogok	NM		0.024	NA
16	**Refinery Cracker Complex** Pollutant: **NH_3** 24 hrs Average Limit: NA	Tg. Pengelih	NM	0.302 Within RAPID	0.008	NA
		Pengelih Naval Base	NM		0.002	NA
		Kg. Pengerang	NM		0.011	NA
		Kg. Sg. Kapal	NM		0.027	NA
		Taman Rengit Jaya	NM		0.043	NA
		Kg. Sg. Buntu	NM		0.020	NA
		Kg. Bukit Buloh	NM		0.188	NA
		Kg. Sg. Rengit	NM		0.006	NA
		Kg. Bukit Gelugor	NM		0.006	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Lepau	NM		0.008	NA
		Kg. Pasir Gogok	NM		0.008	NA
17	**Refinery Cracker Complex** Pollutant: **Methanol** 1 hr Average Limit: NA	Tg. Pengelih	NM	33.3 (Within RAPID)	1.804	NA
		Pengelih Naval Base	NM		0.740	NA
		Kg. Pengerang	NM		2.030	NA
		Kg. Sg. Kapal	NM		3.850	NA
		Taman Rengit Jaya	NM		6.337	NA
		Kg. Sg. Buntu	NM		2.812	NA
		Kg. Bukit Buloh	NM		21.148	NA
		Kg. Sg. Rengit	NM		2.103	NA
		Kg. Bukit Gelugor	NM		1.855	NA
		Kg. Lepau	NM		2.645	NA
		Kg. Pasir Gogok	NM		1.359	NA
18	**Refinery Cracker Complex** Pollutant: **Methanol** 8 hrs Average Limit: NA	Tg. Pengelih	NM	16.9 (Within RAPID)	0.476	NA
		Pengelih Naval Base	NM		0.100	NA
		Kg. Pengerang	NM		0.507	NA
		Kg. Sg. Kapal	NM		1.344	NA
		Taman Rengit Jaya	NM		2.887	NA
		Kg. Sg. Buntu	NM		1.135	NA
		Kg. Bukit Buloh	NM		10.917	NA
		Kg. Sg. Rengit	NM		0.349	NA
		Kg. Bukit Gelugor	NM		0.394	NA
		Kg. Lepau	NM		0.510	NA
		Kg. Pasir Gogok	NM		0.498	NA
19	**Refinery Cracker Complex** Pollutant: **Methanol** 24 hrs Average Limit: NA	Tg. Pengelih	NM	6.2 (Within RAPID)	0.159	NA
		Pengelih Naval Base	NM		0.033	NA
		Kg. Pengerang	NM		0.229	NA
		Kg. Sg. Kapal	NM		0.552	NA
		Taman Rengit Jaya	NM		0.885	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Sg. Buntu	NM		0.406	NA
		Kg. Bukit Buloh	NM		3.836	NA
		Kg. Sg. Rengit	NM		0.117	NA
		Kg. Bukit Gelugor	NM		0.132	NA
		Kg. Lepau	NM		0.170	NA
		Kg. Pasir Gogok	NM		0.166	NA
20	**Refinery Cracker Complex** Pollutant: **NMVOC** 1 hr Average Limit: NA	Tg. Pengelih	NM	42.2 (Bukit Pelali)	1.087	NA
		Pengelih Naval Base	NM		15.255	NA
		Kg. Pengerang	NM		1.964	NA
		Kg. Sg. Kapal	NM		1.967	NA
		Taman Rengit Jaya	NM		2.051	NA
		Kg. Sg. Buntu	NM		1.885	NA
		Kg. Bukit Buloh	NM		2.219	NA
		Kg. Sg. Rengit	NM		2.084	NA
		Kg. Bukit Gelugor	NM		1.865	NA
		Kg. Lepau	NM		1.853	NA
		Kg. Pasir Gogok	NM		1.714	NA
21	**Refinery Cracker Complex** Pollutant: **NMVOC** 8 hrs Average Limit: NA	Tg. Pengelih	NM	9.6 (Bukit Pengerang)	0.228	NA
		Pengelih Naval Base	NM		6.060	NA
		Kg. Pengerang	NM		0.265	NA
		Kg. Sg. Kapal	NM		0.866	NA
		Taman Rengit Jaya	NM		0.794	NA
		Kg. Sg. Buntu	NM		0.658	NA
		Kg. Bukit Buloh	NM		0.444	NA
		Kg. Sg. Rengit	NM		0.364	NA
		Kg. Bukit Gelugor	NM		0.379	NA
		Kg. Lepau	NM		0.516	NA
		Kg. Pasir Gogok	NM		0.305	NA
22	**Refinery Cracker**	Tg. Pengelih	NM	3.2	0.136	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
	Complex Pollutant: **NMVOC** 24 hrs Average Limit: NA	Pengelih Naval Base	NM	(Bukit Pelali)	2.033	NA
		Kg. Pengerang	NM		0.184	NA
		Kg. Sg. Kapal	NM		0.471	NA
		Taman Rengit Jaya	NM		0.464	NA
		Kg. Sg. Buntu	NM		0.360	NA
		Kg. Bukit Buloh	NM		0.188	NA
		Kg. Sg. Rengit	NM		0.149	NA
		Kg. Bukit Gelugor	NM		0.142	NA
		Kg. Lepau	NM		0.206	NA
		Kg. Pasir Gogok	NM		0.115	NA
23	**Refinery Cracker Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	4.2 (Within RAPID)	1.240	NA
		Pengelih Naval Base	NM		0.791	NA
		Kg. Pengerang	NM		1.007	NA
		Kg. Sg. Kapal	NM		1.430	NA
		Taman Rengit Jaya	NM		1.266	NA
		Kg. Sg. Buntu	NM		1.312	NA
		Kg. Bukit Buloh	NM		1.711	NA
		Kg. Sg. Rengit	NM		1.281	NA
		Kg. Bukit Gelugor	NM		1.307	NA
		Kg. Lepau	NM		2.351	NA
		Kg. Pasir Gogok	NM		0.972	NA
24	**Refinery Cracker Complex** Pollutant: **H_2S** 8 hrs Average Limit: NA	Tg. Pengelih	NM	2.4 (Within RAPID)	0.155	NA
		Pengelih Naval Base	NM		0.165	NA
		Kg. Pengerang	NM		0.134	NA
		Kg. Sg. Kapal	NM		0.428	NA
		Taman Rengit Jaya	NM		0.367	NA
		Kg. Sg. Buntu	NM		0.339	NA
		Kg. Bukit Buloh	NM		0.384	NA
		Kg. Sg. Rengit	NM		0.302	NA
		Kg. Bukit Gelugor	NM		0.216	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Lepau	NM		0.625	NA
		Kg. Pasir Gogok	NM		0.243	NA
25	**Refinery Cracker Complex** Pollutant: **H_2S** 24 hrs Average Limit: NA	Tg. Pengelih	NM	0.907 (Within RAPID)	0.096	NA
		Pengelih Naval Base	NM		0.094	NA
		Kg. Pengerang	NM		0.087	NA
		Kg. Sg. Kapal	NM		0.170	NA
		Taman Rengit Jaya	NM		0.145	NA
		Kg. Sg. Buntu	NM		0.136	NA
		Kg. Bukit Buloh	NM		0.153	NA
		Kg. Sg. Rengit	NM		0.120	NA
		Kg. Bukit Gelugor	NM		0.110	NA
		Kg. Lepau	NM		0.253	NA
		Kg. Pasir Gogok	NM		0.083	NA

Note:
All concentration unit in µg/m^3
NM = Not monitored
NA = Not Available

Table 3-8: Predicted Incremental GLC and Cumulative GLC for Refinery Cracker Complex (Abnormal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (μg/m³)	Receptor Incremental (μg/m³)	Cumulative GLC (μg/m³)
1	**Refinery Cracker Complex** Pollutant: **PM_{10}** 1 hr Average Limit: NA	Tg. Pengelih	NM	35.1 (Bukit Pelali)	6.3	NA
		Pengelih Naval Base	NM		16.5	NA
		Kg. Pengerang	NM		6.1	NA
		Kg. Sg. Kapal	NM		11.7	NA
		Taman Rengit Jaya	NM		9.9	NA
		Kg. Sg. Buntu	NM		7.6	NA
		Kg. Bukit Buloh	NM		12.1	NA
		Kg. Sg. Rengit	NM		9.9	NA
		Kg. Bukit Gelugor	NM		9.4	NA
		Kg. Lepau	NM		11.7	NA
		Kg. Pasir Gogok	NM		7.7	NA
2	**Refinery Cracker Complex** Pollutant: **$PM_{2.5}$** 1 hr Average Limit: NA	Tg. Pengelih	NM	13.3 (Bukit Pengerang)	2.5	NA
		Pengelih Naval Base	NM		3.3	NA
		Kg. Pengerang	NM		2.4	NA
		Kg. Sg. Kapal	NM		4.5	NA
		Taman Rengit Jaya	NM		4.1	NA
		Kg. Sg. Buntu	NM		2.9	NA
		Kg. Bukit Buloh	NM		4.5	NA
		Kg. Sg. Rengit	NM		3.5	NA
		Kg. Bukit Gelugor	NM		3.5	NA
		Kg. Lepau	NM		4.0	NA
		Kg. Pasir Gogok	NM		2.7	NA
3	**Refinery Cracker Complex** Pollutant: **NO_2** **Tier1** 1 hr Average Limit: 280 μg/m³	Tg. Pengelih	<5	2073.8 (Within RAPID)	81.7	86.7
		Pengelih Naval Base	<5		923.4	928.4
		Kg. Pengerang	<5		90.5	95.5
		Kg. Sg. Kapal	<5		208.6	213.6
		Taman Rengit Jaya	<5		187.7	192.7
		Kg. Sg. Buntu	<5		157.1	162.1

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
		Kg. Bukit Buloh	<5		295.3	300.3
		Kg. Sg. Rengit	ND		119.2	119.2
		Kg. Bukit Gelugor	<5		112.5	117.5
		Kg. Lepau	<5		170.2	175.2
		Kg. Pasir Gogok	ND		106.8	106.8
4	**Refinery Cracker Complex** Pollutant: **SO_2** 1 hr Average Limit: 250 μg/m^3	Tg. Pengelih	<5	40582.8 (Within RAPID)	1298.9	1303.9
		Pengelih Naval Base	<5		16620.7	16625.7
		Kg. Pengerang	<5		1542.3	1547.3
		Kg. Sg. Kapal	<5		3740.9	3745.9
		Taman Rengit Jaya	<5		3436.2	3441.2
		Kg. Sg. Buntu	<5		2865.0	2870.0
		Kg. Bukit Buloh	<5		5397.5	5402.5
		Kg. Sg. Rengit	ND		2051.7	2051.7
		Kg. Bukit Gelugor	<5		1700.7	1705.7
		Kg. Lepau	<5		3056.3	3061.3
		Kg. Pasir Gogok	ND		1890.4	1890.4
5	**Refinery Cracker Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 μg/m^3	Tg. Pengelih	NM	1814.0 (Western Boundary of RAPID)	99.1	NA
		Pengelih Naval Base	NM		714.5	NA
		Kg. Pengerang	NM		112.1	NA
		Kg. Sg. Kapal	NM		173.2	NA
		Taman Rengit Jaya	NM		160.9	NA
		Kg. Sg. Buntu	NM		132.1	NA
		Kg. Bukit Buloh	NM		455.5	NA
		Kg. Sg. Rengit	NM		111.3	NA
		Kg. Bukit Gelugor	NM		87.7	NA
		Kg. Lepau	NM		147.8	NA
		Kg. Pasir Gogok	NM		84.9	NA
6	**Refinery Cracker Complex**	Tg. Pengelih	NM	57.3 (Bukit Pelali)	1.9	NA
		Pengelih Naval Base	NM		26.0	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
	Pollutant: **NMVOC** 1 hr Average Limit: NA	Kg. Pengerang	NM		2.5	NA
		Kg. Sg. Kapal	NM		3.3	NA
		Taman Rengit Jaya	NM		2.6	NA
		Kg. Sg. Buntu	NM		2.8	NA
		Kg. Bukit Buloh	NM		3.6	NA
		Kg. Sg. Rengit	NM		2.7	NA
		Kg. Bukit Gelugor	NM		2.3	NA
		Kg. Lepau	NM		3.4	NA
		Kg. Pasir Gogok	NM		2.4	NA
7	**Refinery Cracker Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	456.1 (Within RAPID)	24.5	NA
		Pengelih Naval Base	NM		182.3	NA
		Kg. Pengerang	NM		31.3	NA
		Kg. Sg. Kapal	NM		45.8	NA
		Taman Rengit Jaya	NM		50.1	NA
		Kg. Sg. Buntu	NM		39.9	NA
		Kg. Bukit Buloh	NM		62.8	NA
		Kg. Sg. Rengit	NM		29.1	NA
		Kg. Bukit Gelugor	NM		22.1	NA
		Kg. Lepau	NM		38.4	NA
		Kg. Pasir Gogok	NM		22.0	NA
8	**Refinery Cracker Complex** Pollutant: **UHC** 1 hr Average Limit: NA	Tg. Pengelih	NM	4104.6 (Within RAPID)	220.8	NA
		Pengelih Naval Base	NM		1640.3	NA
		Kg. Pengerang	NM		282.0	NA
		Kg. Sg. Kapal	NM		412.0	NA
		Taman Rengit Jaya	NM		450.5	NA
		Kg. Sg. Buntu	NM		358.8	NA
		Kg. Bukit Buloh	NM		565.5	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
		Kg. Sg. Rengit	NM		261.9	NA
		Kg. Bukit Gelugor	NM		198.7	NA
		Kg. Lepau	NM		345.2	NA
		Kg. Pasir Gogok	NM		198.3	NA

Note:
All concentration unit in μg/m^3
NM = Not monitored
NA = Not Available

Table 3-9: Predicted Incremental GLC and Cumulative GLC for Refinery Cracker Complex (Emergency Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
1	**Refinery Cracker Complex** Pollutant: **PM_{10}** 1 hr Average Limit: NA	Tg. Pengelih	NM	11.5 (Ocean – Southern of RAPID)	8.7	NA
		Pengelih Naval Base	NM		9.5	NA
		Kg. Pengerang	NM		7.6	NA
		Kg. Sg. Kapal	NM		9.5	NA
		Taman Rengit Jaya	NM		8.8	NA
		Kg. Sg. Buntu	NM		8.1	NA
		Kg. Bukit Buloh	NM		9.1	NA
		Kg. Sg. Rengit	NM		9.9	NA
		Kg. Bukit Gelugor	NM		10.2	NA
		Kg. Lepau	NM		9.0	NA
		Kg. Pasir Gogok	NM		9.9	NA
2	**Refinery Cracker Complex** Pollutant: **$PM_{2.5}$** 1 hr Average Limit: NA	Tg. Pengelih	NM	6.9 (Ocean – Southern of RAPID)	5.2	NA
		Pengelih Naval Base	NM		5.7	NA
		Kg. Pengerang	NM		4.6	NA
		Kg. Sg. Kapal	NM		5.7	NA
		Taman Rengit Jaya	NM		5.3	NA
		Kg. Sg. Buntu	NM		4.9	NA
		Kg. Bukit Buloh	NM		5.5	NA
		Kg. Sg. Rengit	NM		5.9	NA
		Kg. Bukit Gelugor	NM		6.1	NA
		Kg. Lepau	NM		5.4	NA
		Kg. Pasir Gogok	NM		6.0	NA
3	**Refinery Cracker Complex** Pollutant: **NO_2** **Tier1** 1 hr Average Limit: 280 µg/m³	Tg. Pengelih	<5	9.3 (Ocean – Southern of RAPID)	7.1	12.1
		Pengelih Naval Base	<5		7.7	12.7
		Kg. Pengerang	<5		6.2	11.2
		Kg. Sg. Kapal	<5		7.7	12.7
		Taman Rengit Jaya	<5		7.1	12.1
		Kg. Sg. Buntu	<5		6.6	11.6

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Bukit Buloh	<5		7.4	12.4
		Kg. Sg. Rengit	ND		8.0	8.0
		Kg. Bukit Gelugor	<5		8.2	13.2
		Kg. Lepau	<5		7.3	12.3
		Kg. Pasir Gogok	ND		8.1	8.1
4	**Refinery Cracker Complex** Pollutant: **SO_2** 1 hr Average Limit: 250 µg/m³	Tg. Pengelih	<5	120.4 (Ocean – Southern of RAPID)	91.1	96.1
		Pengelih Naval Base	<5		99.7	104.7
		Kg. Pengerang	<5		80.0	85.0
		Kg. Sg. Kapal	<5		99.3	104.3
		Taman Rengit Jaya	<5		92.2	97.2
		Kg. Sg. Buntu	<5		84.7	89.7
		Kg. Bukit Buloh	<5		95.5	100.5
		Kg. Sg. Rengit	ND		103.3	103.3
		Kg. Bukit Gelugor	<5		106.5	111.5
		Kg. Lepau	<5		93.8	98.8
		Kg. Pasir Gogok	ND		104.1	104.1
5	**Refinery Cracker Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 µg/m³	Tg. Pengelih	NM	50.7 (Ocean – Southern of RAPID)	38.4	NA
		Pengelih Naval Base	NM		42.0	NA
		Kg. Pengerang	NM		33.7	NA
		Kg. Sg. Kapal	NM		41.8	NA
		Taman Rengit Jaya	NM		38.9	NA
		Kg. Sg. Buntu	NM		35.7	NA
		Kg. Bukit Buloh	NM		40.3	NA
		Kg. Sg. Rengit	NM		43.5	NA
		Kg. Bukit Gelugor	NM		44.9	NA
		Kg. Lepau	NM		39.5	NA
		Kg. Pasir Gogok	NM		43.8	NA
6	**Refinery Cracker Complex**	Tg. Pengelih	NM	102.1 (Ocean – Southern of	77.3	NA
		Pengelih Naval Base	NM		84.5	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	Pollutant: **NMVOC** 1 hr Average Limit: NA	Kg. Pengerang	NM	RAPID)	67.9	NA
		Kg. Sg. Kapal	NM		84.2	NA
		Taman Rengit Jaya	NM		78.2	NA
		Kg. Sg. Buntu	NM		71.8	NA
		Kg. Bukit Buloh	NM		81.0	NA
		Kg. Sg. Rengit	NM		87.6	NA
		Kg. Bukit Gelugor	NM		90.3	NA
		Kg. Lepau	NM		79.6	NA
		Kg. Pasir Gogok	NM		88.2	NA
7	**Refinery Cracker Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	1.3 (Ocean – Southern of RAPID)	0.992	NA
		Pengelih Naval Base	NM		1.085	NA
		Kg. Pengerang	NM		0.871	NA
		Kg. Sg. Kapal	NM		1.081	NA
		Taman Rengit Jaya	NM		1.004	NA
		Kg. Sg. Buntu	NM		0.922	NA
		Kg. Bukit Buloh	NM		1.040	NA
		Kg. Sg. Rengit	NM		1.125	NA
		Kg. Bukit Gelugor	NM		1.160	NA
		Kg. Lepau	NM		1.022	NA
		Kg. Pasir Gogok	NM		1.133	NA

Note:
All concentration unit in µg/m^3
NM = Not monitored
NA = Not Available

3.3 Cumulative RAPID Complex

For the cumulative RAPID Complex modelling, only the common air pollutants that are emitted by all RAPID components are assessed for the three scenarios described above.

a) Normal

- The max ground level concentration (GLC) for all criteria pollutants are below the MAAQS 2013 (IT 2020) except for NO_2 where the GLC limit is exceeded at Bukit Pelali for the 1-hour average and Bukit Pengerang for the 24-hour average (Table 3-11). However, at the sensitive receptors, all pollutants meet the Malaysia Ambient Air Quality Standards (MAAQS) Standard 2020 at these identified sensitive receptors.
- The NO_2 Tier 1 and NO_2 Tier 3 1-hour average GLC of 806.7 µg/m^3 (Bukit Pelali) and 523.0 µg/m^3 (Bukit Pelali) exceeded the 1 hour average limit of 280 µg/m^3. With percentile analysis of modelling results, approximately 0.5 percentile or translated into probability to occur at 9 days in every 5 years operating period that the standard limit is exceeded.
- The NO_2 Tier 1 24-hour average GLC of 114.5 (Bukit Pengerang) exceeded the 24 hours averaging limit of 70 µg/m^3 at approximately 0.3 percentile or translated into a probability to occur at 5 days in every 5 years operating period. Tabulated below are the predicted gaseous concentrations at the sensitive and discrete receptors along with the contours of the predicted gaseous concentrations in the 5-km radius receptor grid.

Table 3-10: NO_2 Emission Contribution from Each Complex in RAPID

No.	Sources	Total of NO_2 emission rate (g/s)	Total of NO_2 emission load (Kg/hr)	Percentage (%)
1.	Refinery Cracker Complex	212.9	766.5	50
2.	Petrochemical Complex	26.1	94.1	6
3.	Pengerang Cogeneration Plant (PCP)	174.0	626.4	41
4.	Utilities	15	54.0	4
TOTAL		**428.1**	**1541.0**	**100**

b) Abnormal

- During abnormal operation, the predicted GLCs of CO is below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration. However, predicted SO_2 concentrations exceed the MAAQS Standard 2020 at all receptors and the NO_2 limit is exceeded at Pengelih Naval Base and Kg Bukit Buloh. (**Table 3-12**). With PM_{10} and $PM_{2.5}$, the predicted 1-hour average concentration is even lower than its 24-hour average limit.

c) Emergency

- During emergency operation, the predicted GLCs of CO, SO_2 and NO_2 are below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration. (**Table 3-13**). With PM_{10} and $PM_{2.5}$, the predicted 1-hour average concentration is even lower than its 24-hour average limit.

Table 3-11: Predicted Incremental GLC and Cumulative GLC for Cumulative RAPID Complex (Normal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
1	**Cumulative RAPID Complex** Pollutant: **PM_{10}** 24 hrs Average Limit: 100 µg/m³	Tg. Pengelih	24	3.3 (Bukit Pengerang)	0.339	24.3
		Pengelih Naval Base	24		2.5	26.5
		Kg. Pengerang	36		0.467	36.5
		Kg. Sg. Kapal	25		0.544	25.5
		Taman Rengit Jaya	38		0.531	38.5
		Kg. Sg. Buntu	28		0.476	28.5
		Kg. Bukit Buloh	31		0.513	31.5
		Kg. Sg. Rengit	20		0.428	20.4
		Kg. Bukit Gelugor	22		0.361	22.4
		Kg. Lepau	35		0.666	35.7
		Kg. Pasir Gogok	20		0.381	20.4
2	**Cumulative RAPID Complex** Pollutant: **PM_{10}** Annual Average Limit: 40 µg/m³	Tg. Pengelih	NM	0.496 (Within RAPID)	0.023	NA
		Pengelih Naval Base	NM		0.080	NA
		Kg. Pengerang	NM		0.032	NA
		Kg. Sg. Kapal	NM		0.081	NA
		Taman Rengit Jaya	NM		0.077	NA
		Kg. Sg. Buntu	NM		0.064	NA
		Kg. Bukit Buloh	NM		0.063	NA
		Kg. Sg. Rengit	NM		0.047	NA
		Kg. Bukit Gelugor	NM		0.042	NA
		Kg. Lepau	NM		0.126	NA
		Kg. Pasir Gogok	NM		0.031	NA
3	**Cumulative RAPID**	Tg. Pengelih	NM	2.5	0.244	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	Complex Pollutant: **PM$_{2.5}$** 24 hrs Average Limit: 35 µg/m^3	Pengelih Naval Base	NM	(Bukit Pengerang)	1.6	NA
		Kg. Pengerang	NM		0.321	NA
		Kg. Sg. Kapal	NM		0.361	NA
		Taman Rengit Jaya	NM		0.361	NA
		Kg. Sg. Buntu	NM		0.314	NA
		Kg. Bukit Buloh	NM		0.339	NA
		Kg. Sg. Rengit	NM		0.296	NA
		Kg. Bukit Gelugor	NM		0.253	NA
		Kg. Lepau	NM		0.491	NA
		Kg. Pasir Gogok	NM		0.267	NA
4	**Cumulative RAPID Complex** Pollutant: **PM$_{2.5}$** Annual Average Limit: 15 µg/m^3	Tg. Pengelih	NM	0.331 (Within RAPID)	0.017	NA
		Pengelih Naval Base	NM		0.052	NA
		Kg. Pengerang	NM		0.023	NA
		Kg. Sg. Kapal	NM		0.054	NA
		Taman Rengit Jaya	NM		0.052	NA
		Kg. Sg. Buntu	NM		0.045	NA
		Kg. Bukit Buloh	NM		0.044	NA
		Kg. Sg. Rengit	NM		0.034	NA
		Kg. Bukit Gelugor	NM		0.031	NA
		Kg. Lepau	NM		0.090	NA
		Kg. Pasir Gogok	NM		0.023	NA
5	**Cumulative RAPID Complex** Pollutant: **NO_2 Tier1** 1 hr Average Limit: 280 µg/m^3	Tg. Pengelih	<5	**808.3** **(Bukit Pelali)**	81.0	86.0
		Pengelih Naval Base	<5		**281.4**	**286.4**
		Kg. Pengerang	<5		103.0	108.0
		Kg. Sg. Kapal	<5		181.5	186.5
		Taman Rengit Jaya	<5		141.0	146.0

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Sg. Buntu	<5		99.9	104.9
		Kg. Bukit Buloh	<5		175.6	180.6
		Kg. Sg. Rengit	ND		133.3	133.3
		Kg. Bukit Gelugor	<5		127.8	132.8
		Kg. Lepau	<5		161.9	166.9
		Kg. Pasir Gogok	ND		92.2	92.2
6	**Cumulative RAPID Complex** Pollutant: **NO_2 Tier1** 24 hrs Average Limit: 70 µg/m³	Tg. Pengelih	NM	**115.5 (Bukit Pengerang)**	10.9	NA
		Pengelih Naval Base	NM		41.8	NA
		Kg. Pengerang	NM		13.2	NA
		Kg. Sg. Kapal	NM		21.4	NA
		Taman Rengit Jaya	NM		21.2	NA
		Kg. Sg. Buntu	NM		18.9	NA
		Kg. Bukit Buloh	NM		16.1	NA
		Kg. Sg. Rengit	NM		12.1	NA
		Kg. Bukit Gelugor	NM		12.2	NA
		Kg. Lepau	NM		18.5	NA
		Kg. Pasir Gogok	NM		12.1	NA
7	**Cumulative RAPID Complex** Pollutant: **NO_2 Tier3** 1 hr Average Limit: 280 µg/m³	Tg. Pengelih	<5	**526.9 (Bukit Pelali)**	18.5	23.5
		Pengelih Naval Base	<5		178.9	183.9
		Kg. Pengerang	<5		24.8	29.8
		Kg. Sg. Kapal	<5		86.5	91.5
		Taman Rengit Jaya	<5		77.5	82.5
		Kg. Sg. Buntu	<5		71.4	76.4
		Kg. Bukit Buloh	<5		100.5	105.5
		Kg. Sg. Rengit	ND		77.4	77.4
		Kg. Bukit Gelugor	<5		75.5	80.5

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Lepau	<5		73.0	78.0
		Kg. Pasir Gogok	ND		41.1	41.1
8	**Cumulative RAPID Complex** Pollutant: **NO_2 99.5 Percentile** 1 hr Average Limit: 280 µg/m^3	Tg. Pengelih	<5	256.0 (Bukit Pelali)	16.0	21.0
		Pengelih Naval Base	<5		48.7	53.7
		Kg. Pengerang	<5		22.1	27.1
		Kg. Sg. Kapal	<5		57.3	62.3
		Taman Rengit Jaya	<5		54.1	59.1
		Kg. Sg. Buntu	<5		46.6	51.6
		Kg. Bukit Buloh	<5		62.1	67.1
		Kg. Sg. Rengit	ND		53.2	53.2
		Kg. Bukit Gelugor	<5		41.1	46.1
		Kg. Lepau	<5		56.2	61.2
		Kg. Pasir Gogok	ND		20.4	20.4
9	**Cumulative RAPID Complex** Pollutant: **NO_2 99.7 Percentile** 24 hrs Average Limit: 70 µg/m^3	Tg. Pengelih	NM	66.9 (Bukit Pelali)	4.4	NA
		Pengelih Naval Base	NM		25.9	NA
		Kg. Pengerang	NM		5.9	NA
		Kg. Sg. Kapal	NM		16.0	NA
		Taman Rengit Jaya	NM		15.2	NA
		Kg. Sg. Buntu	NM		13.7	NA
		Kg. Bukit Buloh	NM		13.3	NA
		Kg. Sg. Rengit	NM		10.6	NA
		Kg. Bukit Gelugor	NM		9.4	NA
		Kg. Lepau	NM		17.1	NA
		Kg. Pasir Gogok	NM		9.9	NA
10	**Cumulative RAPID Complex**	Tg. Pengelih	<5	91.0	19.3	24.3
		Pengelih Naval Base	<5		30.3	35.3

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (μg/m^3)	Receptor Incremental (μg/m^3)	Cumulative GLC (μg/m^3)
	Pollutant: **SO_2** 1 hr Average Limit: 250 μg/m^3	Kg. Pengerang	<5	(Within RAPID)	20.7	25.7
		Kg. Sg. Kapal	<5		53.6	58.6
		Taman Rengit Jaya	<5		38.0	43.0
		Kg. Sg. Buntu	<5		29.4	34.4
		Kg. Bukit Buloh	<5		51.9	56.9
		Kg. Sg. Rengit	ND		37.4	37.4
		Kg. Bukit Gelugor	<5		33.9	38.9
		Kg. Lepau	<5		51.8	56.8
		Kg. Pasir Gogok	ND		24.4	24.4
11	**Cumulative RAPID Complex** Pollutant: **SO_2** 24 hrs Average Limit: 80 μg/m^3	Tg. Pengelih	NM	16.6 (Within RAPID)	2.2	NA
		Pengelih Naval Base	NM		4.6	NA
		Kg. Pengerang	NM		2.3	NA
		Kg. Sg. Kapal	NM		5.1	NA
		Taman Rengit Jaya	NM		4.9	NA
		Kg. Sg. Buntu	NM		4.3	NA
		Kg. Bukit Buloh	NM		4.2	NA
		Kg. Sg. Rengit	NM		3.0	NA
		Kg. Bukit Gelugor	NM		2.8	NA
		Kg. Lepau	NM		5.8	NA
		Kg. Pasir Gogok	NM		3.3	NA
12	**Cumulative RAPID Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 μg/m^3	Tg. Pengelih	NM	569.8 (Eastern side of RAPID)	50.1	NA
		Pengelih Naval Base	NM		569.8	NA
		Kg. Pengerang	NM		77.7	NA
		Kg. Sg. Kapal	NM		104.1	NA
		Taman Rengit Jaya	NM		85.3	NA
		Kg. Sg. Buntu	NM		64.5	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Bukit Buloh	NM		455.4	NA
		Kg. Sg. Rengit	NM		87.7	NA
		Kg. Bukit Gelugor	NM		76.4	NA
		Kg. Lepau	NM		86.0	NA
		Kg. Pasir Gogok	NM		48.7	NA
13	**Cumulative RAPID Complex** Pollutant: **CO** 8 hrs Average Limit: 10,000 µg/m³	Tg. Pengelih	<100	205.0 (Within RAPID)	12.8	112.8
		Pengelih Naval Base	<100		164.1	264.1
		Kg. Pengerang	<100		16.8	116.8
		Kg. Sg. Kapal	<100		27.9	127.9
		Taman Rengit Jaya	<100		41.5	141.5
		Kg. Sg. Buntu	<100		21.5	121.5
		Kg. Bukit Buloh	<100		205.0	305.0
		Kg. Sg. Rengit	ND		22.1	22.1
		Kg. Bukit Gelugor	<100		15.8	115.8
		Kg. Lepau	<100		27.1	127.1
		Kg. Pasir Gogok	ND		17.7	17.7
14	**Cumulative RAPID Complex** Pollutant: **NH_3** 1 hr Average Limit: NA	Tg. Pengelih	NM	1.6 Within RAPID	0.088	NA
		Pengelih Naval Base	NM		0.036	NA
		Kg. Pengerang	NM		0.099	NA
		Kg. Sg. Kapal	NM		0.189	NA
		Taman Rengit Jaya	NM		0.311	NA
		Kg. Sg. Buntu	NM		0.138	NA
		Kg. Bukit Buloh	NM		1.036	NA
		Kg. Sg. Rengit	NM		0.103	NA
		Kg. Bukit Gelugor	NM		0.091	NA
		Kg. Lepau	NM		0.130	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
		Kg. Pasir Gogok	NM		0.067	NA
15	**Cumulative RAPID Complex** Pollutant: **NH_3** 8 hrs Average Limit: NA	Tg. Pengelih	NM	0.828 Within RAPID	0.023	NA
		Pengelih Naval Base	NM		0.005	NA
		Kg. Pengerang	NM		0.025	NA
		Kg. Sg. Kapal	NM		0.066	NA
		Taman Rengit Jaya	NM		0.141	NA
		Kg. Sg. Buntu	NM		0.056	NA
		Kg. Bukit Buloh	NM		0.535	NA
		Kg. Sg. Rengit	NM		0.017	NA
		Kg. Bukit Gelugor	NM		0.019	NA
		Kg. Lepau	NM		0.025	NA
		Kg. Pasir Gogok	NM		0.024	NA
16	**Cumulative RAPID Complex** Pollutant: **NH_3** 24 hrs Average Limit: NA	Tg. Pengelih	NM	0.302 Within RAPID	0.008	NA
		Pengelih Naval Base	NM		0.002	NA
		Kg. Pengerang	NM		0.011	NA
		Kg. Sg. Kapal	NM		0.027	NA
		Taman Rengit Jaya	NM		0.043	NA
		Kg. Sg. Buntu	NM		0.020	NA
		Kg. Bukit Buloh	NM		0.188	NA
		Kg. Sg. Rengit	NM		0.006	NA
		Kg. Bukit Gelugor	NM		0.006	NA
		Kg. Lepau	NM		0.008	NA
		Kg. Pasir Gogok	NM		0.008	NA
17	**Cumulative RAPID Complex** Pollutant: **Methanol**	Tg. Pengelih	NM	33.3 (Within RAPID)	1.804	NA
		Pengelih Naval Base	NM		0.740	NA
		Kg. Pengerang	NM		2.030	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m³)	Receptor Incremental (µg/m³)	Cumulative GLC (µg/m³)
	1 hr Average Limit: NA	Kg. Sg. Kapal	NM		3.850	NA
		Taman Rengit Jaya	NM		6.337	NA
		Kg. Sg. Buntu	NM		2.812	NA
		Kg. Bukit Buloh	NM		21.148	NA
		Kg. Sg. Rengit	NM		2.103	NA
		Kg. Bukit Gelugor	NM		1.855	NA
		Kg. Lepau	NM		2.645	NA
		Kg. Pasir Gogok	NM		1.359	NA
18	**Cumulative RAPID Complex** Pollutant: **Methanol** 8 hrs Average Limit: NA	Tg. Pengelih	NM	16.9 (Within RAPID)	0.476	NA
		Pengelih Naval Base	NM		0.100	NA
		Kg. Pengerang	NM		0.507	NA
		Kg. Sg. Kapal	NM		1.344	NA
		Taman Rengit Jaya	NM		2.887	NA
		Kg. Sg. Buntu	NM		1.135	NA
		Kg. Bukit Buloh	NM		10.917	NA
		Kg. Sg. Rengit	NM		0.349	NA
		Kg. Bukit Gelugor	NM		0.394	NA
		Kg. Lepau	NM		0.510	NA
		Kg. Pasir Gogok	NM		0.498	NA
19	**Cumulative RAPID Complex** Pollutant: **Methanol** 24 hrs Average Limit: NA	Tg. Pengelih	NM	6.2 (Within RAPID)	0.159	NA
		Pengelih Naval Base	NM		0.033	NA
		Kg. Pengerang	NM		0.229	NA
		Kg. Sg. Kapal	NM		0.552	NA
		Taman Rengit Jaya	NM		0.885	NA
		Kg. Sg. Buntu	NM		0.406	NA
		Kg. Bukit Buloh	NM		3.836	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Sg. Rengit	NM		0.117	NA
		Kg. Bukit Gelugor	NM		0.132	NA
		Kg. Lepau	NM		0.170	NA
		Kg. Pasir Gogok	NM		0.166	NA
20	**Cumulative RAPID Complex** Pollutant: **NMVOC** 1 hr Average Limit: NA	Tg. Pengelih	NM	42.2 (Bukit Pelali)	1.087	NA
		Pengelih Naval Base	NM		15.255	NA
		Kg. Pengerang	NM		1.964	NA
		Kg. Sg. Kapal	NM		1.967	NA
		Taman Rengit Jaya	NM		2.051	NA
		Kg. Sg. Buntu	NM		1.885	NA
		Kg. Bukit Buloh	NM		2.219	NA
		Kg. Sg. Rengit	NM		2.084	NA
		Kg. Bukit Gelugor	NM		1.865	NA
		Kg. Lepau	NM		1.853	NA
		Kg. Pasir Gogok	NM		1.714	NA
21	**Cumulative RAPID Complex** Pollutant: **NMVOC** 8 hrs Average Limit: NA	Tg. Pengelih	NM	9.6 (Bukit Pengerang)	0.228	NA
		Pengelih Naval Base	NM		6.060	NA
		Kg. Pengerang	NM		0.265	NA
		Kg. Sg. Kapal	NM		0.866	NA
		Taman Rengit Jaya	NM		0.794	NA
		Kg. Sg. Buntu	NM		0.658	NA
		Kg. Bukit Buloh	NM		0.444	NA
		Kg. Sg. Rengit	NM		0.364	NA
		Kg. Bukit Gelugor	NM		0.379	NA
		Kg. Lepau	NM		0.516	NA
		Kg. Pasir Gogok	NM		0.305	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
22	**Cumulative RAPID Complex** Pollutant: **NMVOC** 24 hrs Average Limit: NA	Tg. Pengelih	NM	3.2 (Bukit Pelali)	0.136	NA
		Pengelih Naval Base	NM		2.033	NA
		Kg. Pengerang	NM		0.184	NA
		Kg. Sg. Kapal	NM		0.471	NA
		Taman Rengit Jaya	NM		0.464	NA
		Kg. Sg. Buntu	NM		0.360	NA
		Kg. Bukit Buloh	NM		0.188	NA
		Kg. Sg. Rengit	NM		0.149	NA
		Kg. Bukit Gelugor	NM		0.142	NA
		Kg. Lepau	NM		0.206	NA
		Kg. Pasir Gogok	NM		0.115	NA
23	**Cumulative RAPID Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	4.2 (Within RAPID)	1.240	NA
		Pengelih Naval Base	NM		0.791	NA
		Kg. Pengerang	NM		1.007	NA
		Kg. Sg. Kapal	NM		1.430	NA
		Taman Rengit Jaya	NM		1.266	NA
		Kg. Sg. Buntu	NM		1.312	NA
		Kg. Bukit Buloh	NM		1.711	NA
		Kg. Sg. Rengit	NM		1.281	NA
		Kg. Bukit Gelugor	NM		1.307	NA
		Kg. Lepau	NM		2.351	NA
		Kg. Pasir Gogok	NM		0.972	NA
24	**Cumulative RAPID Complex** Pollutant: **H_2S** 8 hrs Average	Tg. Pengelih	NM	2.4 (Within RAPID)	0.155	NA
		Pengelih Naval Base	NM		0.165	NA
		Kg. Pengerang	NM		0.134	NA
		Kg. Sg. Kapal	NM		0.428	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Normal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	Limit: NA	Taman Rengit Jaya	NM		0.367	NA
		Kg. Sg. Buntu	NM		0.339	NA
		Kg. Bukit Buloh	NM		0.384	NA
		Kg. Sg. Rengit	NM		0.302	NA
		Kg. Bukit Gelugor	NM		0.216	NA
		Kg. Lepau	NM		0.625	NA
		Kg. Pasir Gogok	NM		0.243	NA
25	**Cumulative RAPID Complex** Pollutant: **H_2S** 24 hrs Average Limit: NA	Tg. Pengelih	NM	0.907 (Within RAPID)	0.096	NA
		Pengelih Naval Base	NM		0.094	NA
		Kg. Pengerang	NM		0.087	NA
		Kg. Sg. Kapal	NM		0.170	NA
		Taman Rengit Jaya	NM		0.145	NA
		Kg. Sg. Buntu	NM		0.136	NA
		Kg. Bukit Buloh	NM		0.153	NA
		Kg. Sg. Rengit	NM		0.120	NA
		Kg. Bukit Gelugor	NM		0.110	NA
		Kg. Lepau	NM		0.253	NA
		Kg. Pasir Gogok	NM		0.083	NA

Note:
All concentration unit in µg/m^3
NM = Not monitored
NA = Not Available

Table 3-12: Predicted Incremental GLC and Cumulative GLC for RAPID Complex (Abnormal Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
1	**Cumulative RAPID Complex** Pollutant: **PM_{10}** 1 hr Average Limit: NA	Tg. Pengelih	NM	35.1 (Bukit Pelali)	7.2	NA
		Pengelih Naval Base	NM		22.8	NA
		Kg. Pengerang	NM		7.0	NA
		Kg. Sg. Kapal	NM		12.6	NA
		Taman Rengit Jaya	NM		11.0	NA
		Kg. Sg. Buntu	NM		8.2	NA
		Kg. Bukit Buloh	NM		13.0	NA
		Kg. Sg. Rengit	NM		10.5	NA
		Kg. Bukit Gelugor	NM		10.2	NA
		Kg. Lepau	NM		12.0	NA
		Kg. Pasir Gogok	NM		8.4	NA
2	**Cumulative RAPID Complex** Pollutant: **$PM_{2.5}$** 1 hr Average Limit: NA	Tg. Pengelih	NM	14.7 (Bukit Pengerang)	3.1	NA
		Pengelih Naval Base	NM		13.6	NA
		Kg. Pengerang	NM		3.1	NA
		Kg. Sg. Kapal	NM		5.1	NA
		Taman Rengit Jaya	NM		4.8	NA
		Kg. Sg. Buntu	NM		3.6	NA
		Kg. Bukit Buloh	NM		5.1	NA
		Kg. Sg. Rengit	NM		4.0	NA
		Kg. Bukit Gelugor	NM		4.1	NA
		Kg. Lepau	NM		4.6	NA
		Kg. Pasir Gogok	NM		3.3	NA
3	**Cumulative RAPID Complex** Pollutant: **NO_2** **Tier1** 1 hr Average Limit: 280 µg/m^3	Tg. Pengelih	<5	2073.8 (Within RAPID)	87.4	92.4
		Pengelih Naval Base	<5		931.1	936.1
		Kg. Pengerang	<5		95.0	100.0
		Kg. Sg. Kapal	<5		208.7	213.7
		Taman Rengit Jaya	<5		188.0	193.0
		Kg. Sg. Buntu	<5		158.5	163.5

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Bukit Buloh	<5		295.3	300.3
		Kg. Sg. Rengit	ND		127.2	127.2
		Kg. Bukit Gelugor	<5		121.6	126.6
		Kg. Lepau	<5		175.8	180.8
		Kg. Pasir Gogok	ND		112.1	112.1
4	**Cumulative RAPID Complex** Pollutant: **SO_2** 1 hr Average Limit: 250 µg/m^3	Tg. Pengelih	<5	40582.8 (Within RAPID)	1298.9	1303.9
		Pengelih Naval Base	<5		16620.7	16625.7
		Kg. Pengerang	<5		1542.3	1547.3
		Kg. Sg. Kapal	<5		3740.9	3745.9
		Taman Rengit Jaya	<5		3436.2	3441.2
		Kg. Sg. Buntu	<5		2865.0	2870.0
		Kg. Bukit Buloh	<5		5397.5	5402.5
		Kg. Sg. Rengit	ND		2051.7	2051.7
		Kg. Bukit Gelugor	<5		1700.7	1705.7
		Kg. Lepau	<5		3056.3	3061.3
		Kg. Pasir Gogok	ND		1890.4	1890.4
5	**Cumulative RAPID Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 µg/m^3	Tg. Pengelih	NM	1814.1 (Western Boundary of RAPID)	99.5	NA
		Pengelih Naval Base	NM		744.4	NA
		Kg. Pengerang	NM		112.1	NA
		Kg. Sg. Kapal	NM		174.5	NA
		Taman Rengit Jaya	NM		160.9	NA
		Kg. Sg. Buntu	NM		142.3	NA
		Kg. Bukit Buloh	NM		455.6	NA
		Kg. Sg. Rengit	NM		111.3	NA
		Kg. Bukit Gelugor	NM		93.5	NA
		Kg. Lepau	NM		184.9	NA
		Kg. Pasir Gogok	NM		107.1	NA
6	**Cumulative RAPID Complex** Pollutant: **NMVOC**	Tg. Pengelih	NM	57.3 (Bukit Pelali)	1.9	NA
		Pengelih Naval Base	NM		26.0	NA
		Kg. Pengerang	NM		2.5	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Abnormal Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	1 hr Average Limit: NA	Kg. Sg. Kapal	NM		3.3	NA
		Taman Rengit Jaya	NM		2.6	NA
		Kg. Sg. Buntu	NM		2.8	NA
		Kg. Bukit Buloh	NM		3.6	NA
		Kg. Sg. Rengit	NM		2.7	NA
		Kg. Bukit Gelugor	NM		2.3	NA
		Kg. Lepau	NM		3.4	NA
		Kg. Pasir Gogok	NM		2.4	NA
7	**Cumulative RAPID Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	456.1 (Within RAPID)	24.5	NA
		Pengelih Naval Base	NM		182.3	NA
		Kg. Pengerang	NM		31.3	NA
		Kg. Sg. Kapal	NM		45.8	NA
		Taman Rengit Jaya	NM		50.1	NA
		Kg. Sg. Buntu	NM		39.9	NA
		Kg. Bukit Buloh	NM		62.8	NA
		Kg. Sg. Rengit	NM		29.1	NA
		Kg. Bukit Gelugor	NM		22.1	NA
		Kg. Lepau	NM		38.4	NA
		Kg. Pasir Gogok	NM		22.0	NA
8	**Cumulative RAPID Complex** Pollutant: **UHC** 1 hr Average Limit: NA	Tg. Pengelih	NM	4104.6 Within RAPID)	220.8	NA
		Pengelih Naval Base	NM		1640.3	NA
		Kg. Pengerang	NM		282.0	NA
		Kg. Sg. Kapal	NM		412.0	NA
		Taman Rengit Jaya	NM		450.5	NA
		Kg. Sg. Buntu	NM		358.8	NA
		Kg. Bukit Buloh	NM		565.5	NA
		Kg. Sg. Rengit	NM		261.9	NA
		Kg. Bukit Gelugor	NM		198.7	NA
		Kg. Lepau	NM		345.2	NA
		Kg. Pasir Gogok	NM		198.3	NA

Note:
All concentration unit in μg/m³
NM = Not monitored. NA = Not Available

Table 3-13: Predicted Incremental GLC and Cumulative GLC for Cumulative RAPID Complex (Emergency Operation)

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (μg/m³)	Receptor Incremental (μg/m³)	Cumulative GLC (μg/m³)
1	**Cumulative RAPID Complex** Pollutant: **PM_{10}** 1 hr Average Limit: 100 μg/m³	Tg. Pengelih	NM	21.7 (Bukit Pengerang)	8.9	NA
		Pengelih Naval Base	NM		21.7	NA
		Kg. Pengerang	NM		7.8	NA
		Kg. Sg. Kapal	NM		10.0	NA
		Taman Rengit Jaya	NM		9.2	NA
		Kg. Sg. Buntu	NM		8.3	NA
		Kg. Bukit Buloh	NM		9.3	NA
		Kg. Sg. Rengit	NM		10.1	NA
		Kg. Bukit Gelugor	NM		10.5	NA
		Kg. Lepau	NM		9.4	NA
		Kg. Pasir Gogok	NM		10.2	NA
2	**Cumulative RAPID Complex** Pollutant: **$PM_{2.5}$** 1 hr Average Limit: 35 μg/m³	Tg. Pengelih	NM	12.4 (Bukit Pengerang)	5.4	NA
		Pengelih Naval Base	NM		12.4	NA
		Kg. Pengerang	NM		4.7	NA
		Kg. Sg. Kapal	NM		6.1	NA
		Taman Rengit Jaya	NM		5.7	NA
		Kg. Sg. Buntu	NM		5.0	NA
		Kg. Bukit Buloh	NM		5.6	NA
		Kg. Sg. Rengit	NM		6.2	NA
		Kg. Bukit Gelugor	NM		6.4	NA
		Kg. Lepau	NM		5.8	NA
		Kg. Pasir Gogok	NM		6.2	NA
3	**Cumulative RAPID Complex**	Tg. Pengelih	<5	165.0	15.7	20.7
		Pengelih Naval Base	<5		165.0	170.0

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
	Pollutant: **NO_2 Tier1** 1 hr Average Limit: 280 µg/m^3	Kg. Pengerang	<5	(Bukit Pengerang)	17.0	22.0
		Kg. Sg. Kapal	<5		18.1	23.1
		Taman Rengit Jaya	<5		19.8	24.8
		Kg. Sg. Buntu	<5		16.2	21.2
		Kg. Bukit Buloh	<5		20.3	25.3
		Kg. Sg. Rengit	ND		19.4	19.4
		Kg. Bukit Gelugor	<5		21.0	26.0
		Kg. Lepau	<5		24.5	29.5
		Kg. Pasir Gogok	ND		15.8	15.8
4	**Cumulative RAPID Complex** Pollutant: **SO_2** 1 hr Average Limit: 250 µg/m^3	Tg. Pengelih	<5	120.5 (Ocean – Southern of RAPID)	91.2	96.2
		Pengelih Naval Base	<5		99.8	104.8
		Kg. Pengerang	<5		80.1	85.1
		Kg. Sg. Kapal	<5		99.5	104.5
		Taman Rengit Jaya	<5		92.4	97.4
		Kg. Sg. Buntu	<5		84.8	89.8
		Kg. Bukit Buloh	<5		95.6	100.6
		Kg. Sg. Rengit	ND		103.5	103.5
		Kg. Bukit Gelugor	<5		106.7	111.7
		Kg. Lepau	<5		94.1	99.1
		Kg. Pasir Gogok	ND		104.2	104.2
5	**Cumulative RAPID Complex** Pollutant: **CO** 1 hr Average Limit: 30,000 µg/m^3	Tg. Pengelih	NM	546.4 (Bukit Pengerang)	42.7	NA
		Pengelih Naval Base	NM		546.4	NA
		Kg. Pengerang	NM		47.3	NA
		Kg. Sg. Kapal	NM		57.7	NA
		Taman Rengit Jaya	NM		65.8	NA
		Kg. Sg. Buntu	NM		52.3	NA
		Kg. Bukit Buloh	NM		53.2	NA
		Kg. Sg. Rengit	NM		49.8	NA
		Kg. Bukit Gelugor	NM		51.3	NA
		Kg. Lepau	NM		82.4	NA

No	Scenario	Receptor	Baseline (Oct 2012)	Emergency Operating Scenario		
				Max Incremental (µg/m^3)	Receptor Incremental (µg/m^3)	Cumulative GLC (µg/m^3)
		Kg. Pasir Gogok	NM		50.1	NA
6	**Cumulative RAPID Complex** Pollutant: **NMVOC** 1 hr Average Limit: NA	Tg. Pengelih	NM	102.1 (Ocean – Southern of RAPID)	77.3	NA
		Pengelih Naval Base	NM		84.5	NA
		Kg. Pengerang	NM		67.9	NA
		Kg. Sg. Kapal	NM		84.2	NA
		Taman Rengit Jaya	NM		78.2	NA
		Kg. Sg. Buntu	NM		71.8	NA
		Kg. Bukit Buloh	NM		81.0	NA
		Kg. Sg. Rengit	NM		87.6	NA
		Kg. Bukit Gelugor	NM		90.3	NA
		Kg. Lepau	NM		79.6	NA
		Kg. Pasir Gogok	NM		88.2	NA
7	**Cumulative RAPID Complex** Pollutant: **H_2S** 1 hr Average Limit: NA	Tg. Pengelih	NM	1.3 (Ocean – Southern of RAPID)	0.992	NA
		Pengelih Naval Base	NM		1.085	NA
		Kg. Pengerang	NM		0.871	NA
		Kg. Sg. Kapal	NM		1.081	NA
		Taman Rengit Jaya	NM		1.004	NA
		Kg. Sg. Buntu	NM		0.922	NA
		Kg. Bukit Buloh	NM		1.040	NA
		Kg. Sg. Rengit	NM		1.125	NA
		Kg. Bukit Gelugor	NM		1.160	NA
		Kg. Lepau	NM		1.022	NA
		Kg. Pasir Gogok	NM		1.133	NA

Note:
All concentration unit in µg/m^3
NM = Not monitored
NA = Not Available

4.0 CONCLUSION

For gaseous emission, the normal operations of EURO5 MOGAS expansion indicate that it meets the MAAQS 2013 Standard 2020 limits for all pollutants. No abnormal operation for EURO5 MOGAS modelled. As for Olefin Storage tankages, no normal continuous emission from it as the vent will be routed to either the Cold Flare or Refinery Tank Farm Flare. Under abnormal operation, the cold flare modelling result shows the predicted GLCs of CO is below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration while the predicted maximum GLC of NO_2 exceeds the stipulated limit but it is located within the RAPID Complex. While under emergency operation, the predicted GLCs of CO, SO_2 and NO_2 are below the required respective MAAQS (Standard 2020) at all receptors and the predicted maximum 1 hour average concentration for the prescribed parameters were well within the MAAQS Standard 2020.

During normal operations based on cumulative emissions from all process units in the Refinery and Cracker Complex, predicted ground level concentrations (GLC) of all pollutants except NO_2 are within the Malaysia Ambient Air Quality Standards (MAAQS) Standard 2020 limits. NO_2 concentrations exceeded the limit only at Bukit Pelali (1-hour average) and Bukit Pengerang (24-hour average) for less than 0.4% of the time which is equivalent to less than 7 days over a 5-year period. Predicted concentrations of ammonia (NH_3), methanol, NMVOC and hydrogen sulphide (H_2S) are insignificant and are further assess in the health impact assessment. With the inclusion of cumulative emissions from other RAPID components, modelling findings indicated no issue of concern except for NO_2 where the NO_2 level exceeds the MAAQS 2013 (Standard 2020) limit. Results indicated that the maximum GLC takes place at Bukit Pelali and Bukit Pengerang for the normal operating conditions and three locations at sensitive receptor located surrounding the RAPID Complex i.e. Pengelih Naval Base, Sg Rengit and Kg Bukit Buloh will have NO_2 level marginally exceeding the MAAQS 2013 (Standard 2020).

With abnormal operating conditions, which is temporary and transient, predicted CO, PM_{10} and $PM_{2.5}$, concentrations are within the required limits. However, SO_2 and NO_2 concentrations exceed the MAAQS Standard 2020 for the maximum 1 hour average concentration. A similar set of results and conclusions are arrived at with the inclusion of other RAPID components.

During an emergency, operating condition when emissions are totally flared, predicted concentrations of CO, SO_2 and NO_2 are below the required respective MAAQS Standard 2020 at all receptors for the maximum 1 hour average concentration and for comparison purposes, predicted 1-hour average PM10 and PM2.5 concentrations are even below its 24-hour average limit. A similar set of results and conclusions are arrived at with the inclusion of other RAPID components.

SUB-APPENDIX 1A: INDIVIDUAL UNITS AIR DISPERSION CONCENTRATION CONTOUR

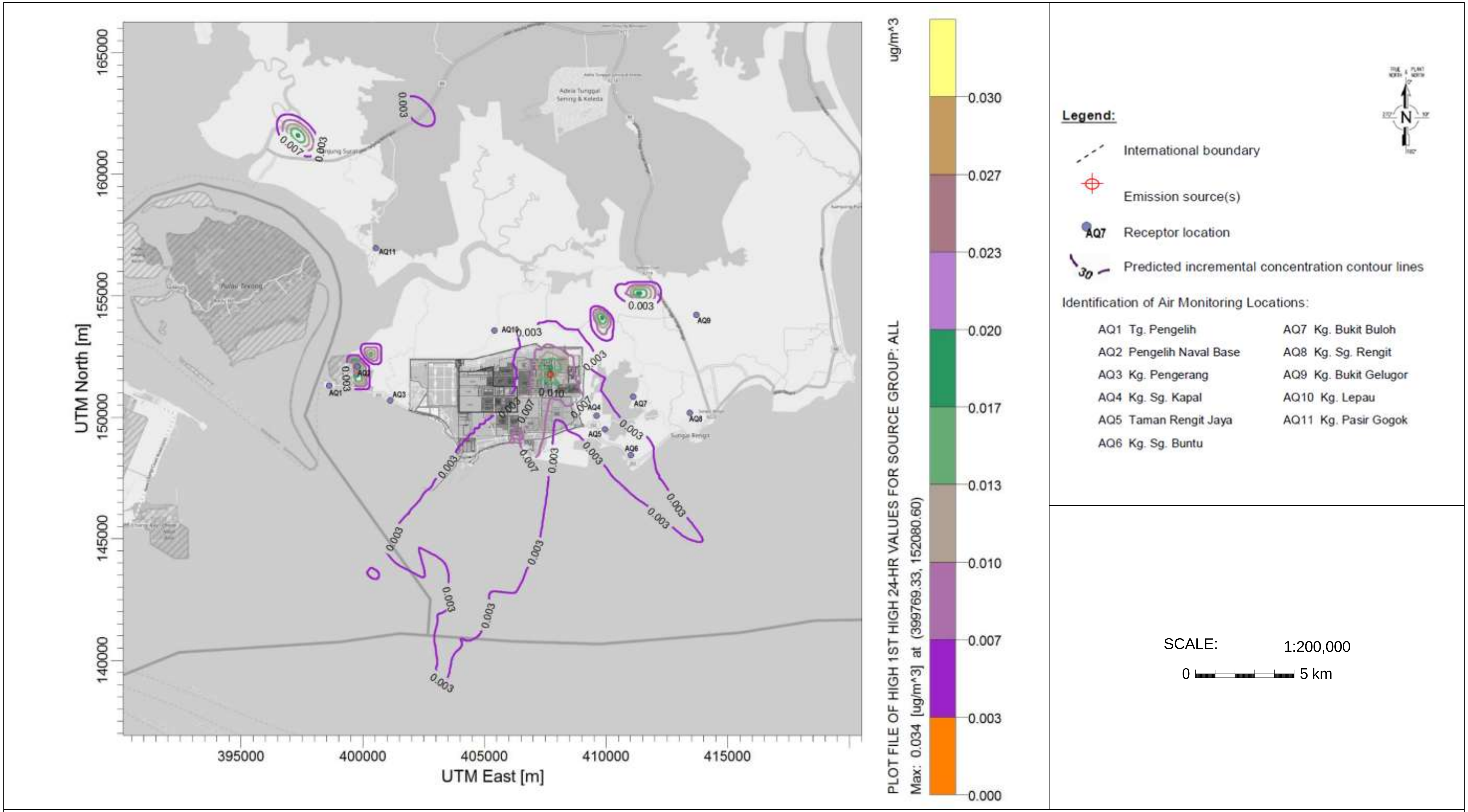

Figure 1: Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for EURO5 MOGAS (Maximum 24 hours Average in $\mu g/m^3$)

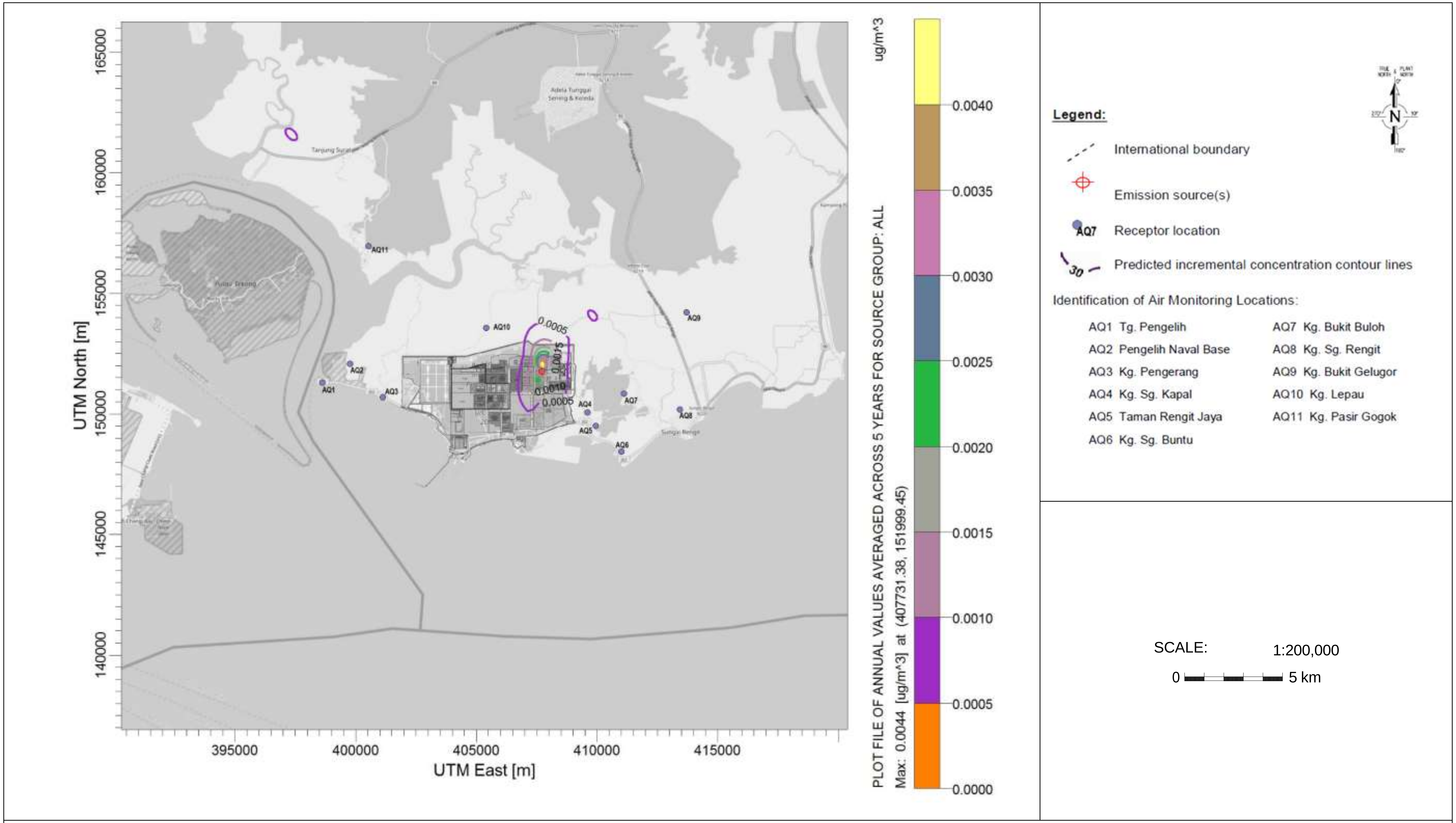

Figure 2: Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for EURO5 MOGAS (Maximum Annual Average in µg/m³)

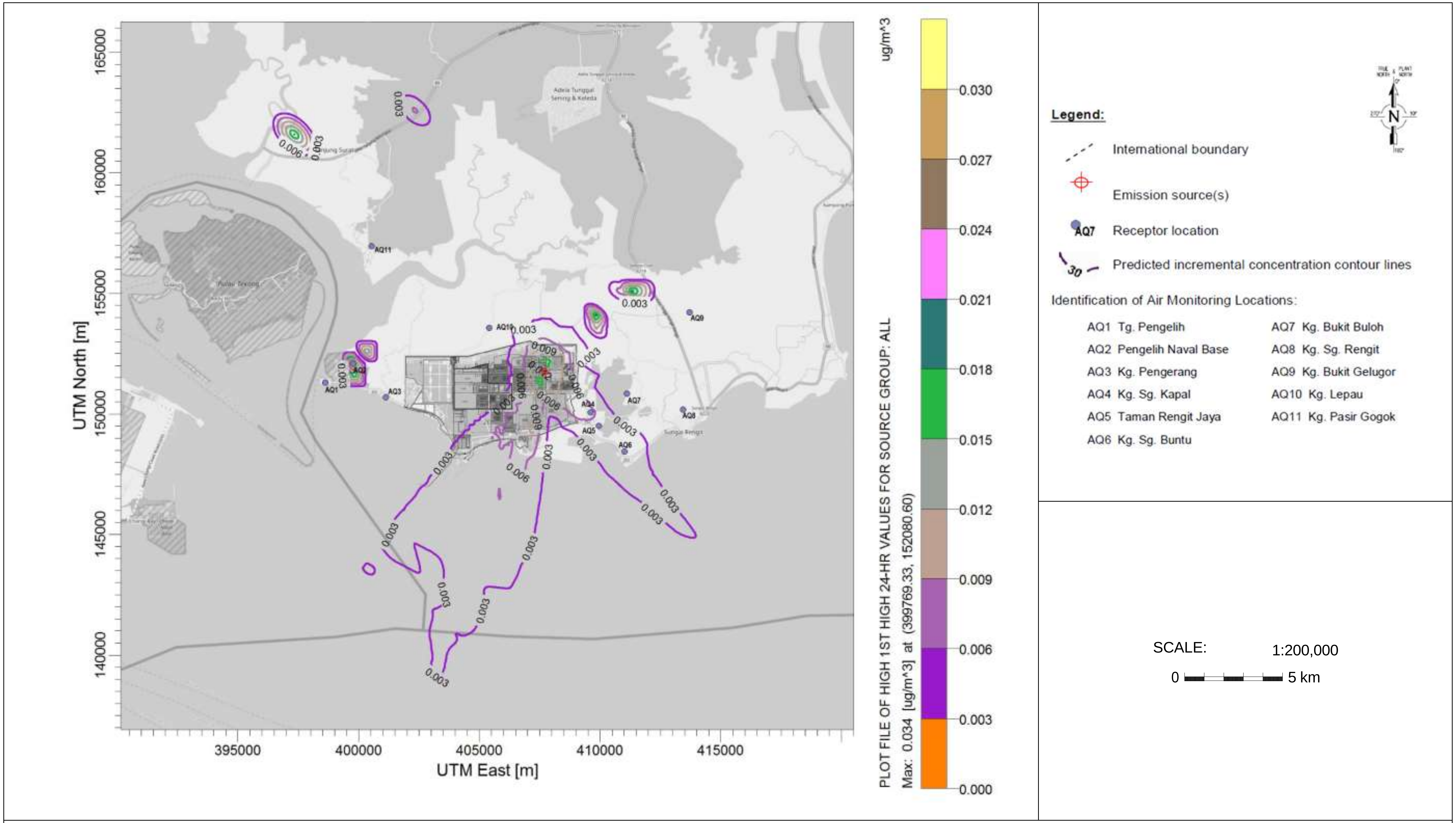

Figure 3: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for EURO5 MOGAS (Maximum 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

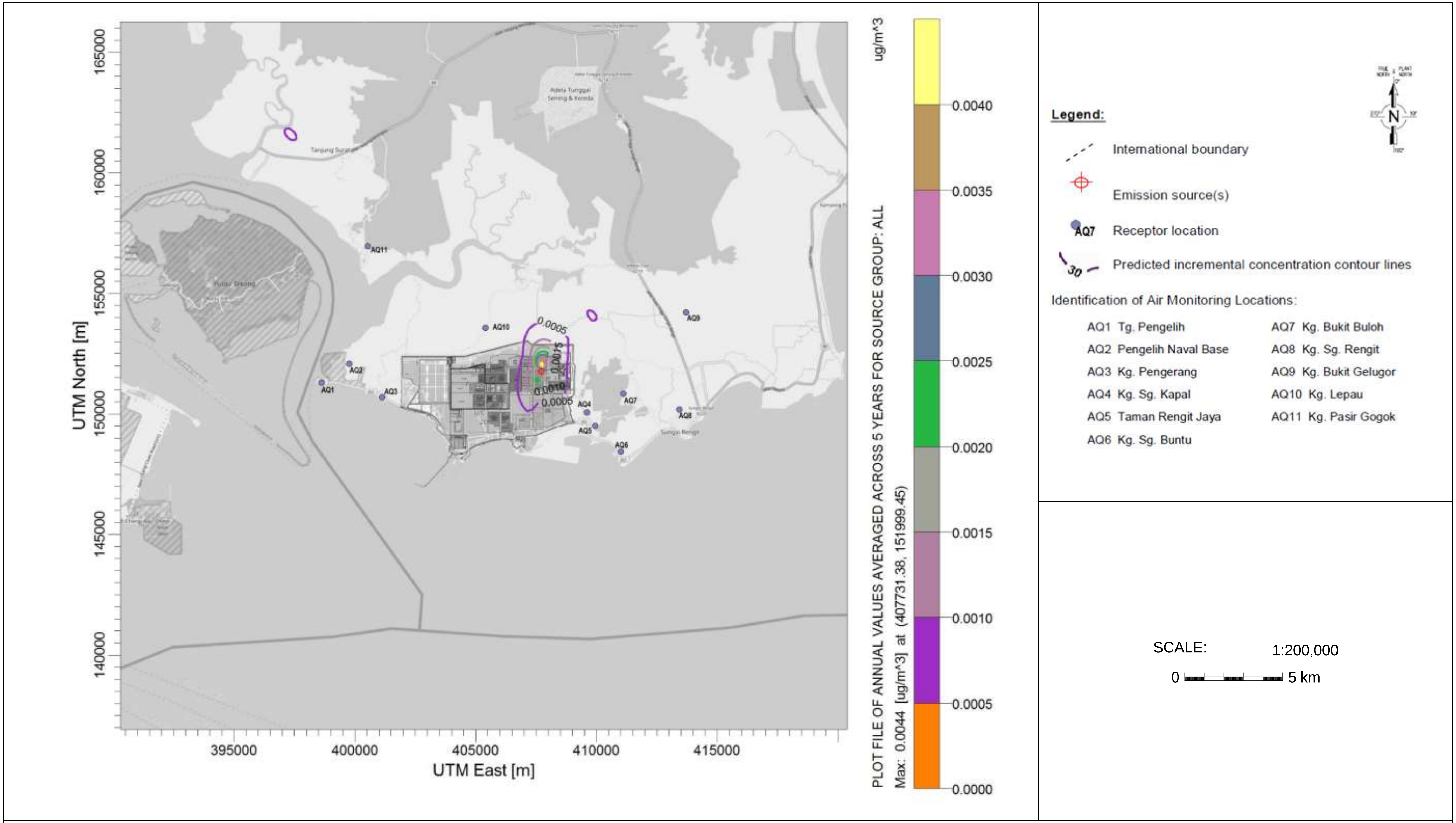

Figure 4: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for EURO5 MOGAS (Maximum Annual Average in $\mu g/m^3$)

AERMOD View - Lakes Environmental Software

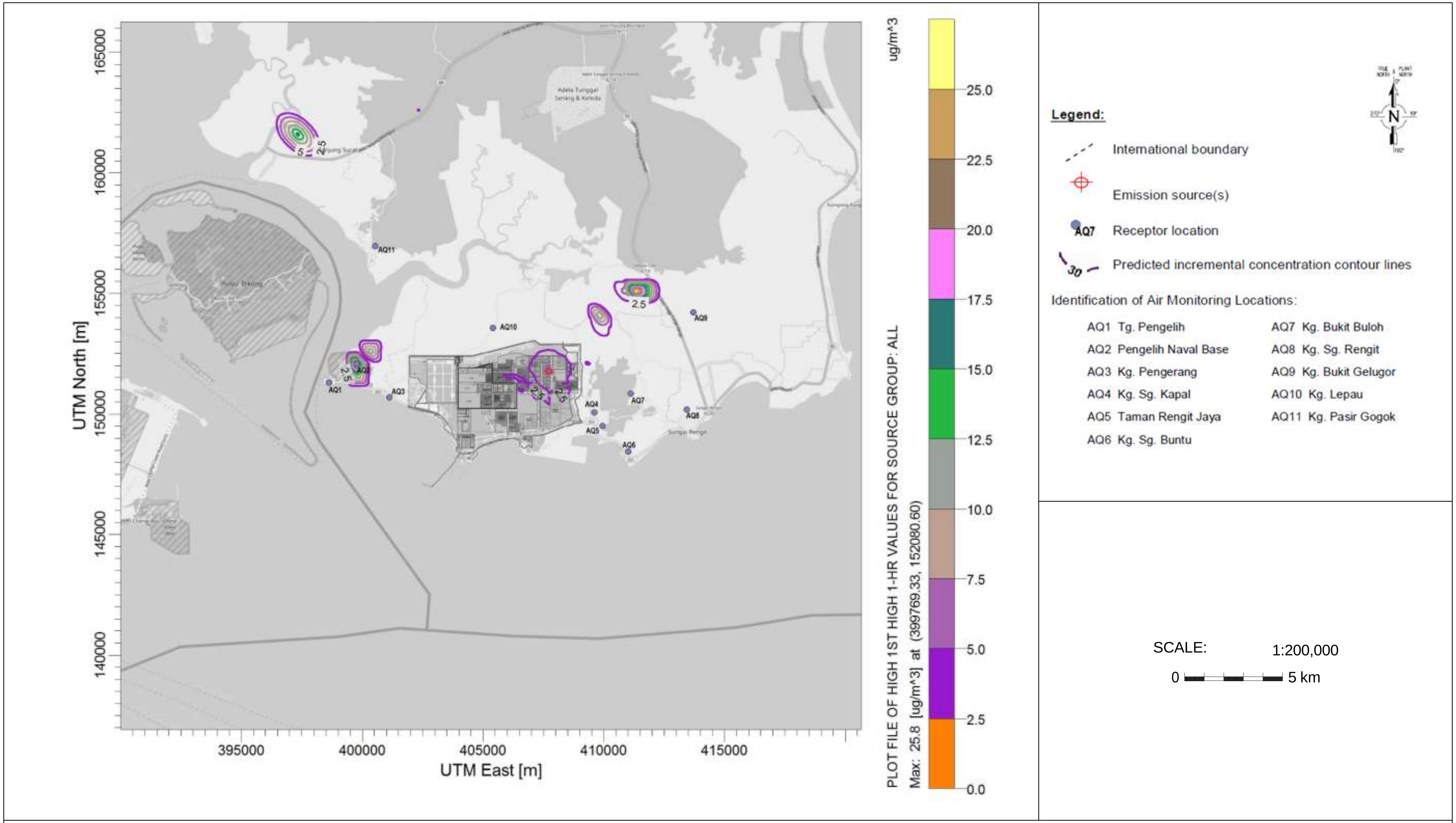

Figure 5: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for EURO5 MOGAS (Maximum 1 hour Average in µg/m^3)

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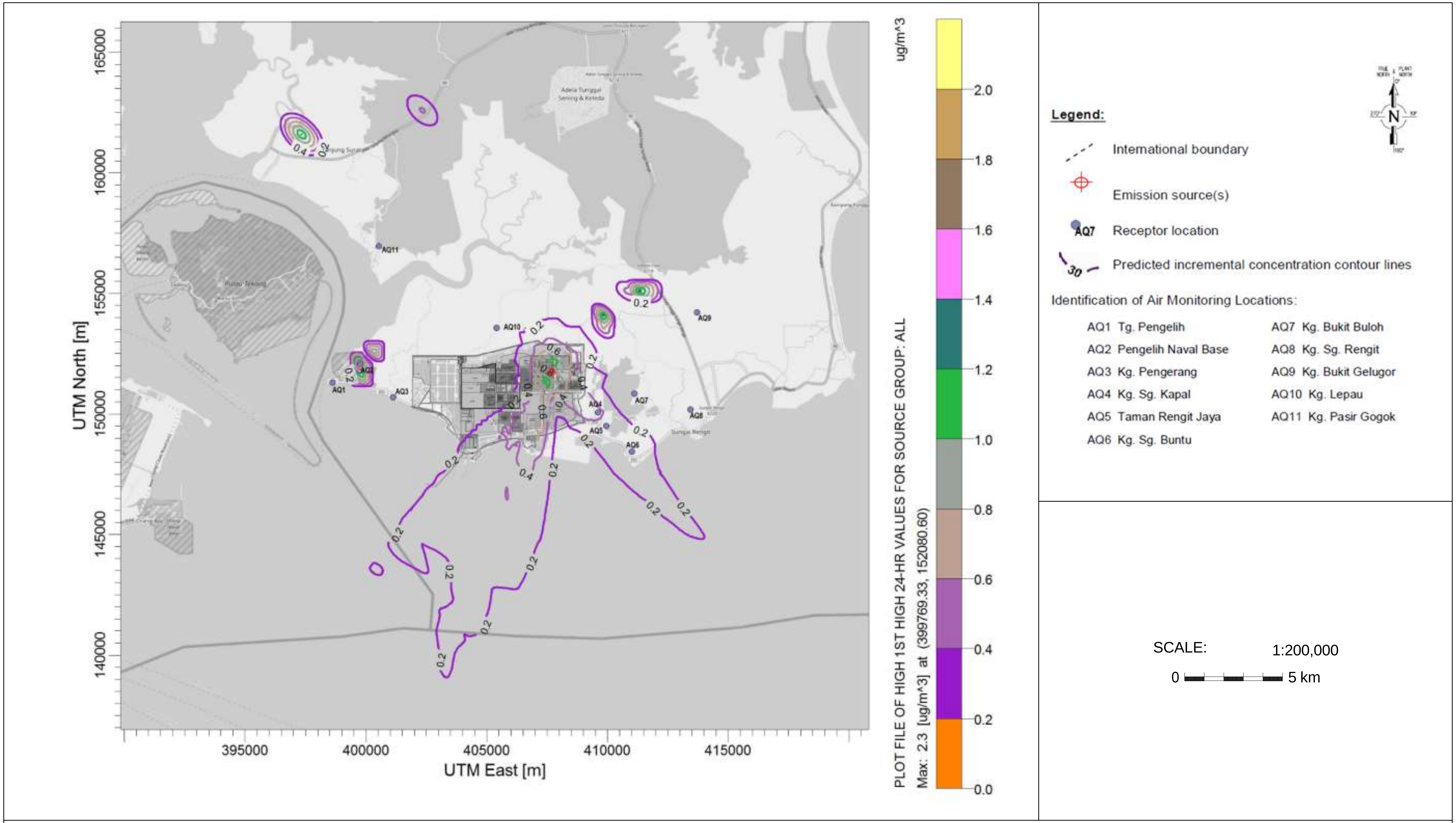

Figure 6: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for EURO5 MOGAS (Maximum 24 hours Average in µg/m^3)

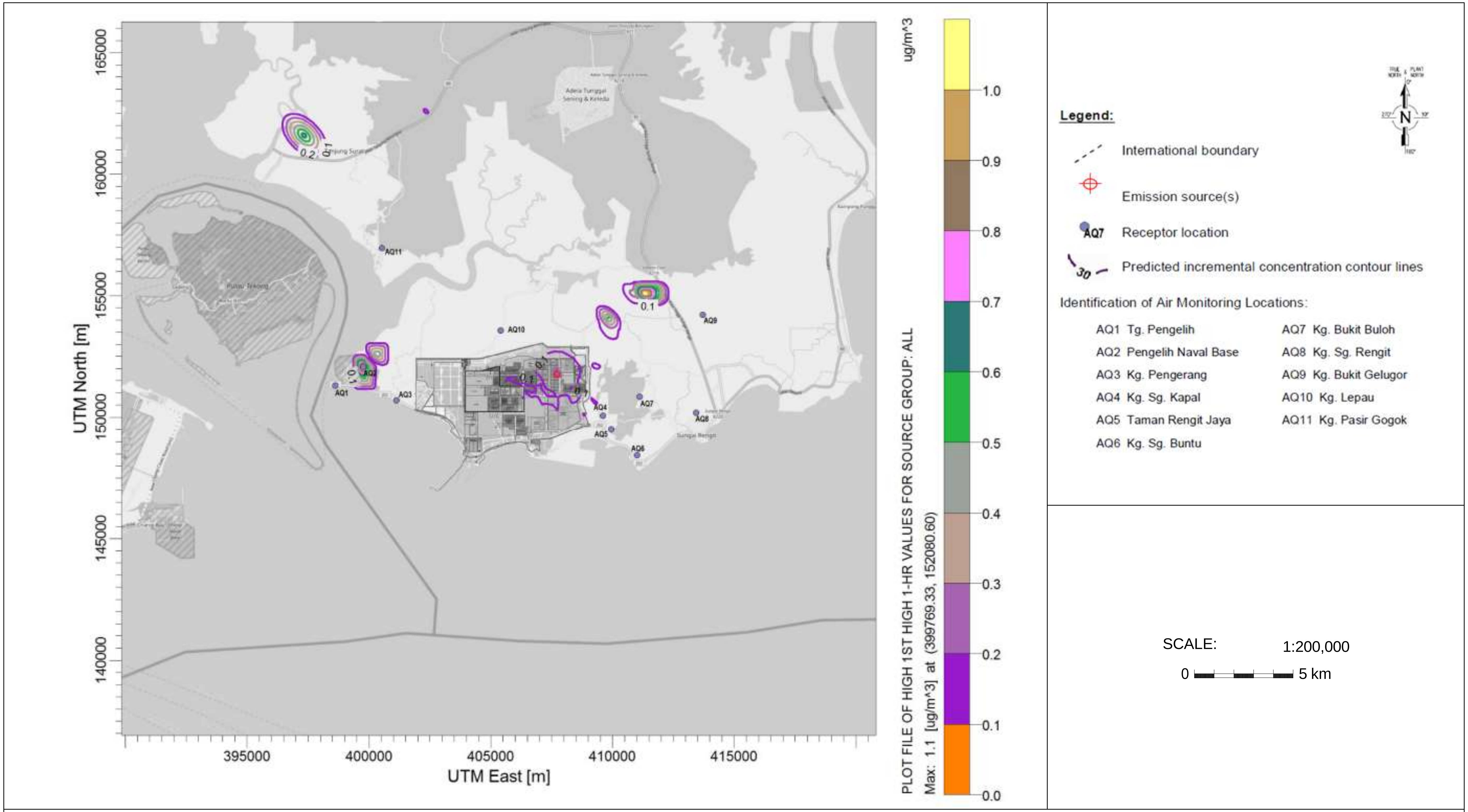

Figure 7: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for EURO5 MOGAS (Maximum 1 hour Average in μg/m^3)

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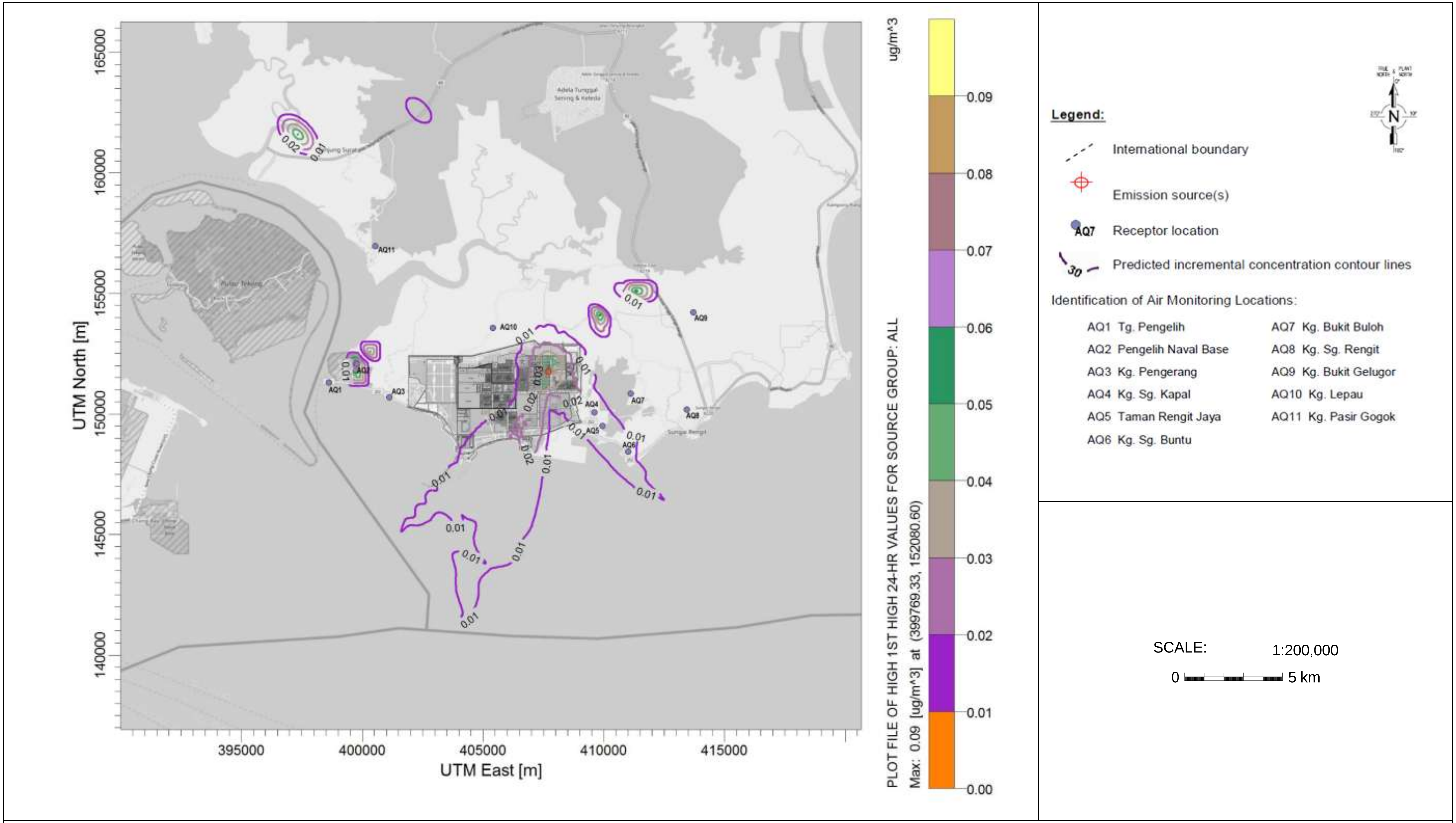

Figure 8: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for EURO5 MOGAS (Maximum 24 hours Average in µg/m^3)

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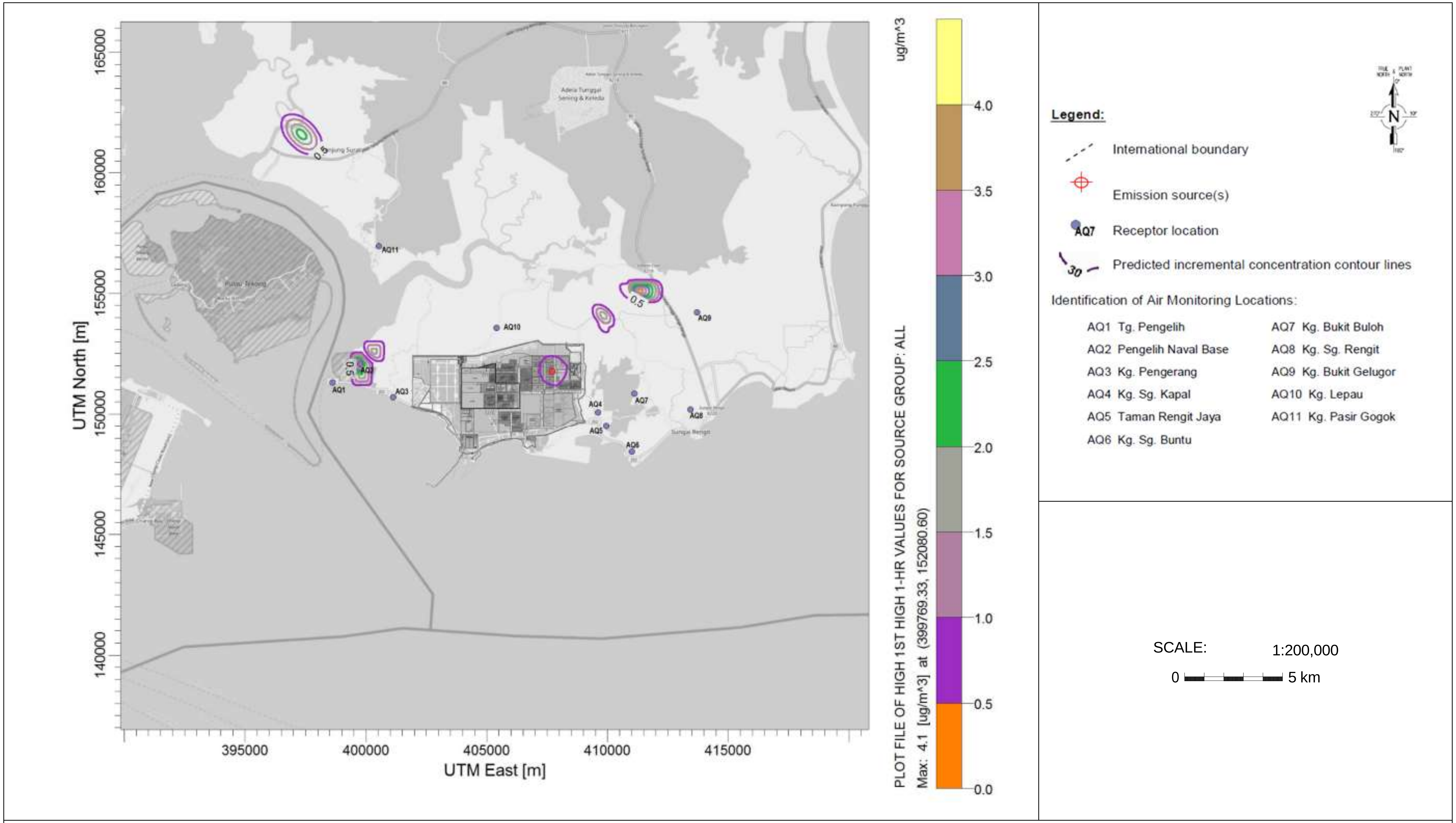

Figure 9: Predicted Incremental Ground Level Concentration for CO During Normal Operation for EURO5 MOGAS (Maximum 1 hour Average in µg/m^3)

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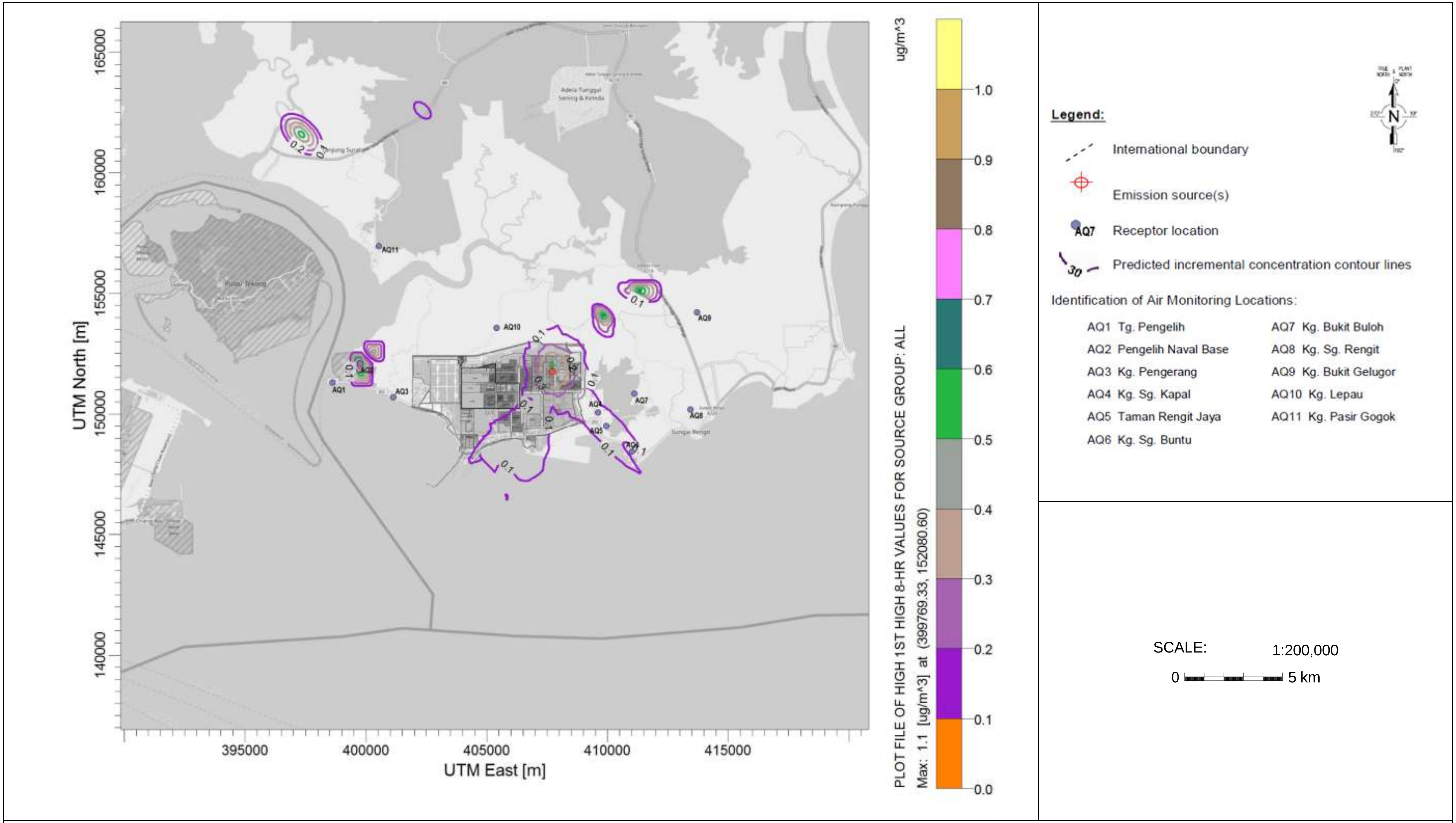

Figure 10: Predicted Incremental Ground Level Concentration for CO During Normal Operation for EURO5 MOGAS (Maximum 8 hours Average in µg/m^3)

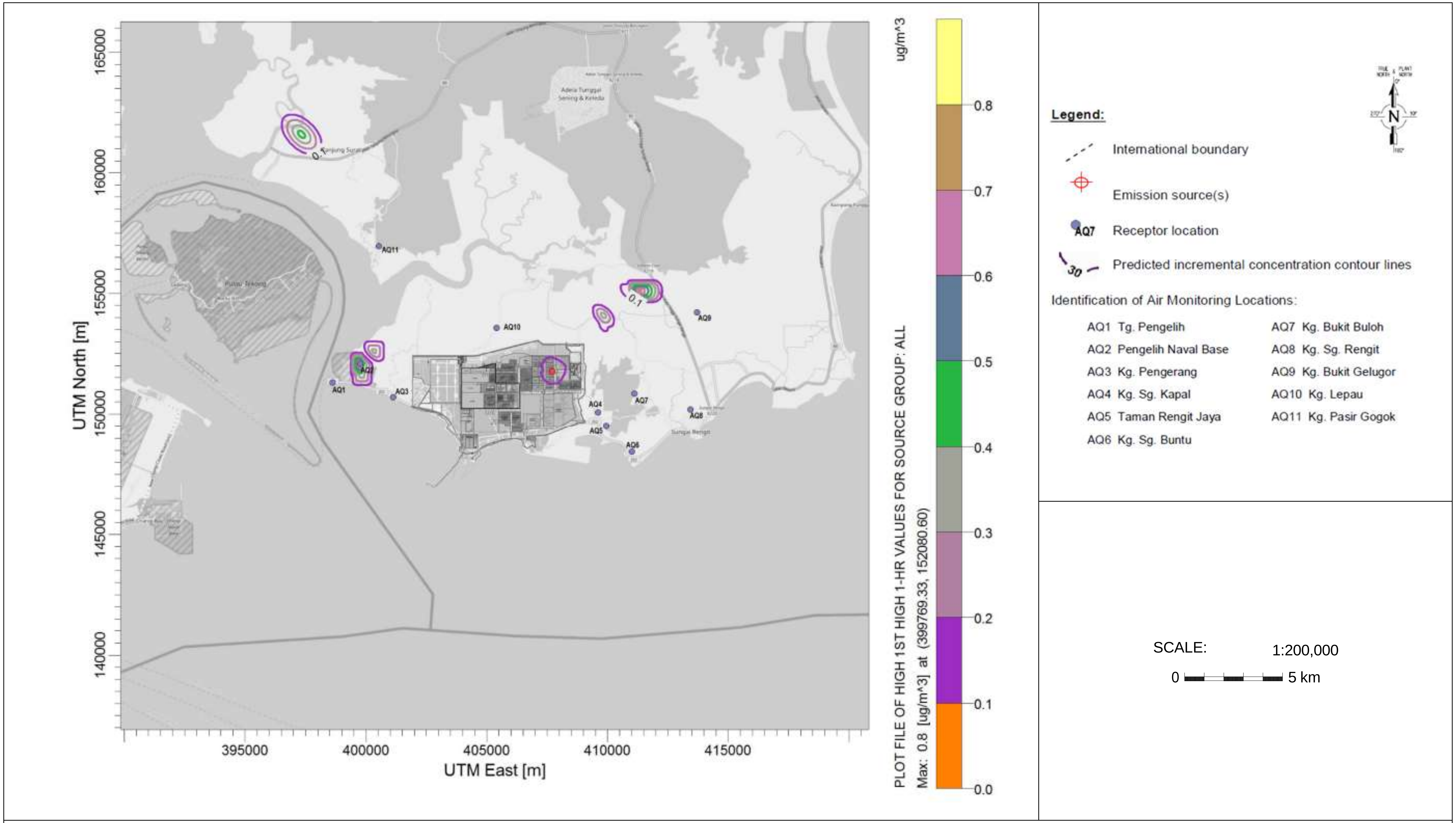

Figure 11: Predicted Incremental Ground Level Concentration for NMVOC During Normal Operation for EURO5 MOGAS (Maximum 1 hour Average in µg/m³)

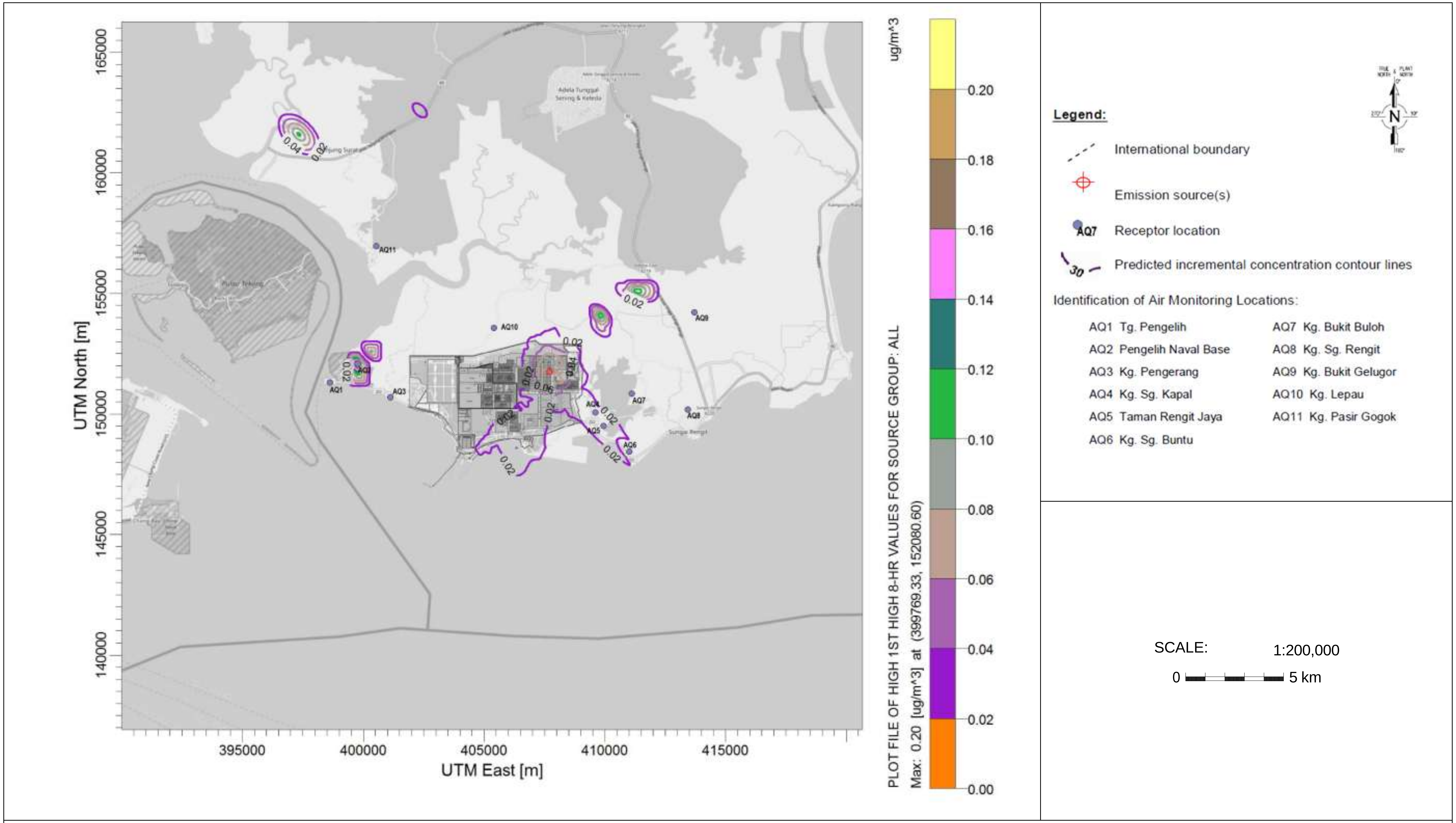

Figure 12: Predicted Incremental Ground Level Concentration for NMVOC During Normal Operation for EURO5 MOGAS (Maximum 8 hours Average in µg/m^3)

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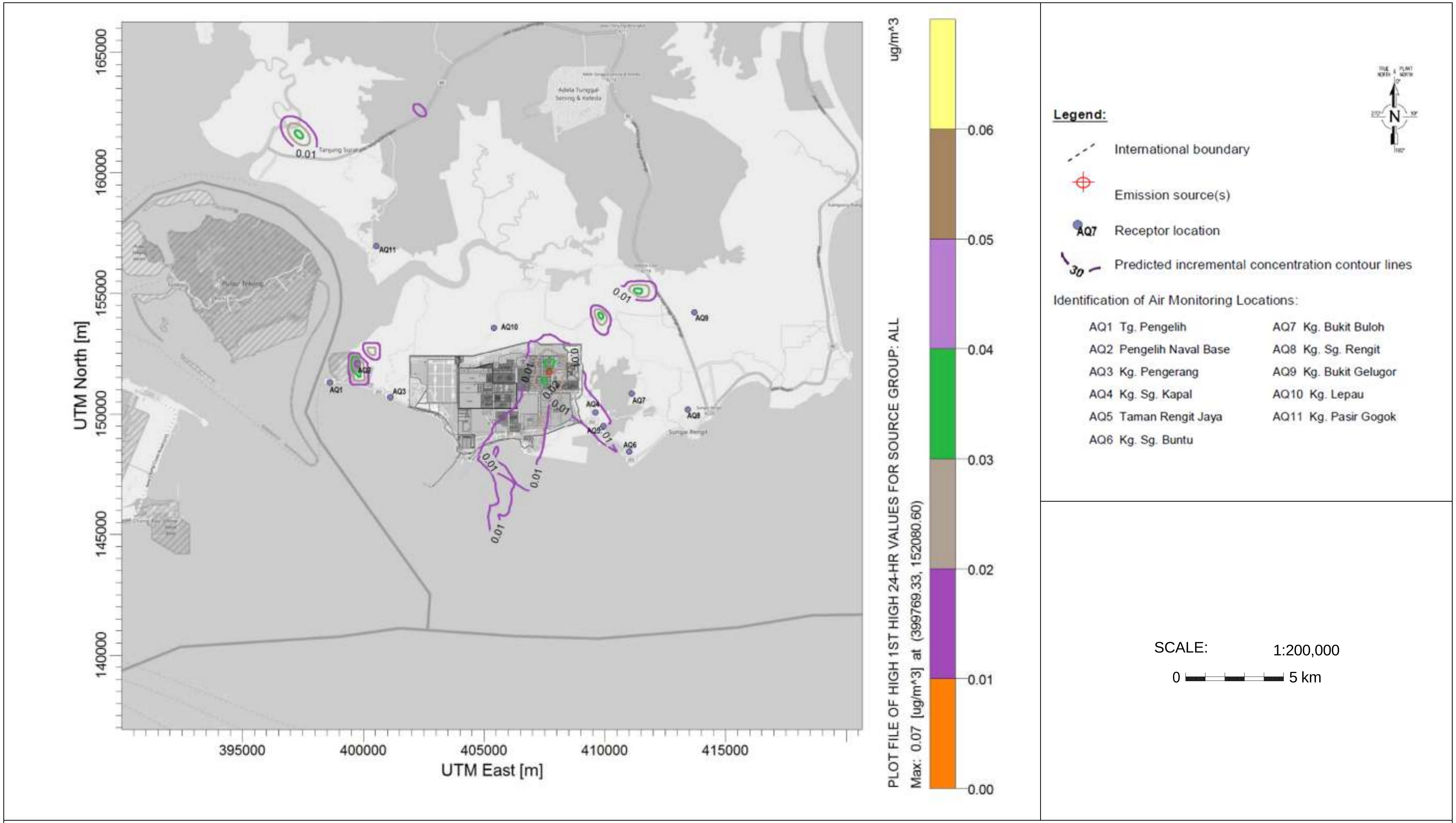


Figure 13: Predicted Incremental Ground Level Concentration for NMVOC During Normal Operation for EURO5 MOGAS (Maximum 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

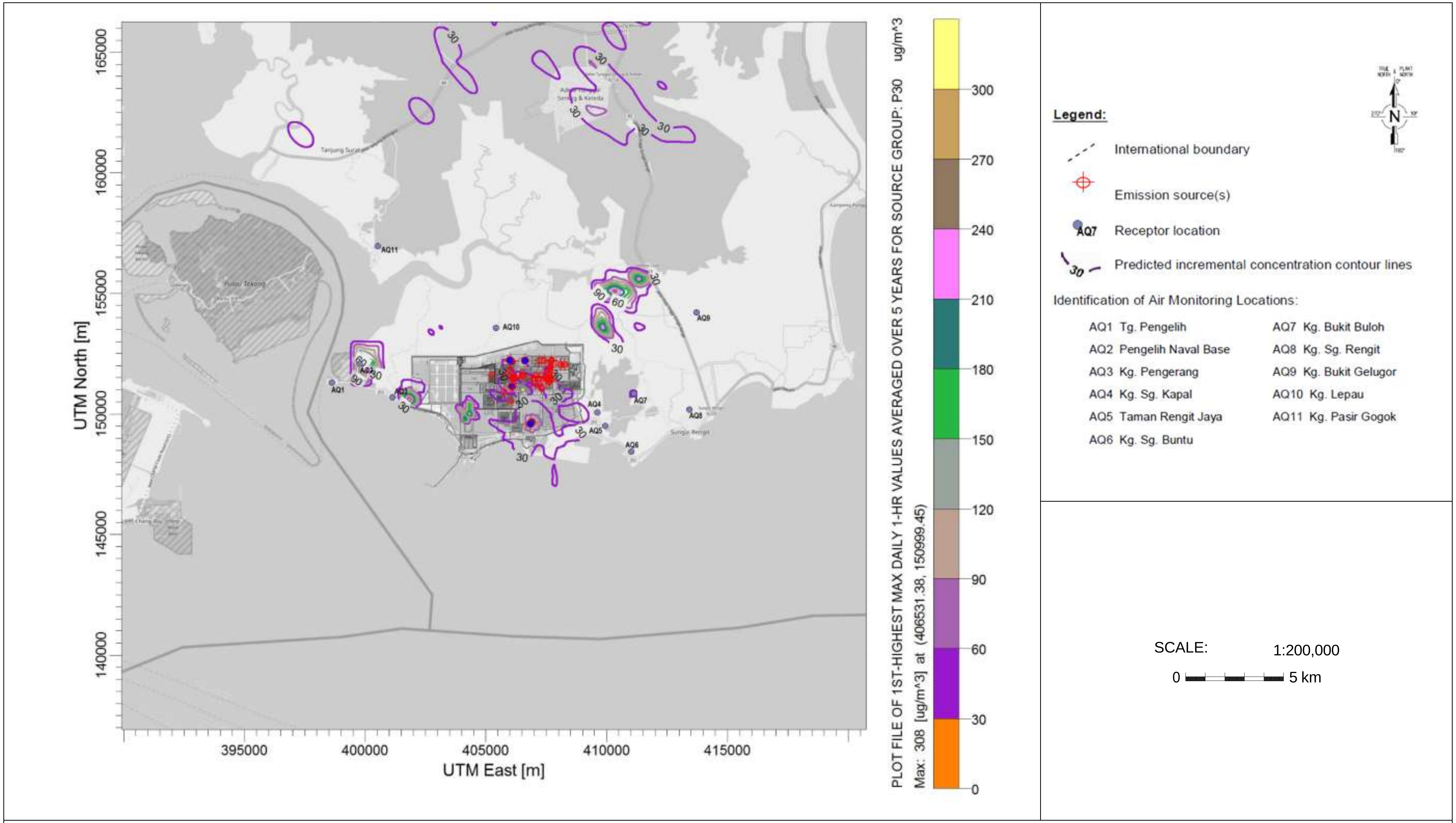


Figure 14: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Abnormal Operation for Olefin Storage (Maximum 1 hour Average in µg/m³)

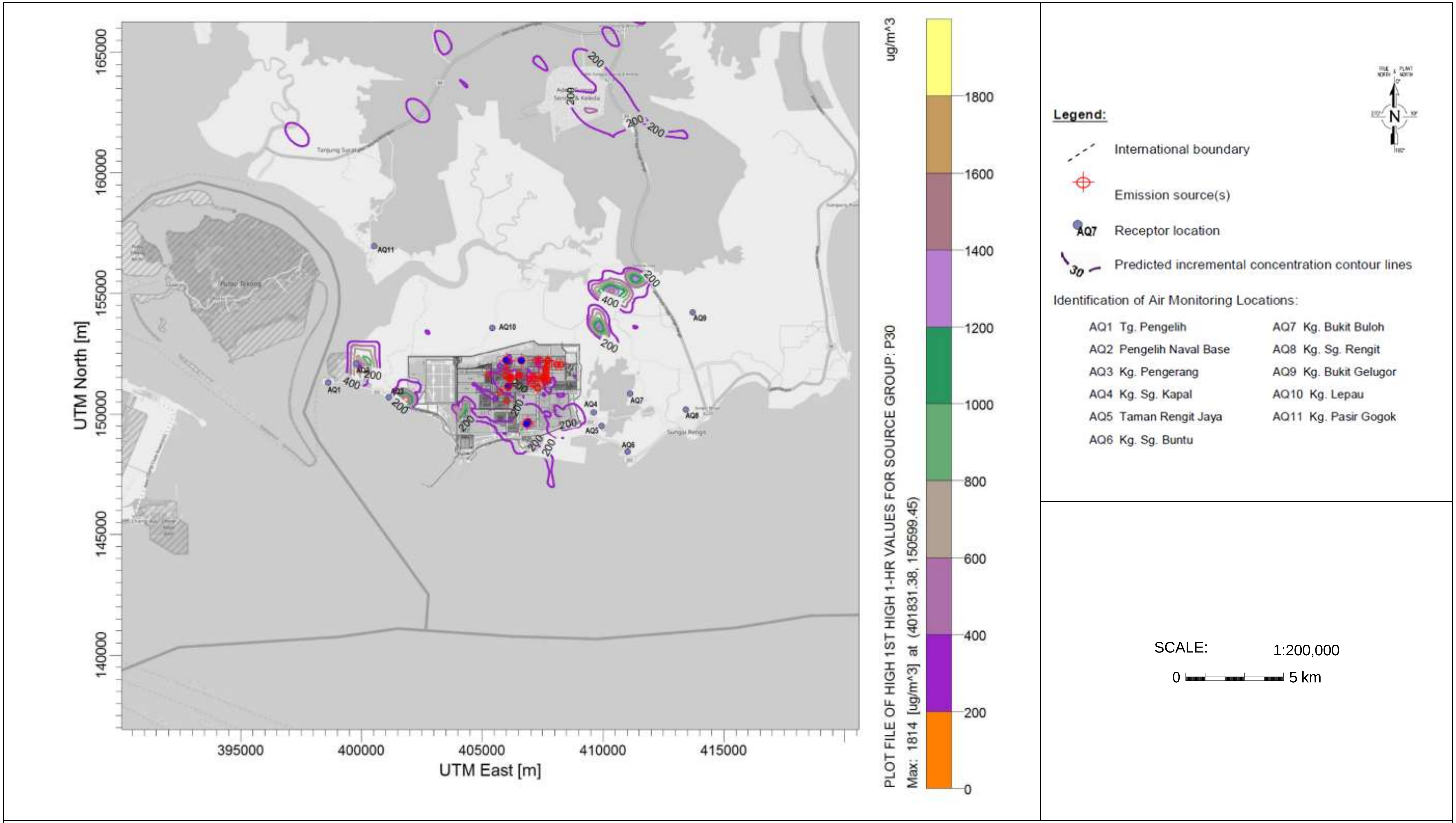


Figure 15: Predicted Incremental Ground Level Concentration for CO During Abnormal Operation for Olefin Storage (Maximum 1 hour Average in µg/m^3)

SUB-APPENDIX 1B: CUMULATIVE AIR DISPERSION CONCENTRATION CONTOUR

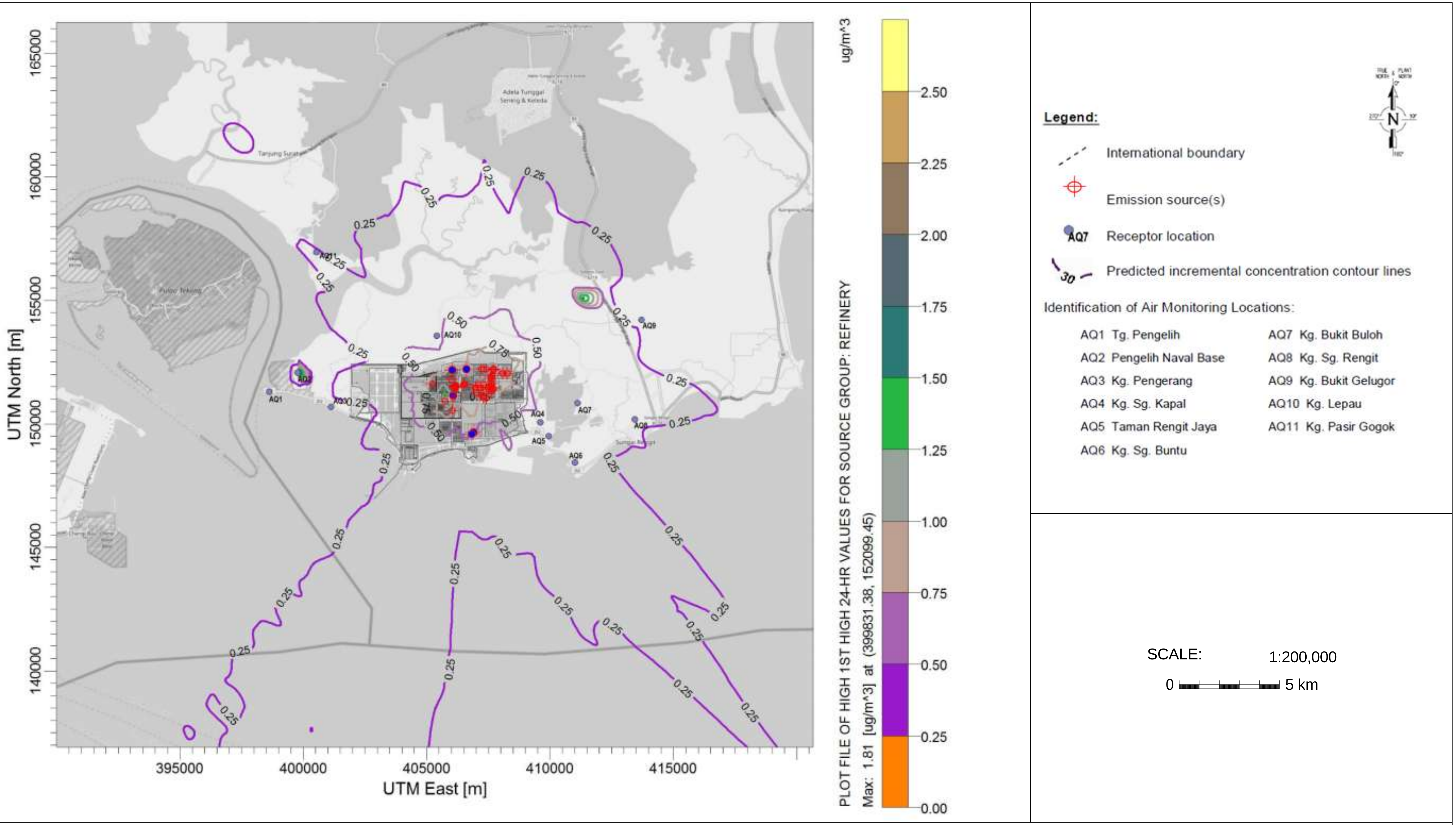


Figure 1:Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

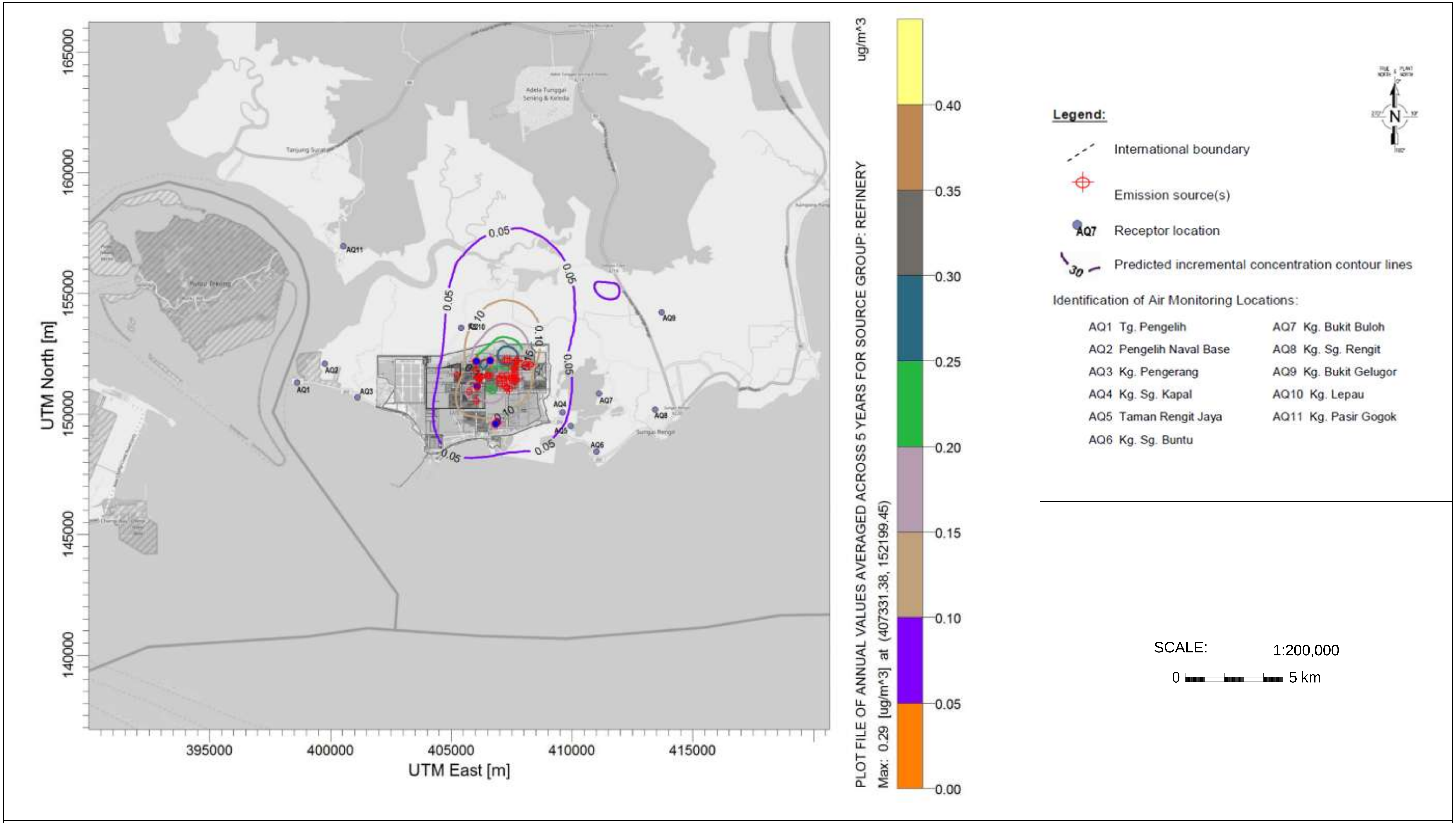


Figure 2: Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for Cumulative Refinery Cracker Complex (Maximum Annual Average in µg/m^3)

AERMOD View - Lakes Environmental Software

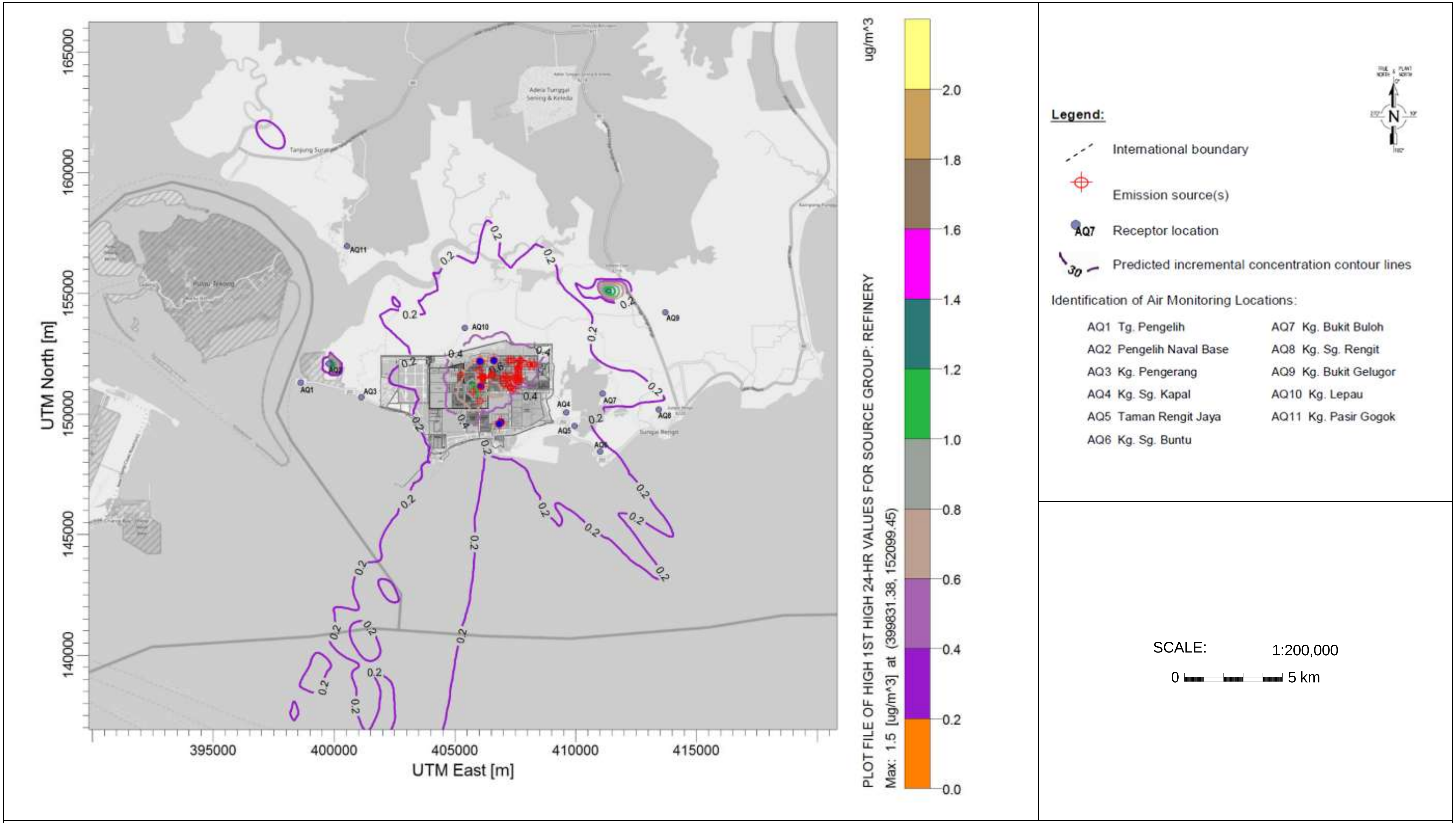


Figure 3: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 24 hours Average in µg/m³)

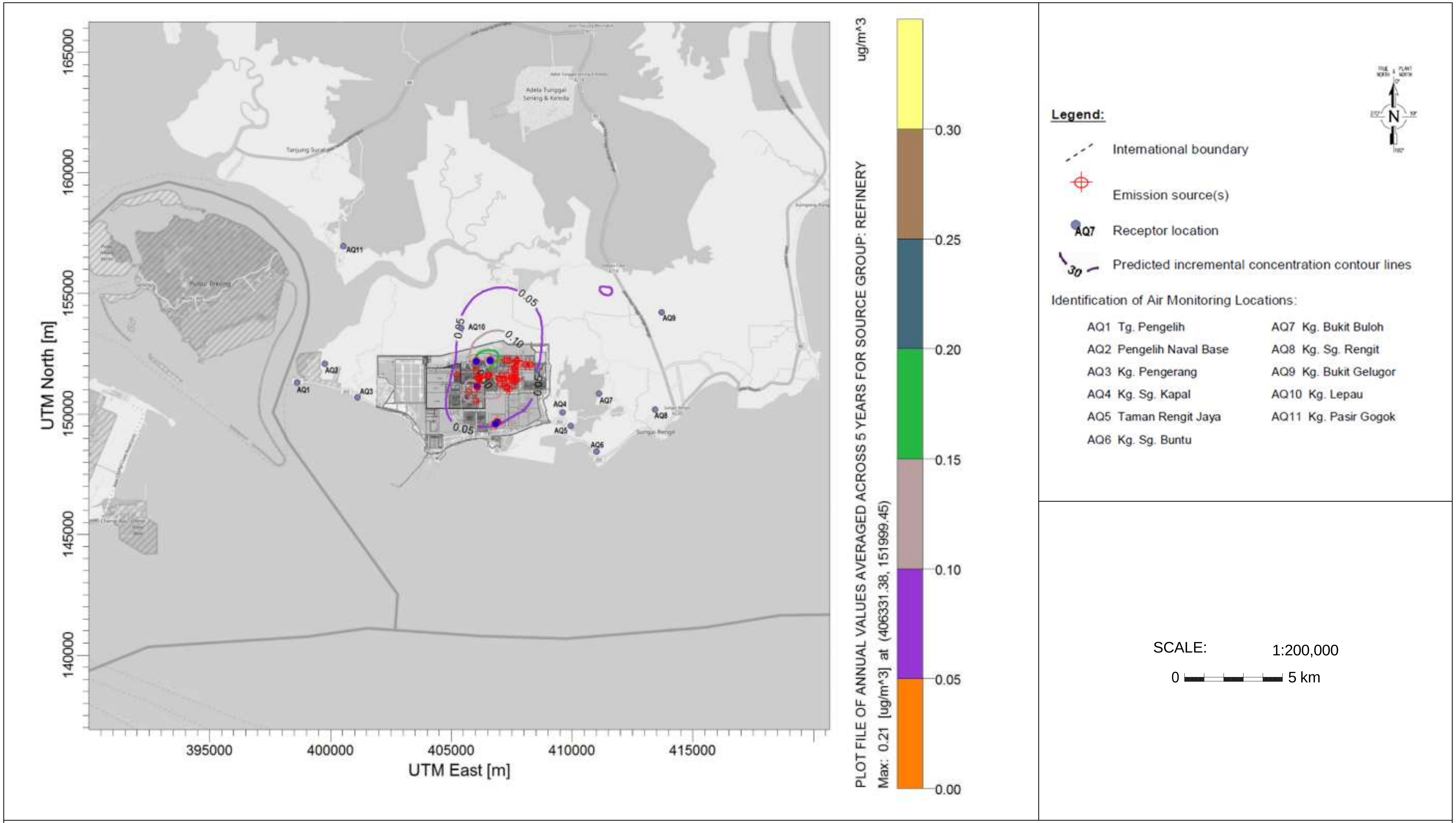


Figure 4: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for Cumulative Refinery Cracker Complex (Maximum Annual Average in µg/m^3)

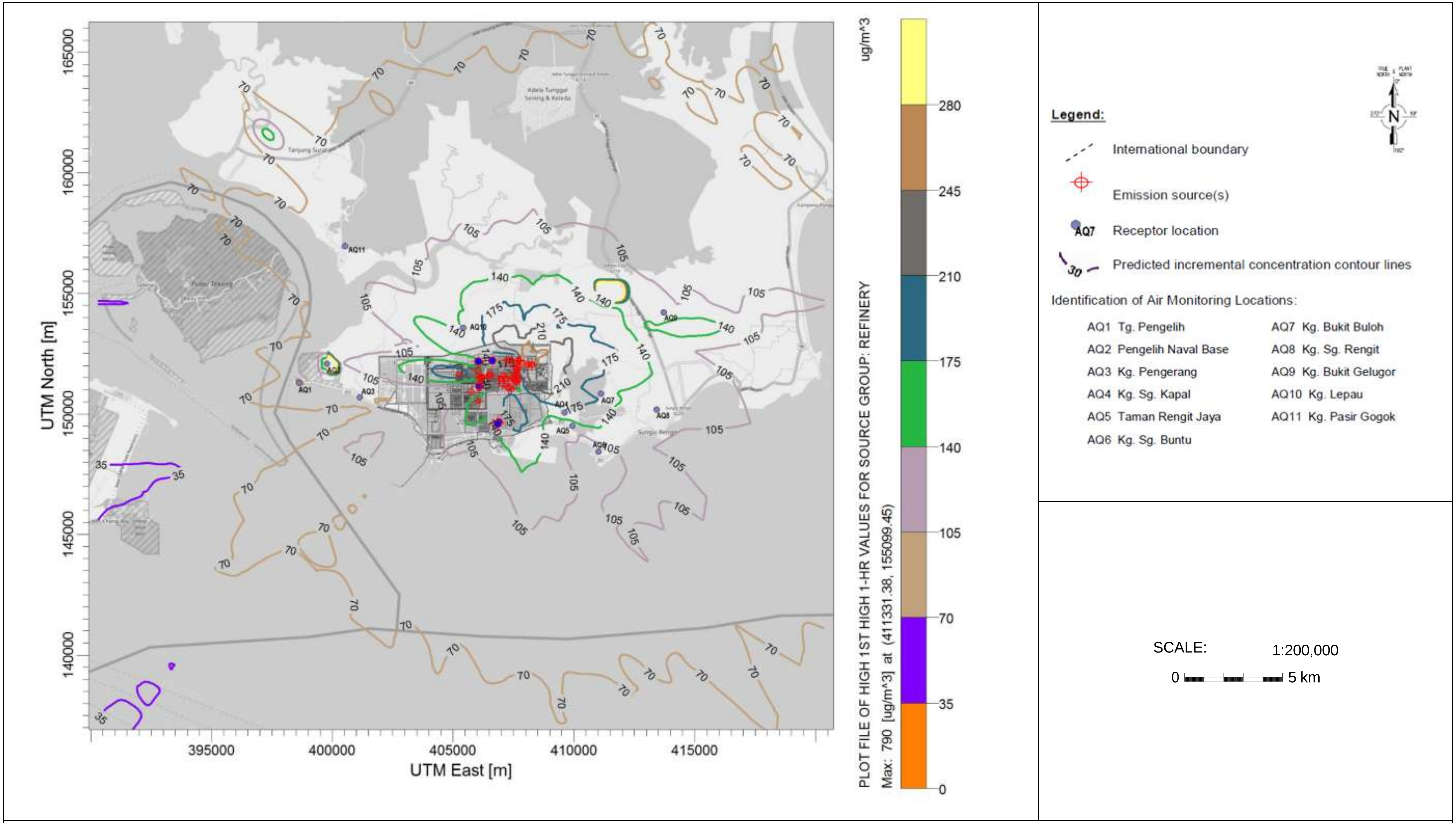


Figure 5: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

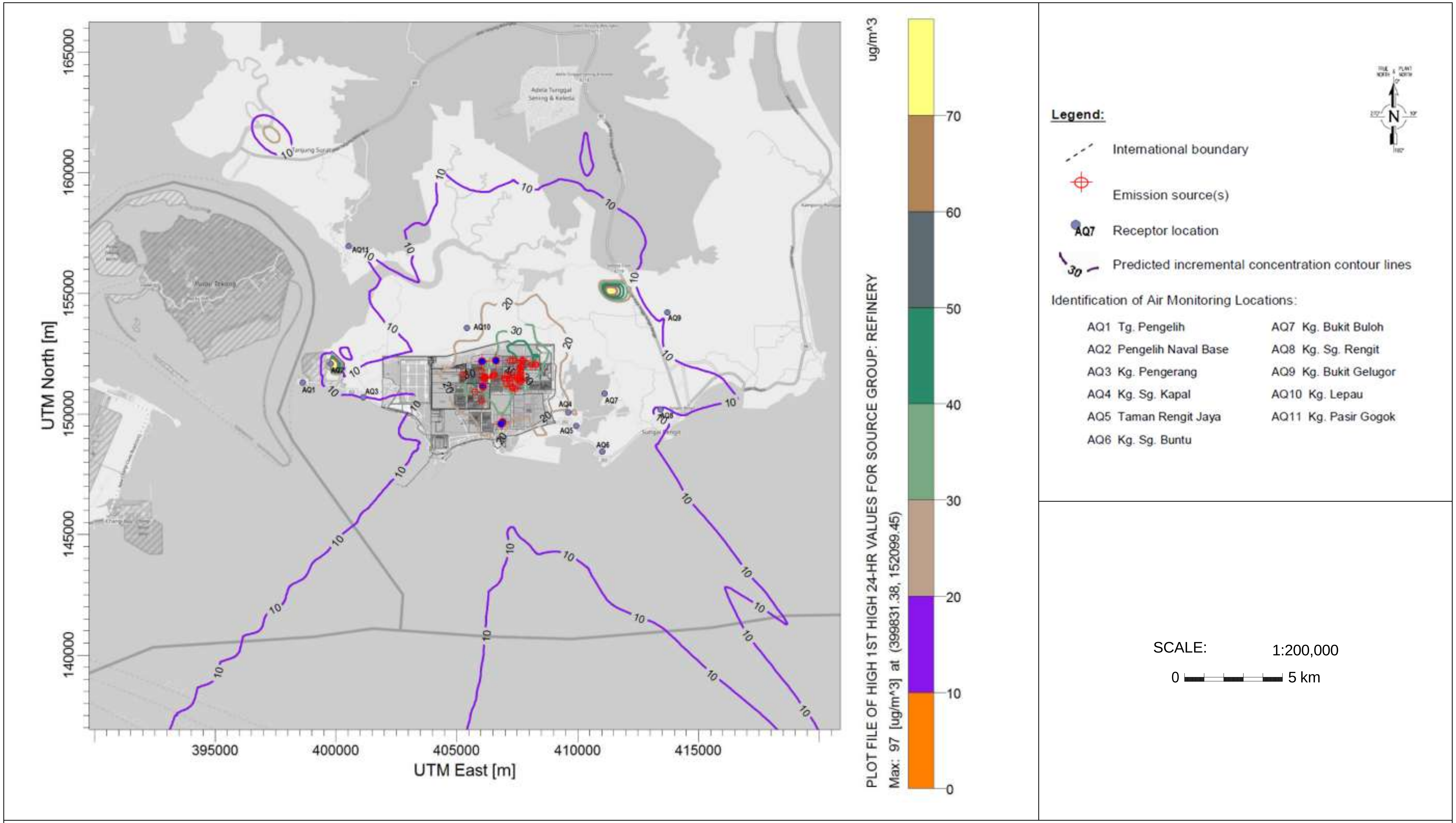


Figure 6: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 24 hours Average in µg/m^3)

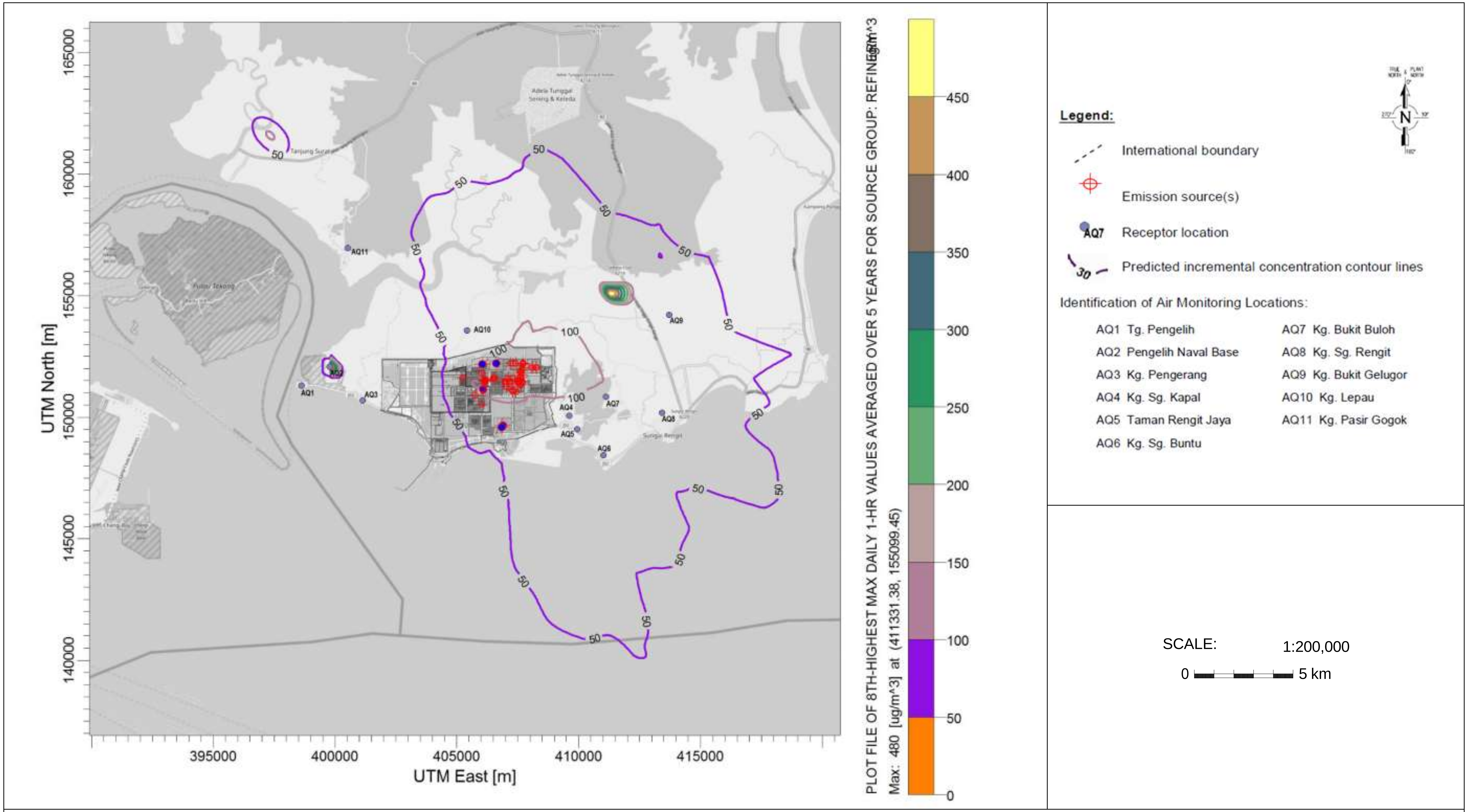


Figure 7: Predicted Incremental Ground Level Concentration for NO_2 Tier3 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

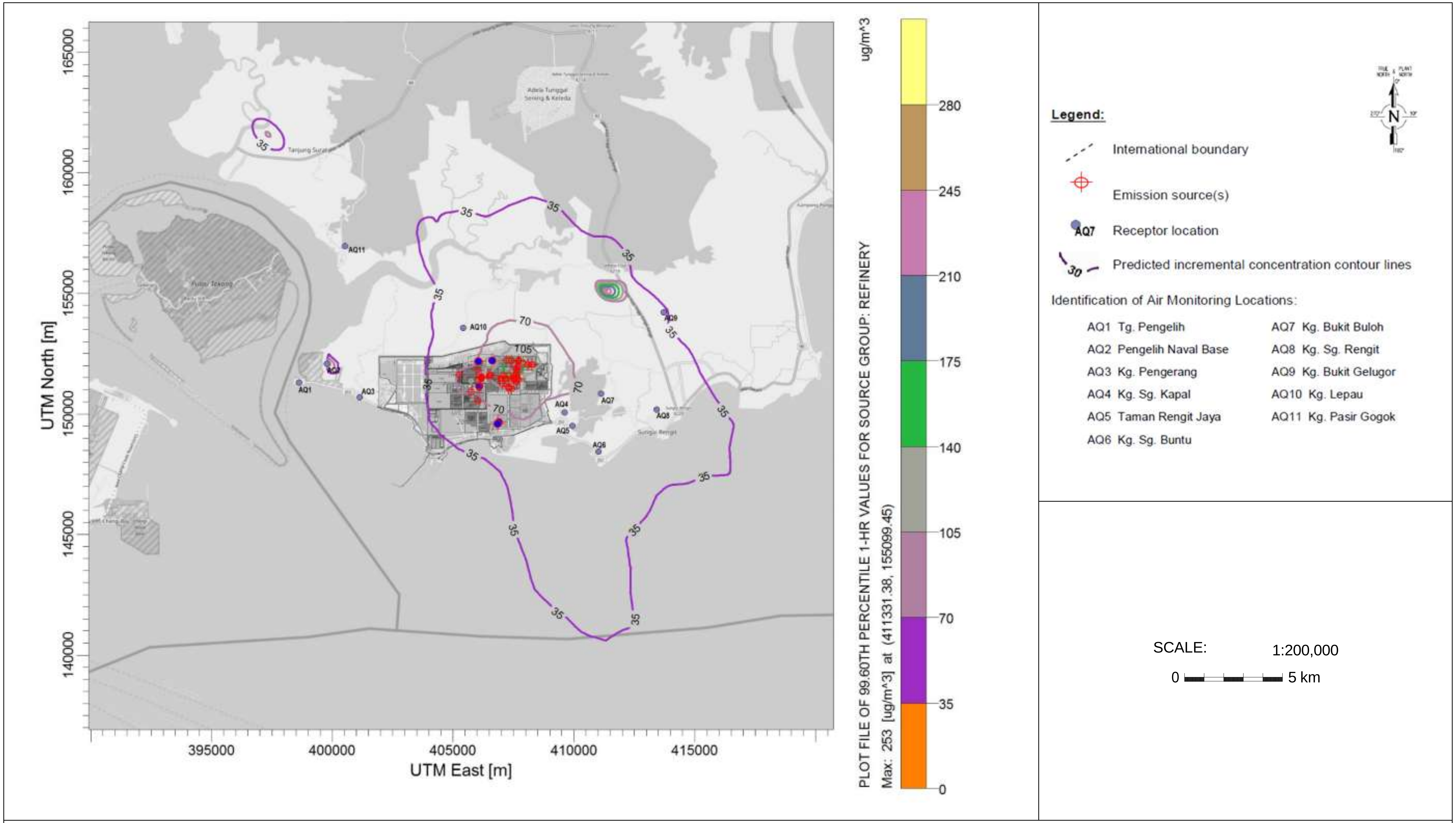


Figure 8: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 99.6 Percentile 1 hour Average in µg/m³)

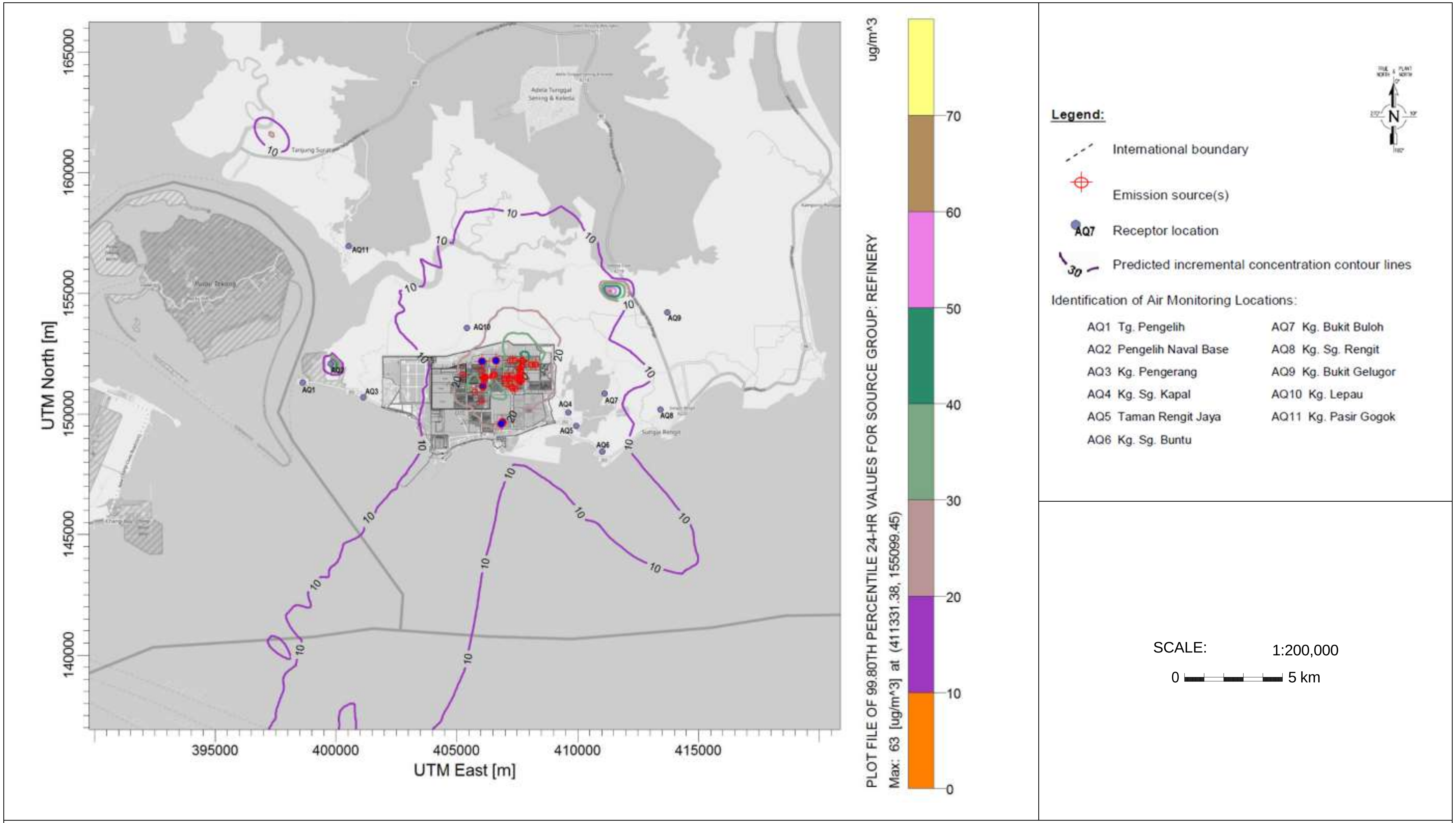
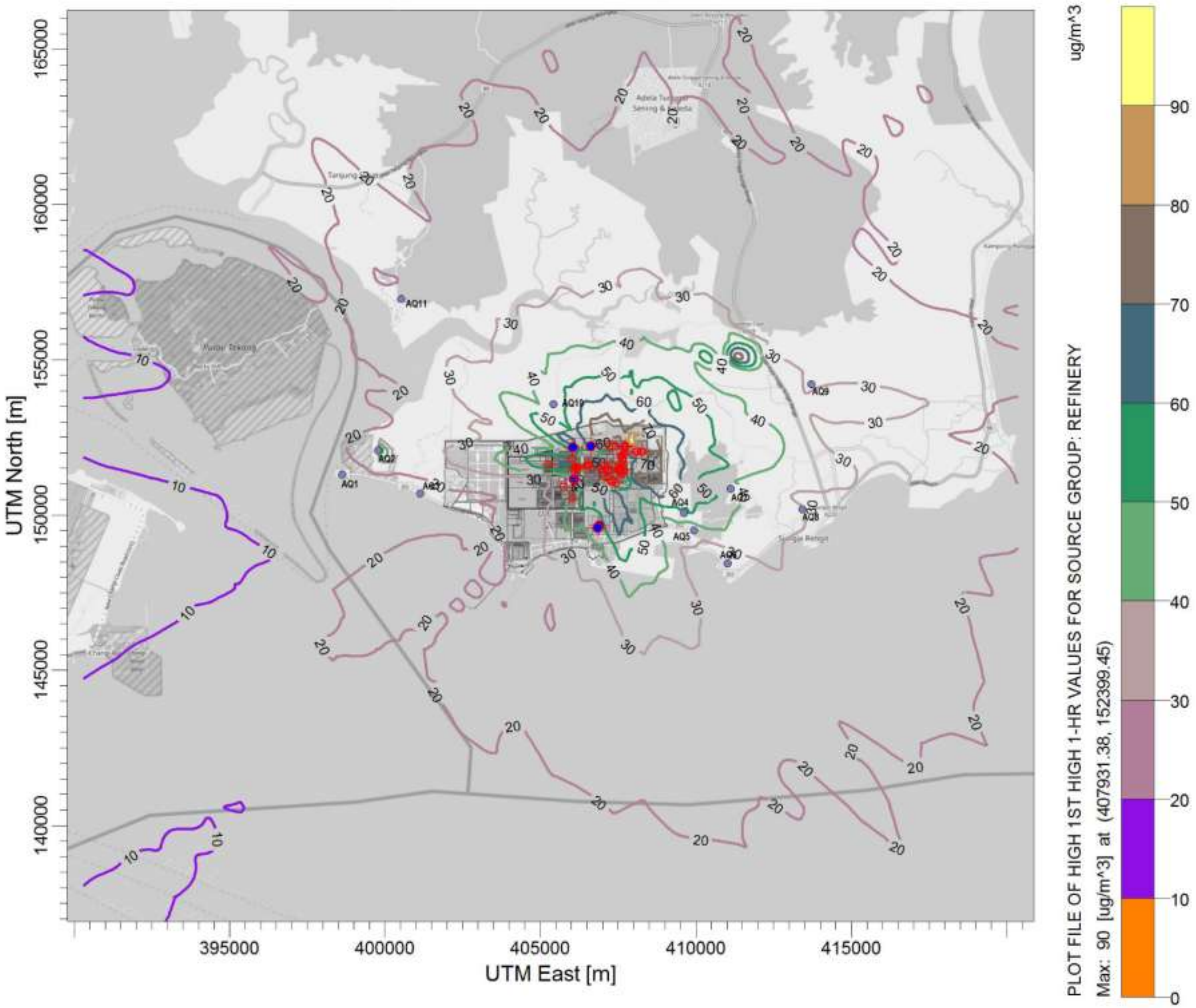


Figure 9: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 99.8 Percentile 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software



Legend:

International boundary

Emission source(s)

Receptor location

Predicted incremental concentration contour lines

Identification of Air Monitoring Locations:

AQ1 Tg. Pengelih	AQ7 Kg. Bukit Buloh
AQ2 Pengelih Naval Base	AQ8 Kg. Sg. Rengit
AQ3 Kg. Pengerang	AQ9 Kg. Bukit Gelugor
AQ4 Kg. Sg. Kapal	AQ10 Kg. Lepau
AQ5 Taman Rengit Jaya	AQ11 Kg. Pasir Gogok
AQ6 Kg. Sg. Buntu	

SCALE: 1:200,000

0 — 5 km

Figure 10: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

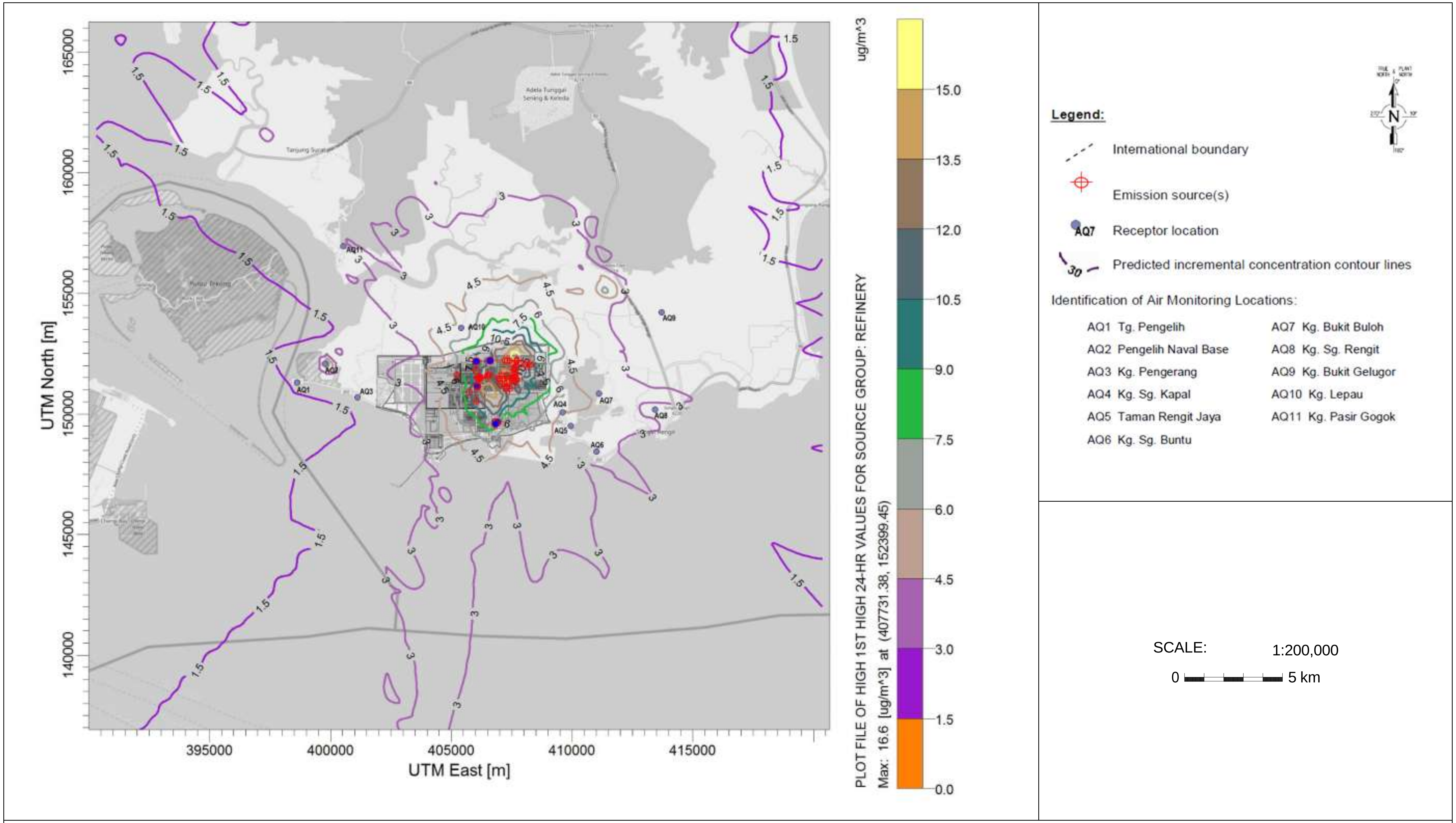


Figure 11: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

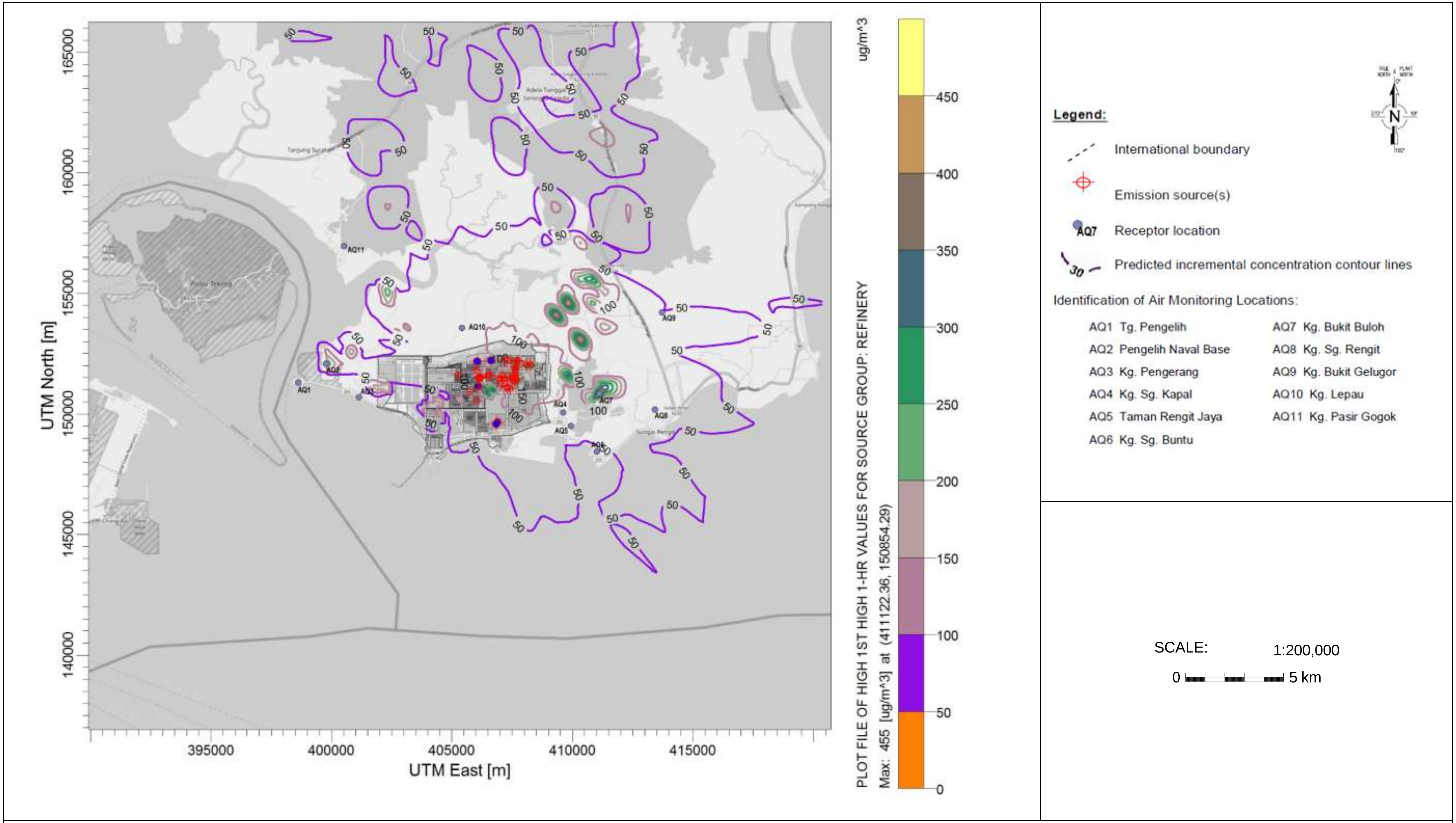


Figure 12: Predicted Incremental Ground Level Concentration for CO During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

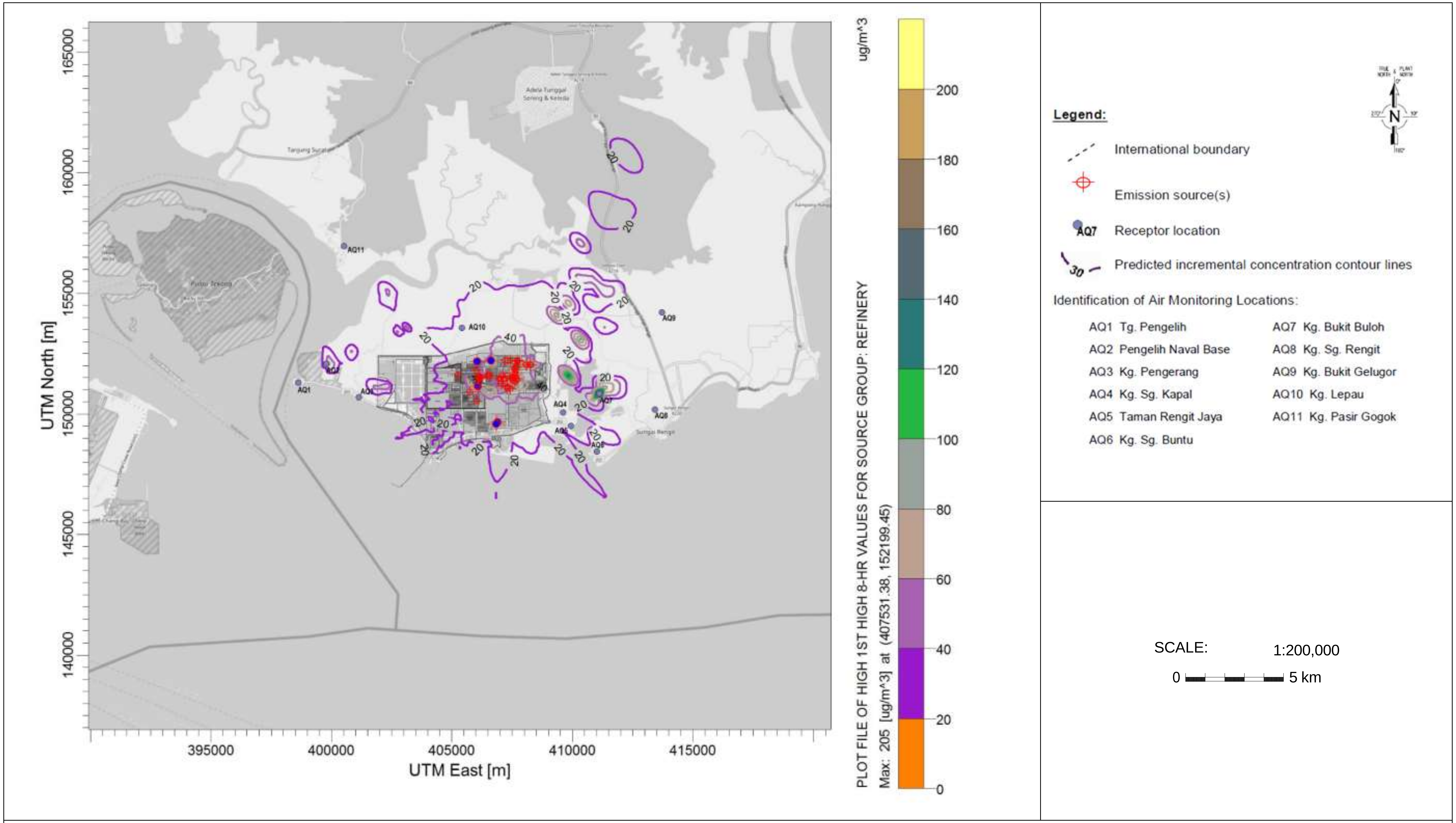


Figure 13: Predicted Incremental Ground Level Concentration for CO During Normal Operation for Cumulative Refinery Cracker Complex (Maximum 8 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

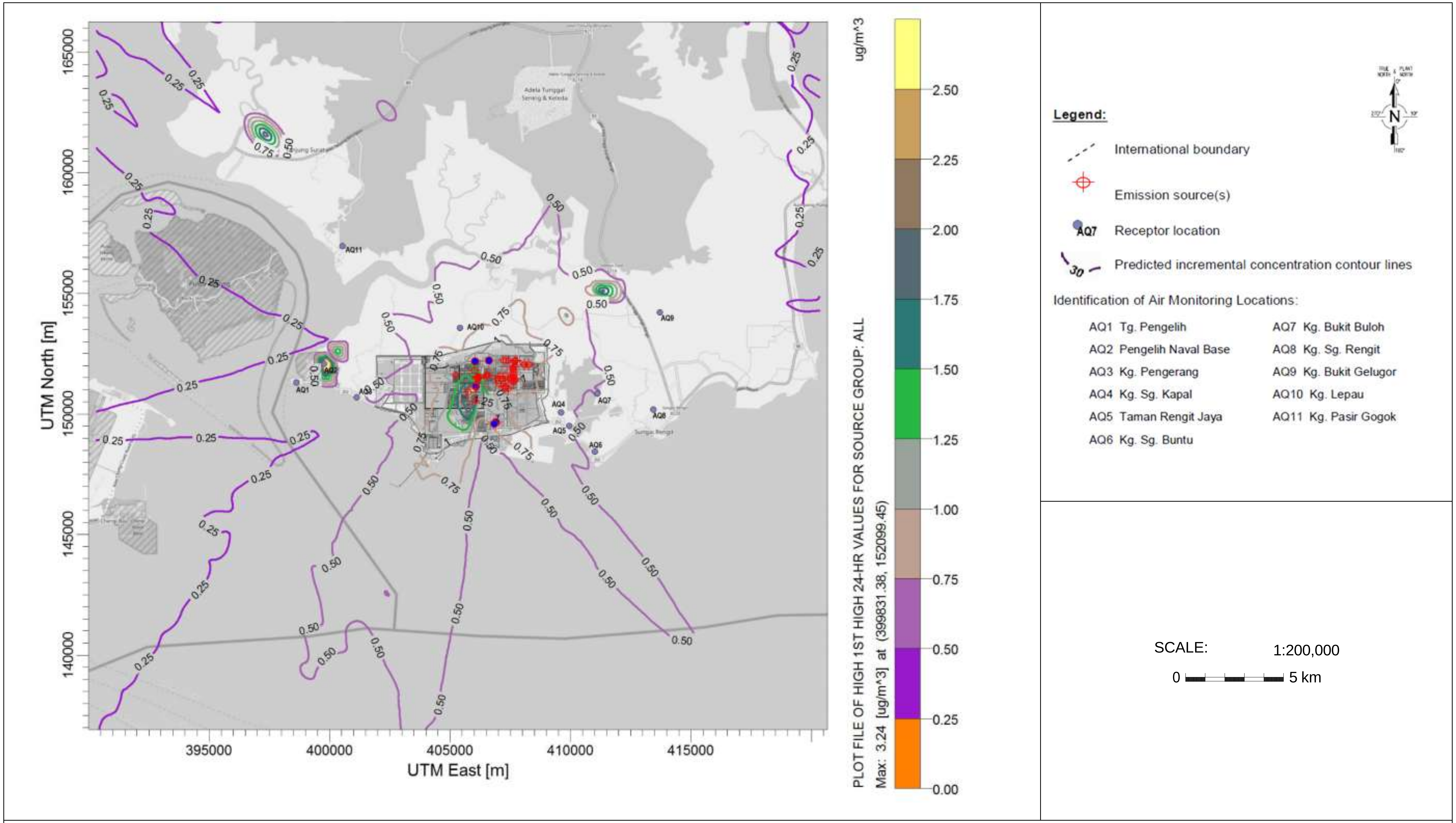


Figure 14: Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for Cumulative RAPID Complex (Maximum 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

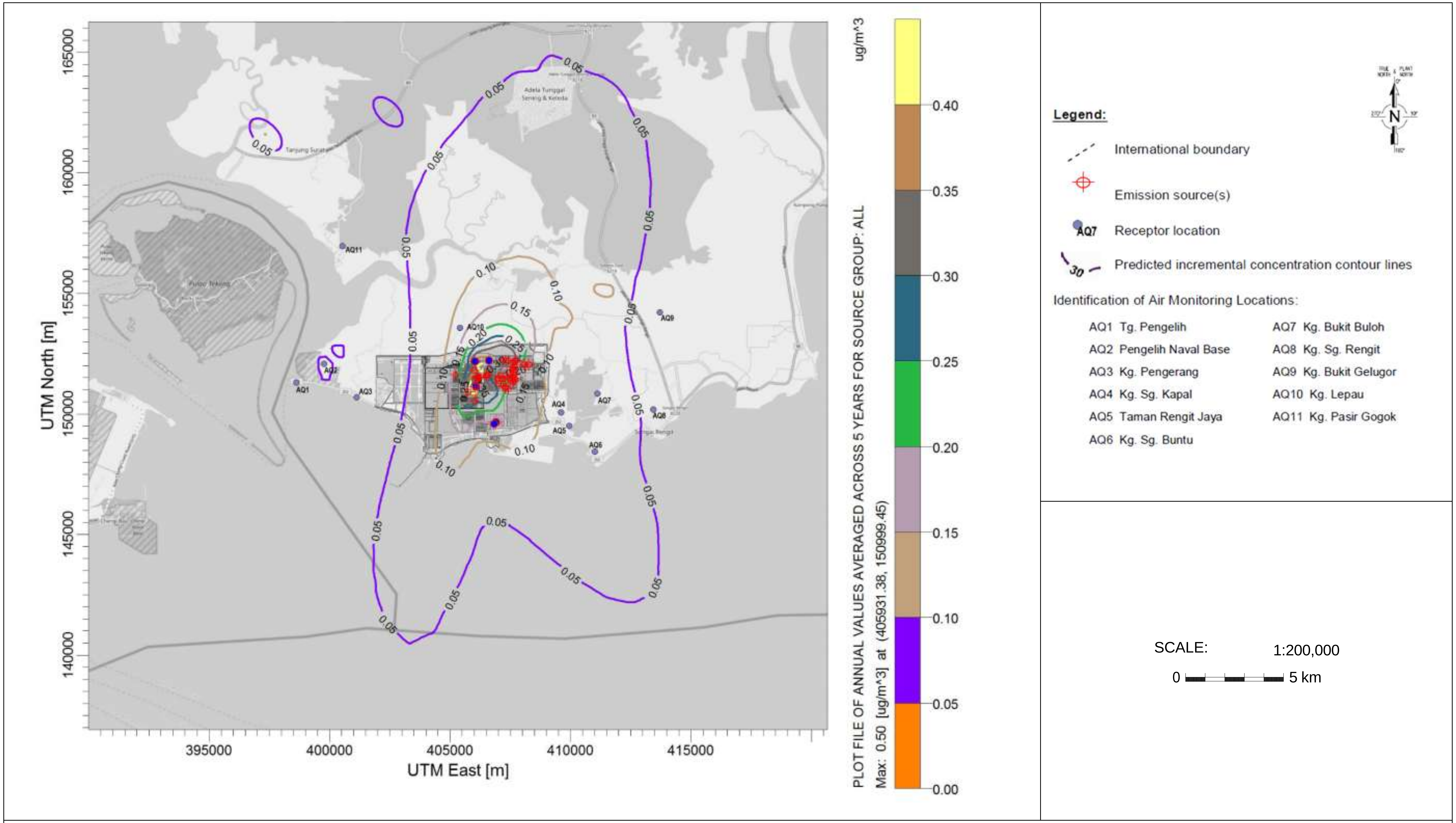


Figure 15: Predicted Incremental Ground Level Concentration for PM_{10} During Normal Operation for Cumulative RAPID Complex (Maximum Annual Average in µg/m^3)

AERMOD View - Lakes Environmental Software

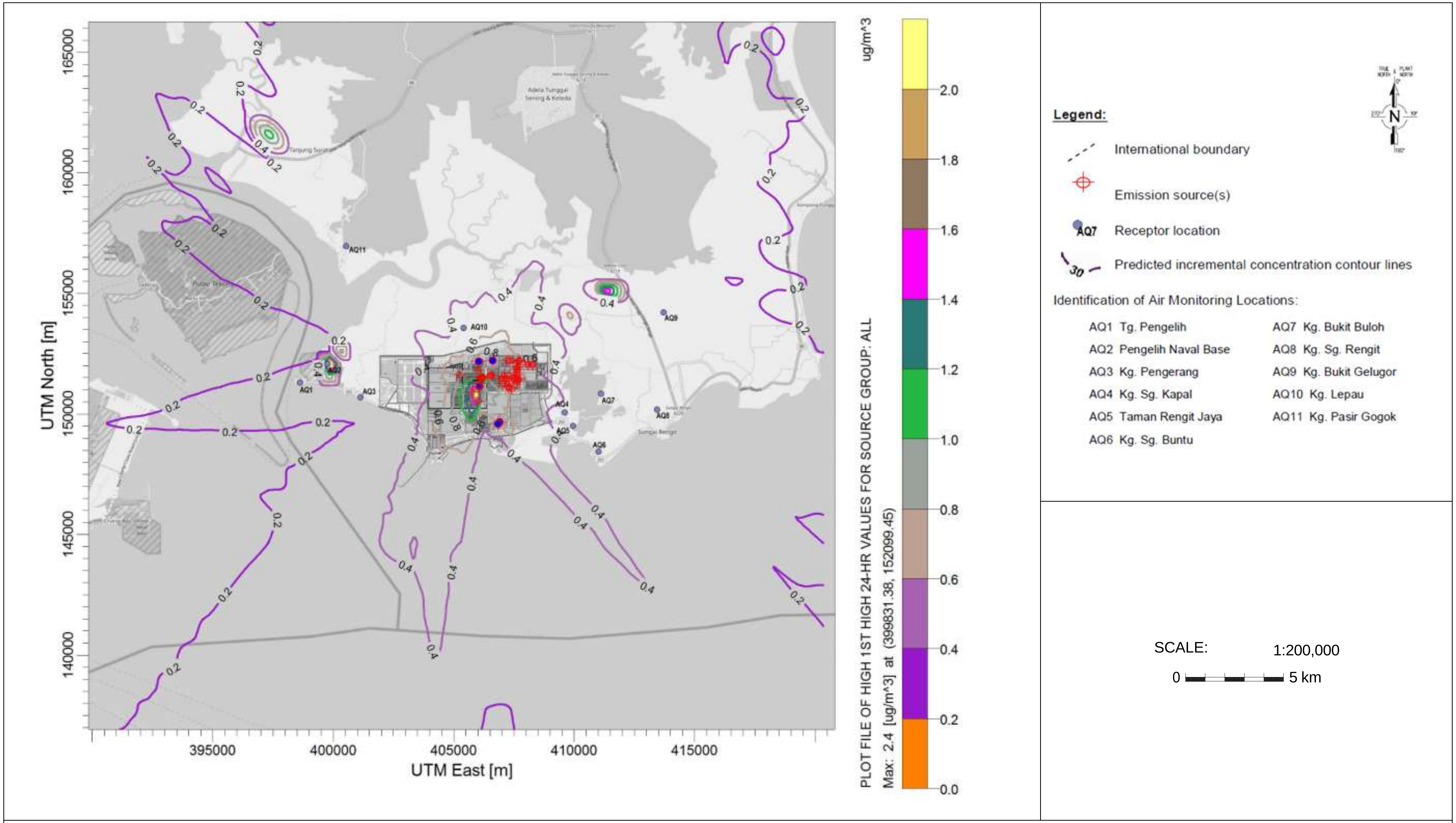


Figure 16: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for Cumulative RAPID Complex (Maximum 24 hours Average in µg/m³)

AERMOD View - Lakes Environmental Software

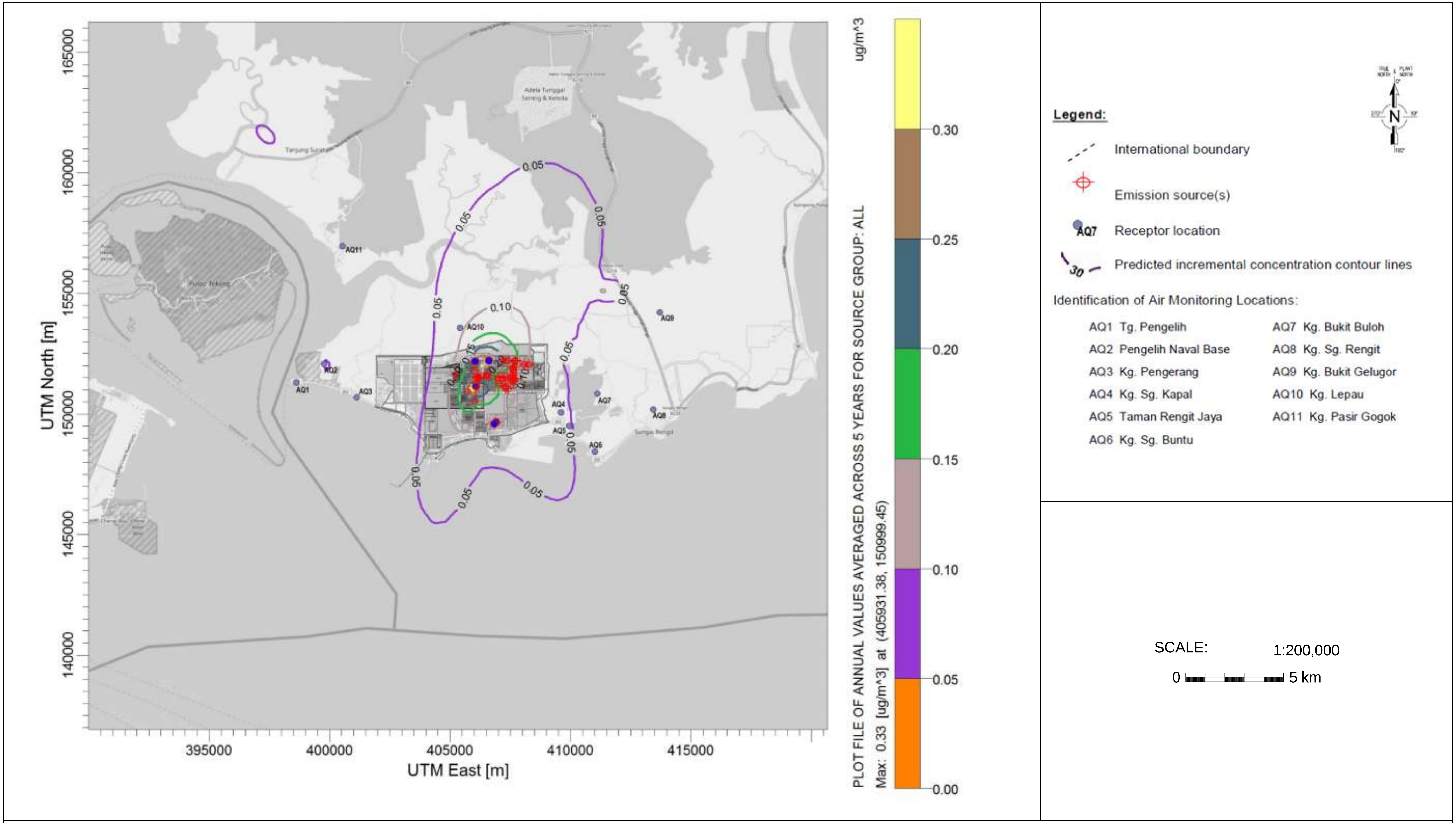


Figure 17: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Normal Operation for Cumulative RAPID Complex (Maximum Annual Average in µg/m^3)

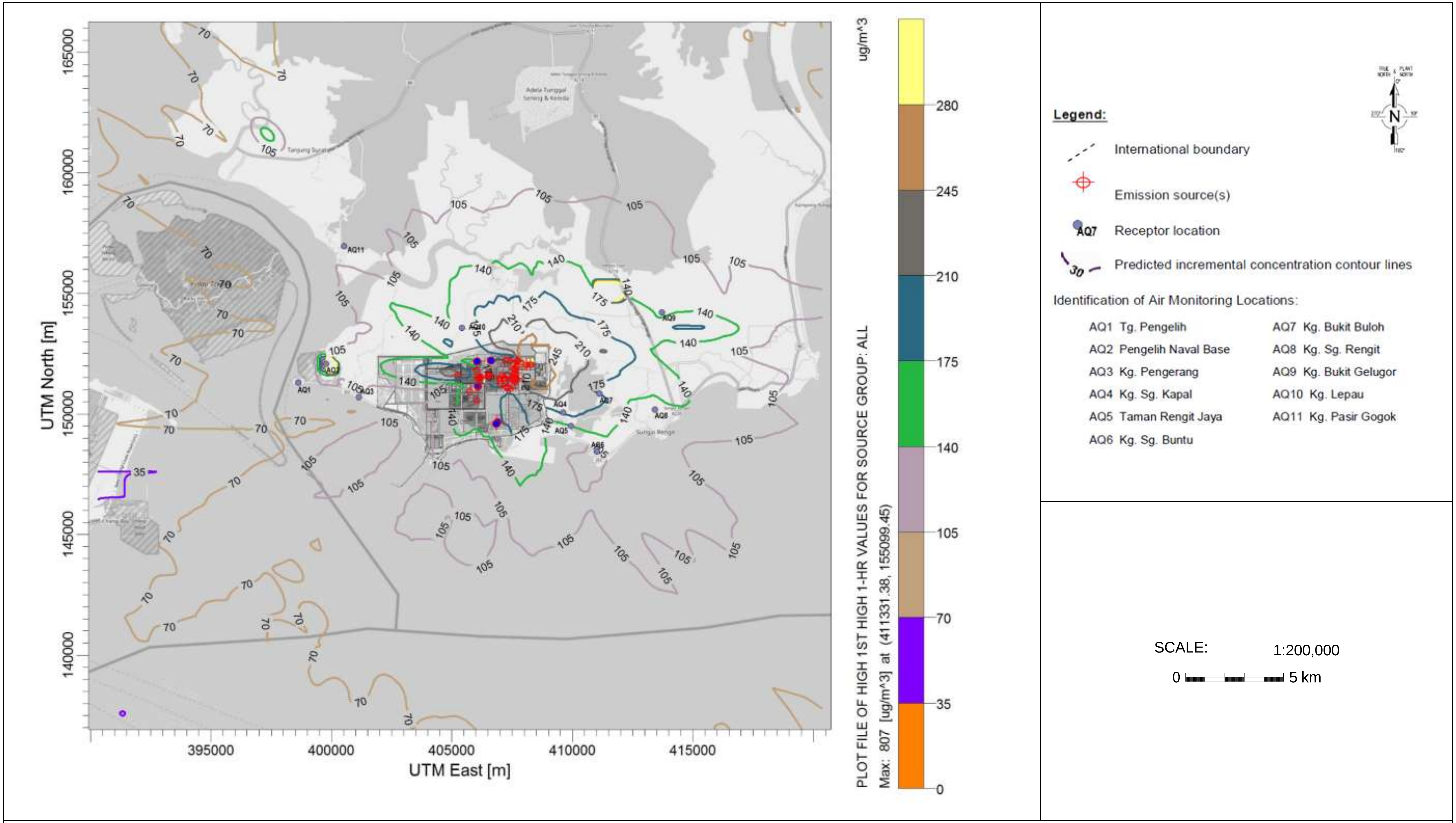


Figure 18: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

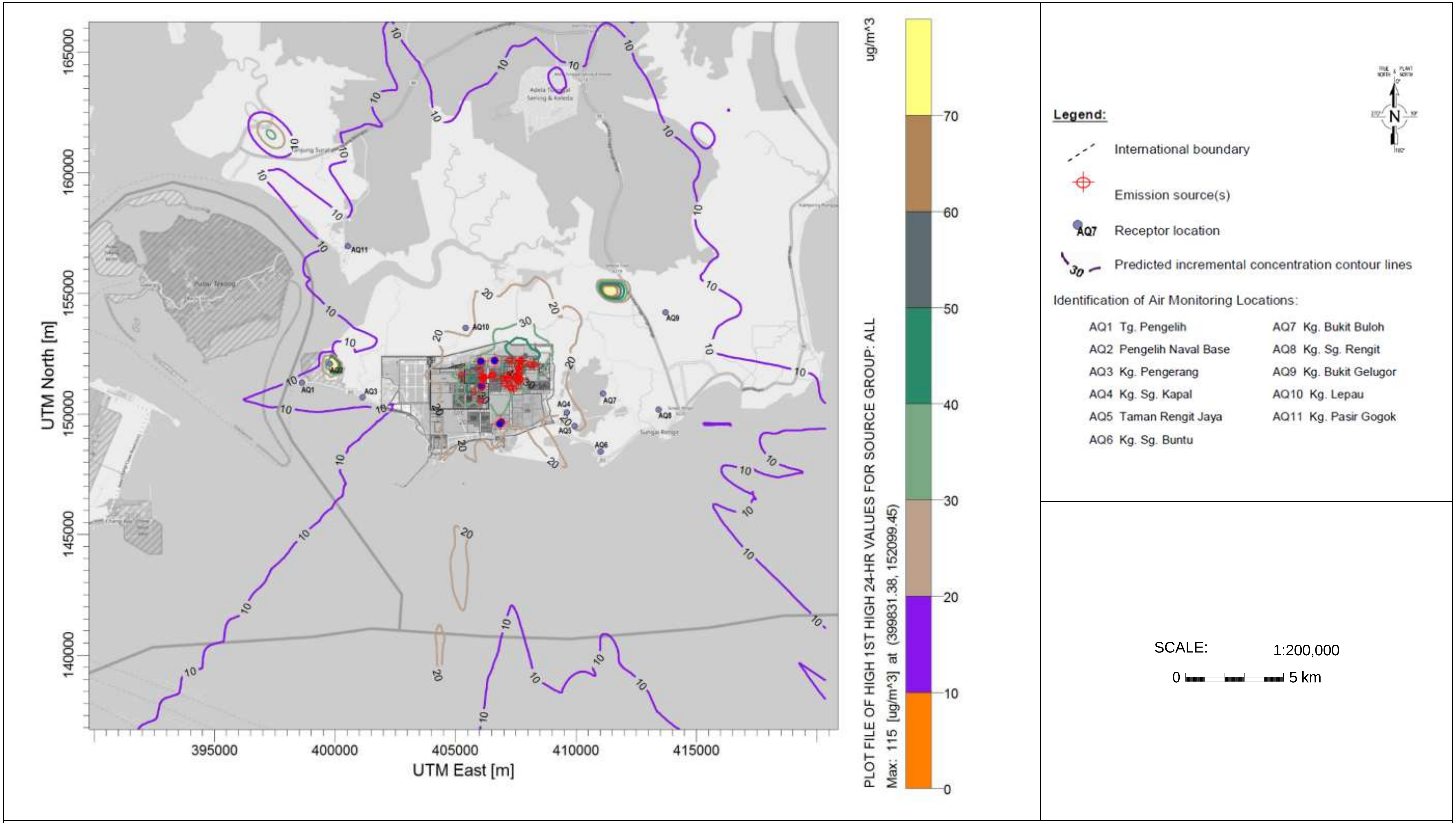


Figure 19: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative RAPID Complex (Maximum 24 hours Average in µg/m^3)

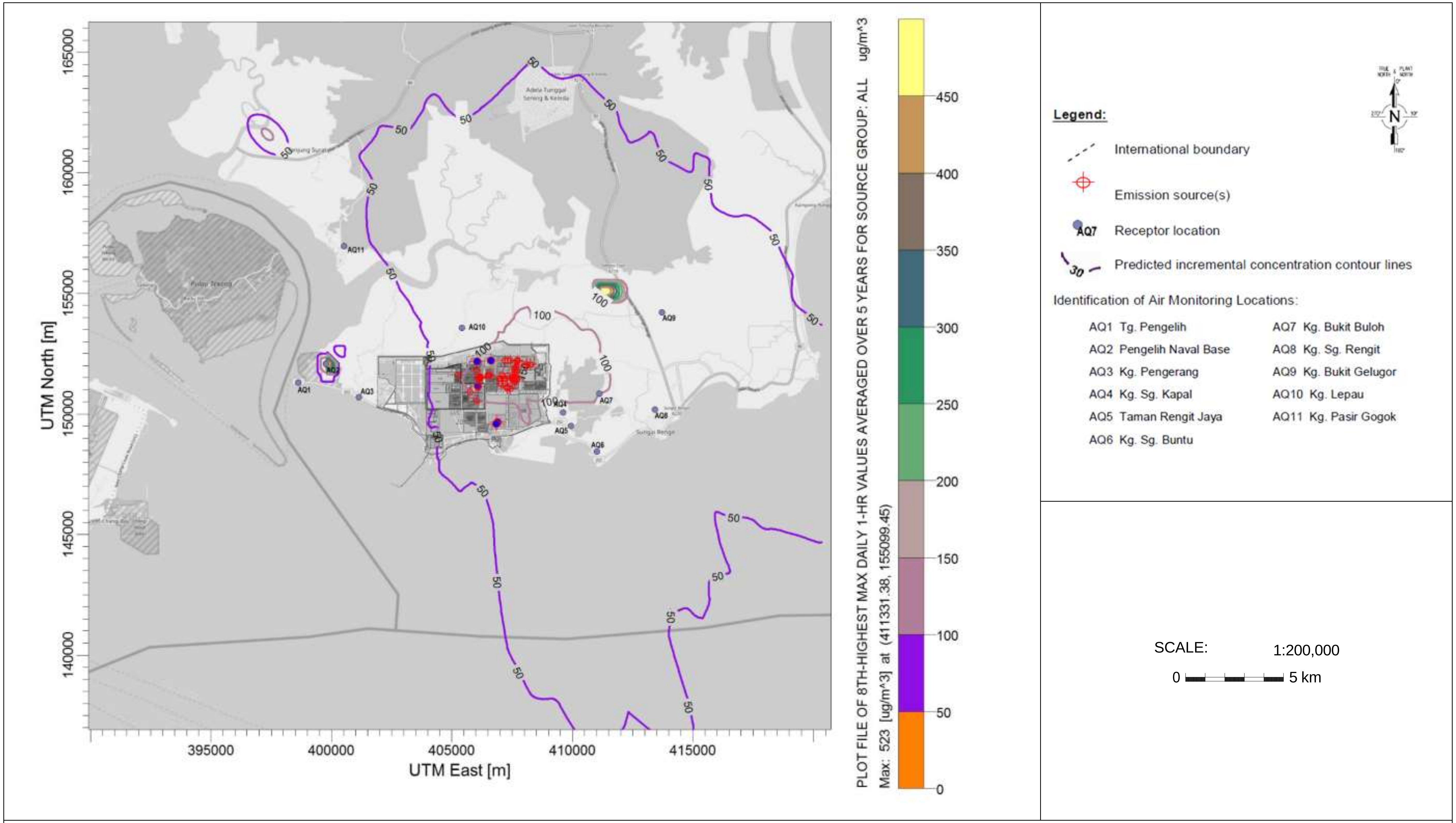


Figure 20: Predicted Incremental Ground Level Concentration for NO_2 Tier3 During Normal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

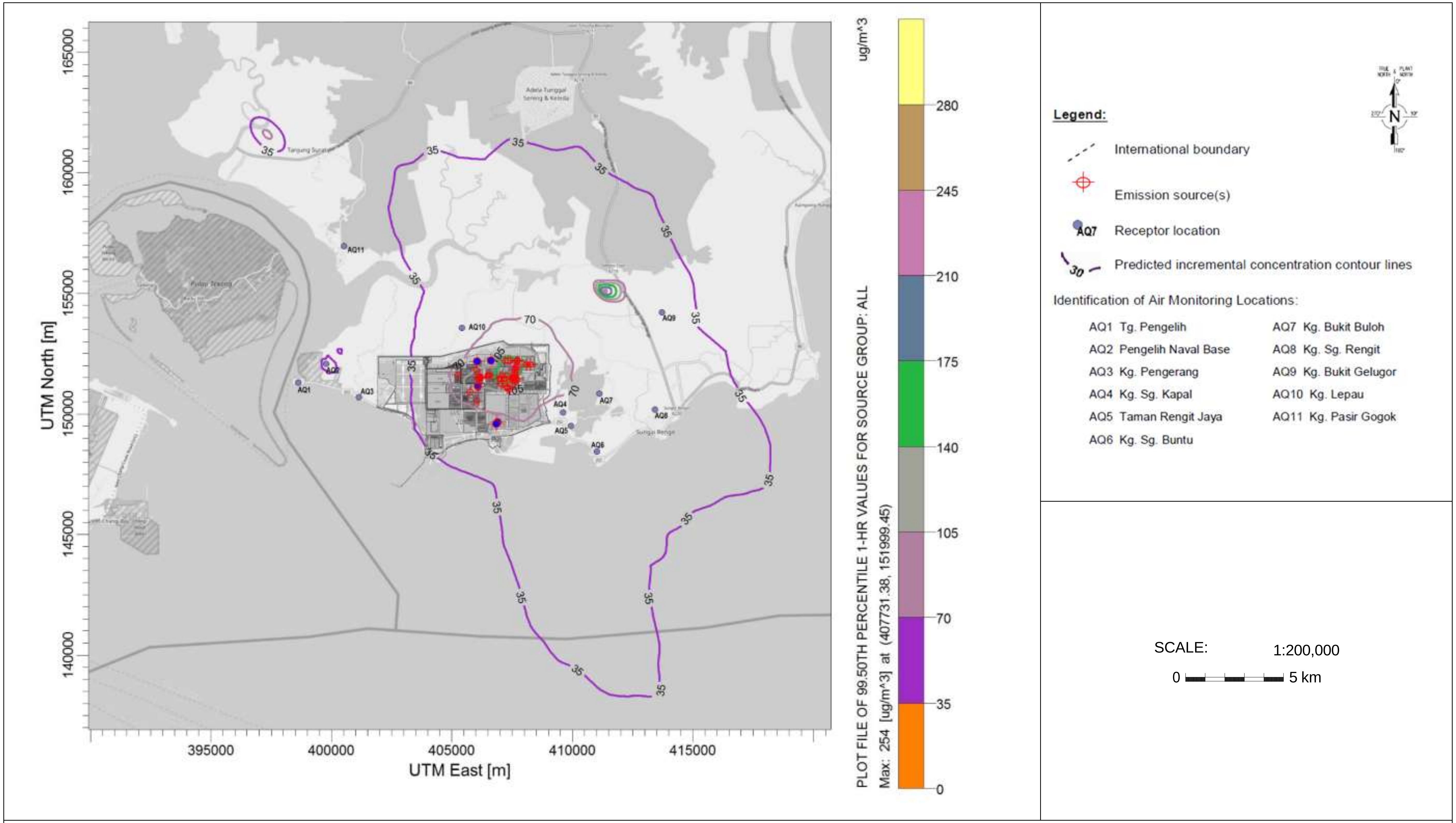


Figure 21: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative RAPID Complex (Maximum 99.5 Percentile 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

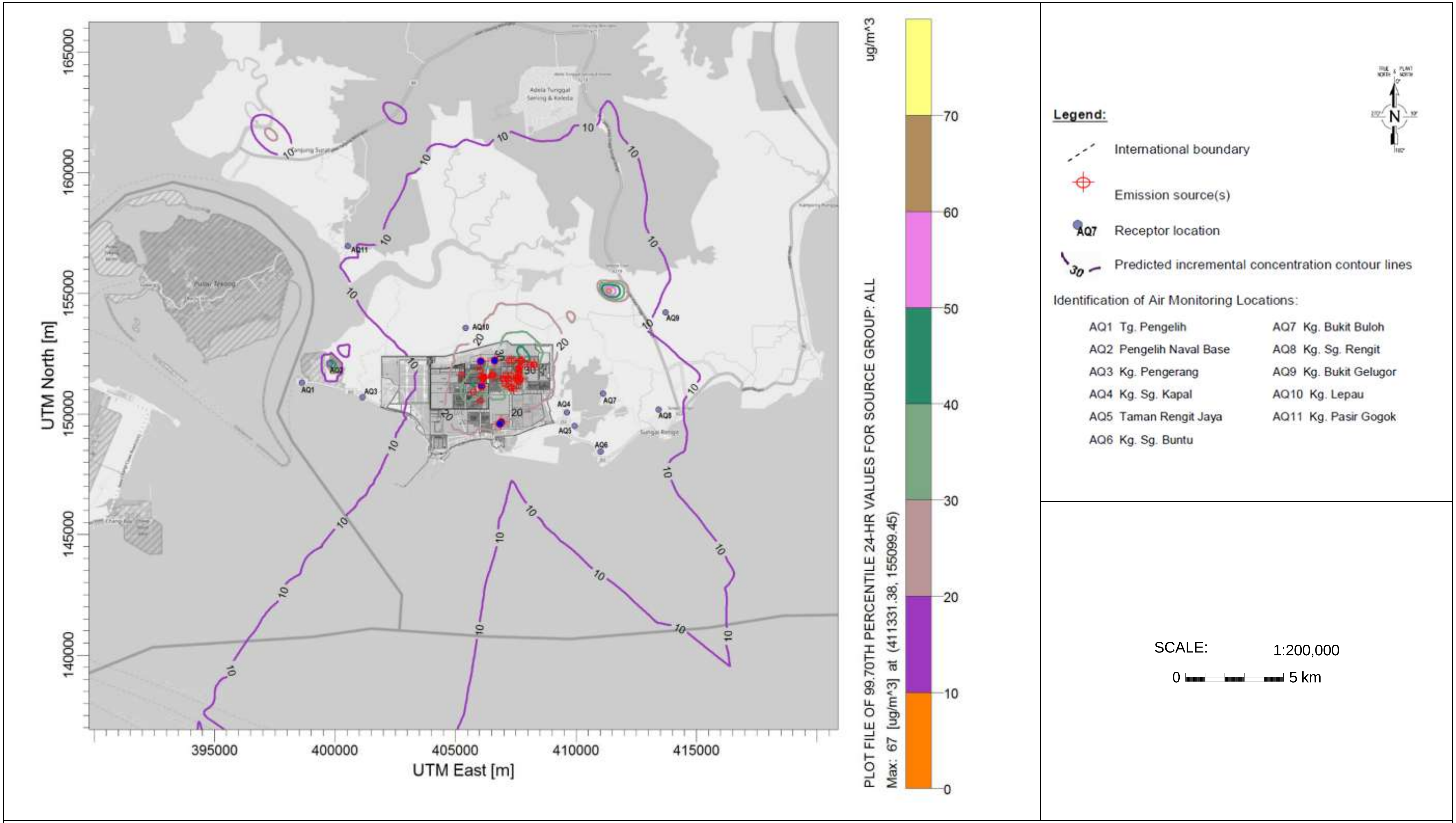


Figure 22: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Normal Operation for Cumulative RAPID Complex (Maximum 99.7 Percentile 24 hours Average in µg/m^3)

AERMOD View - Lakes Environmental Software

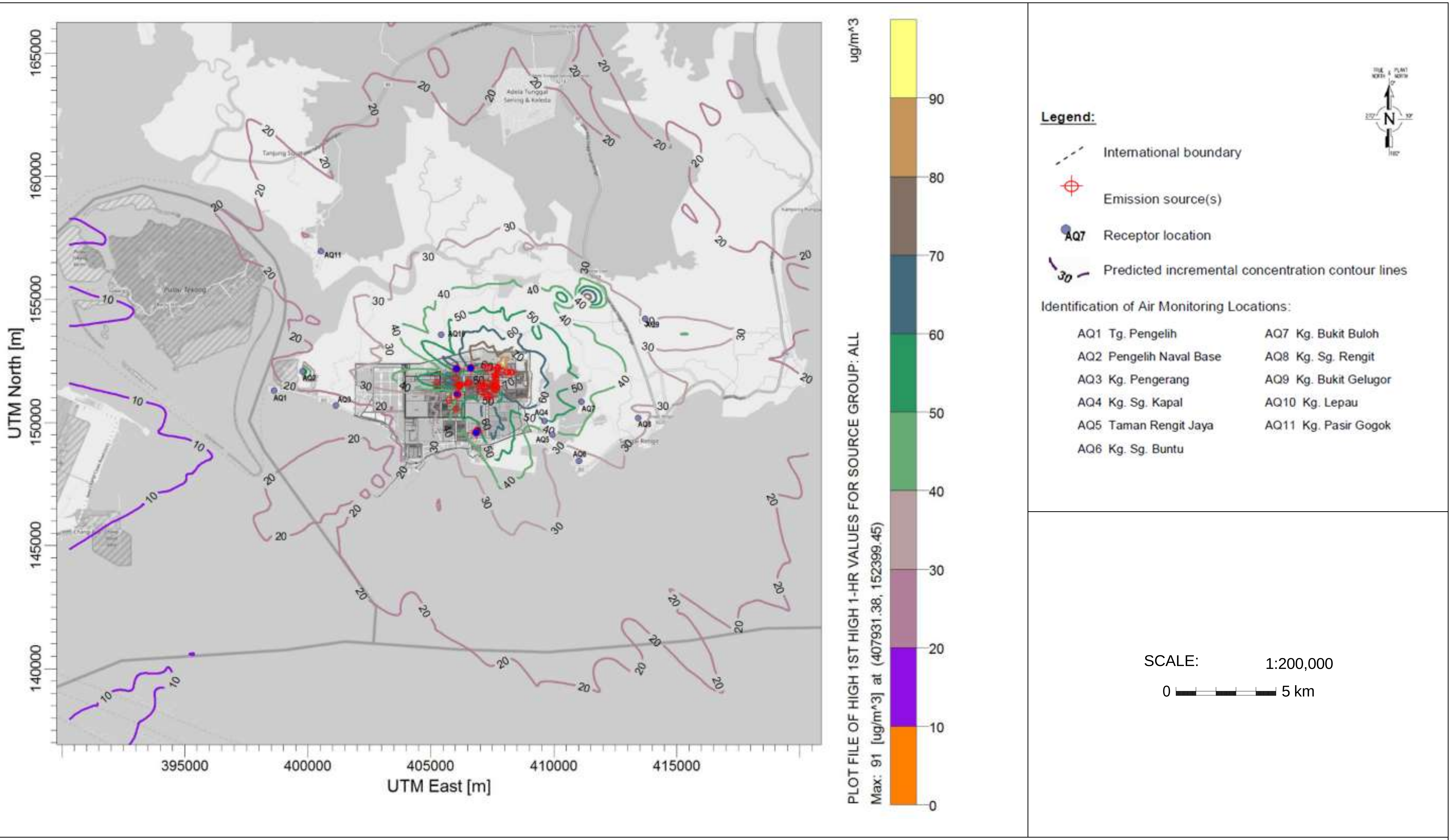


Figure 23: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

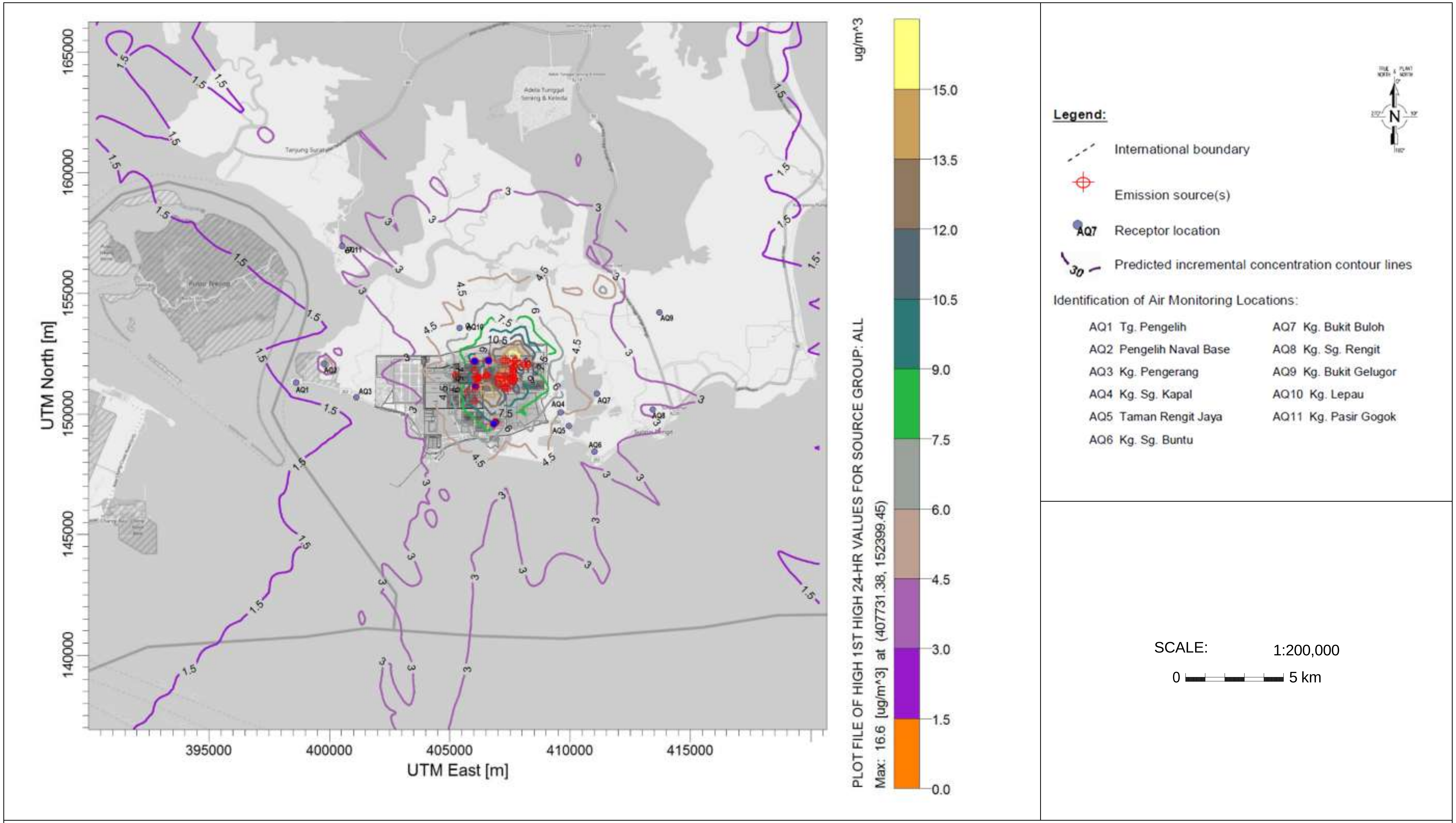


Figure 24: Predicted Incremental Ground Level Concentration for SO_2 During Normal Operation for Cumulative RAPID Complex (Maximum 24 hours Average in µg/m^3)

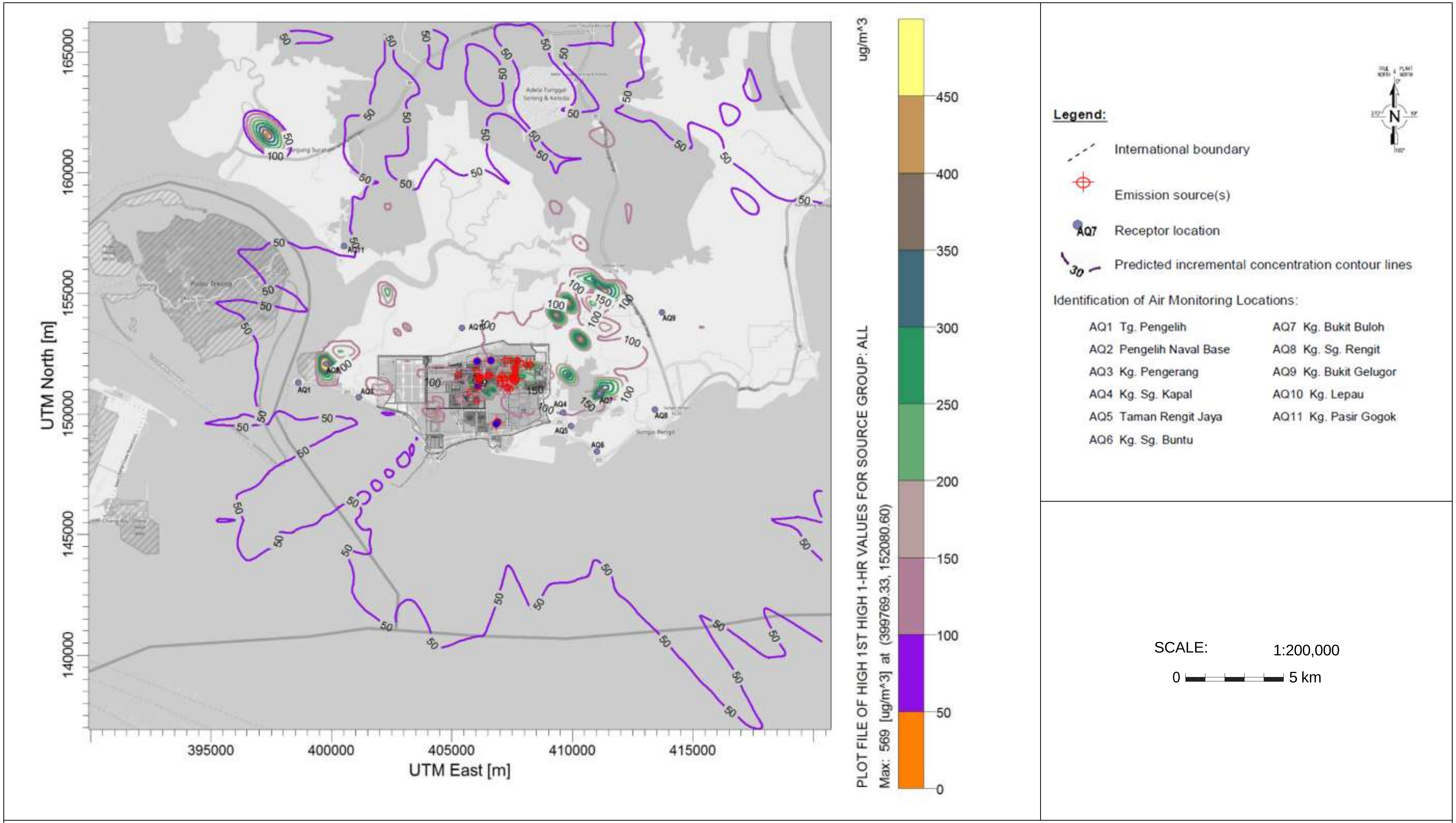


Figure 25: Predicted Incremental Ground Level Concentration for CO During Normal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

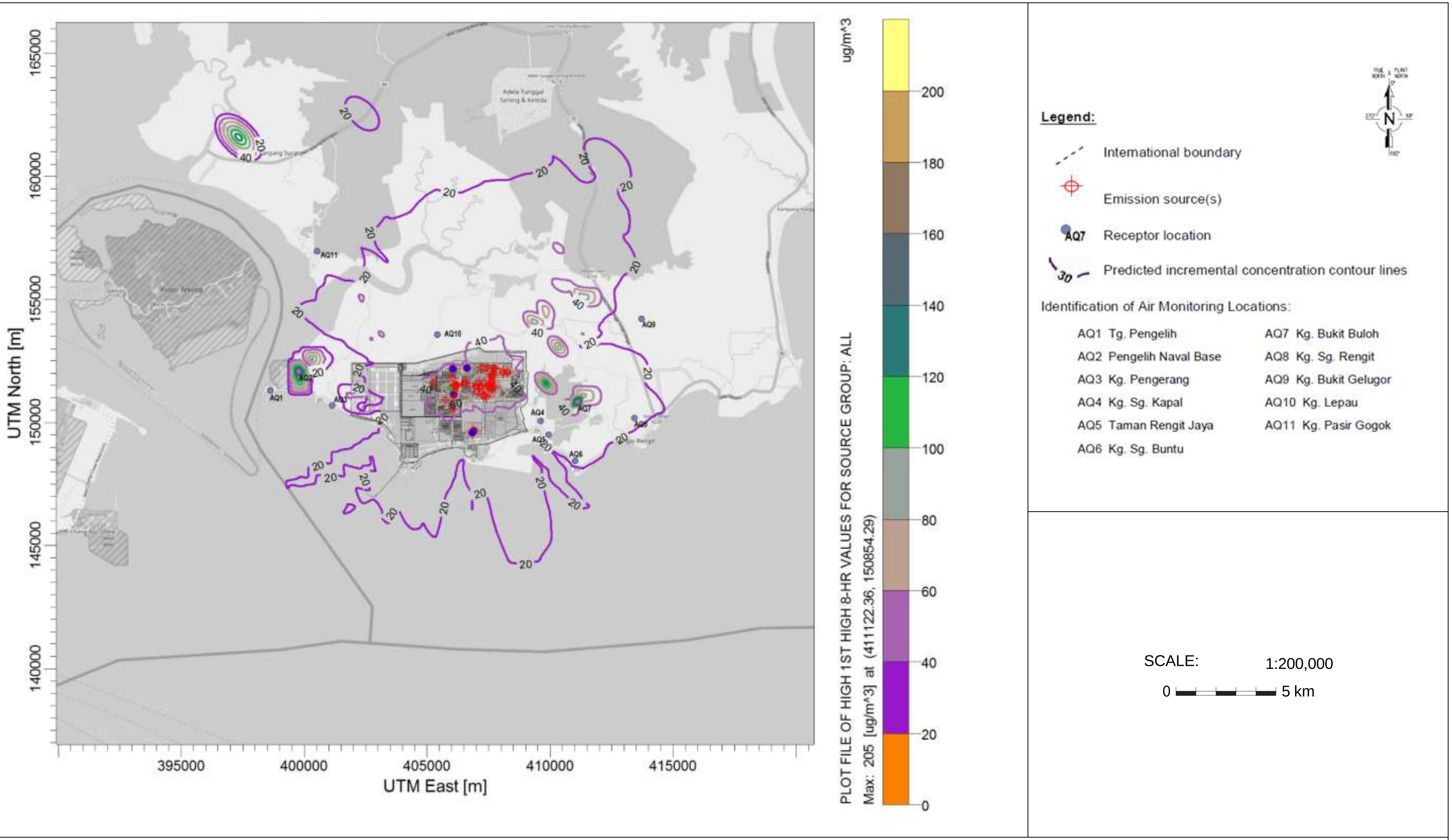


Figure 26: Predicted Incremental Ground Level Concentration for CO During Normal Operation for Cumulative RAPID Complex (Maximum 8 hours Average in µg/m³)

AERMOD View - Lakes Environmental Software

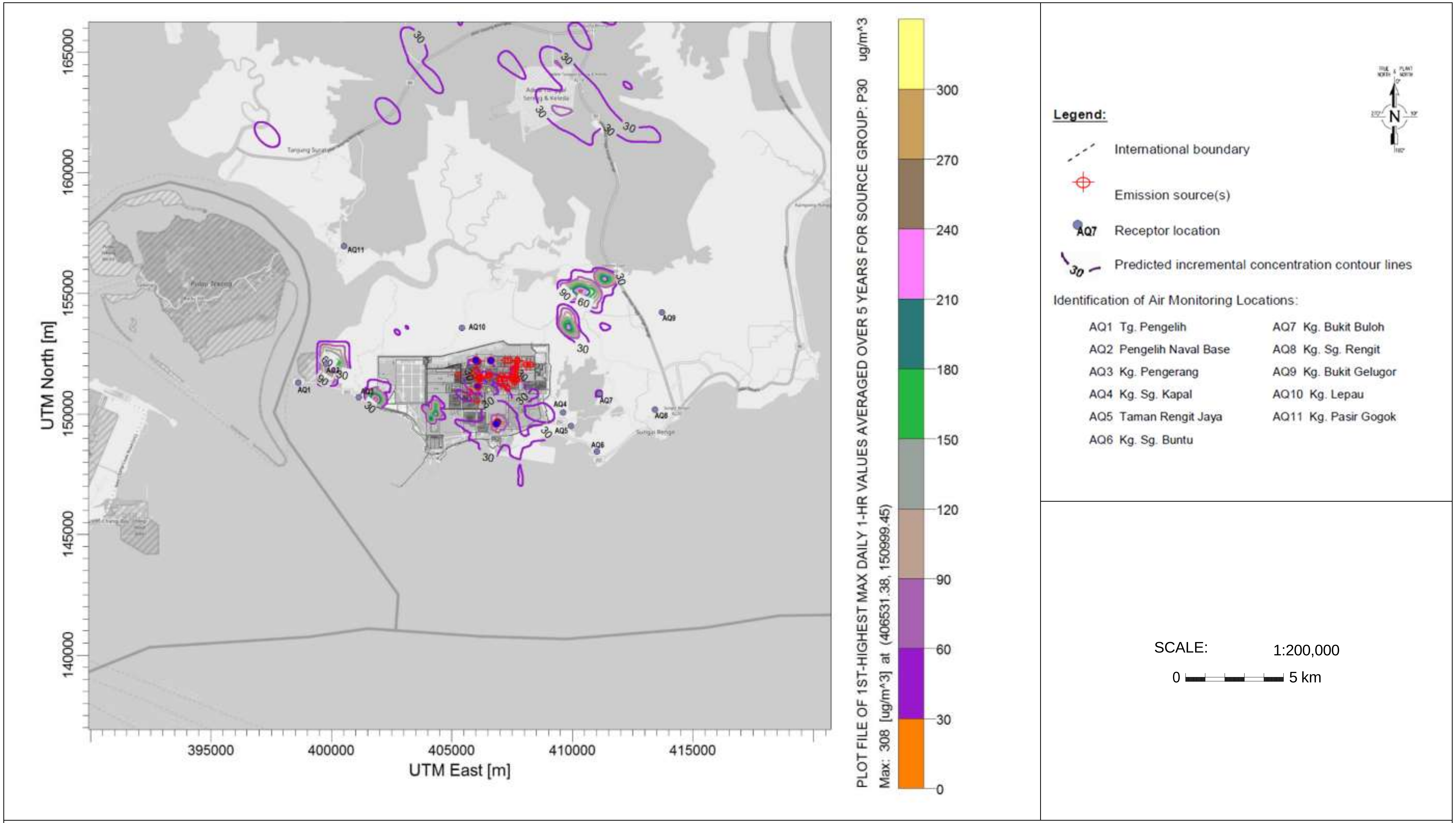


Figure 27: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Abnormal Operation for Olefin Storage Tankages (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

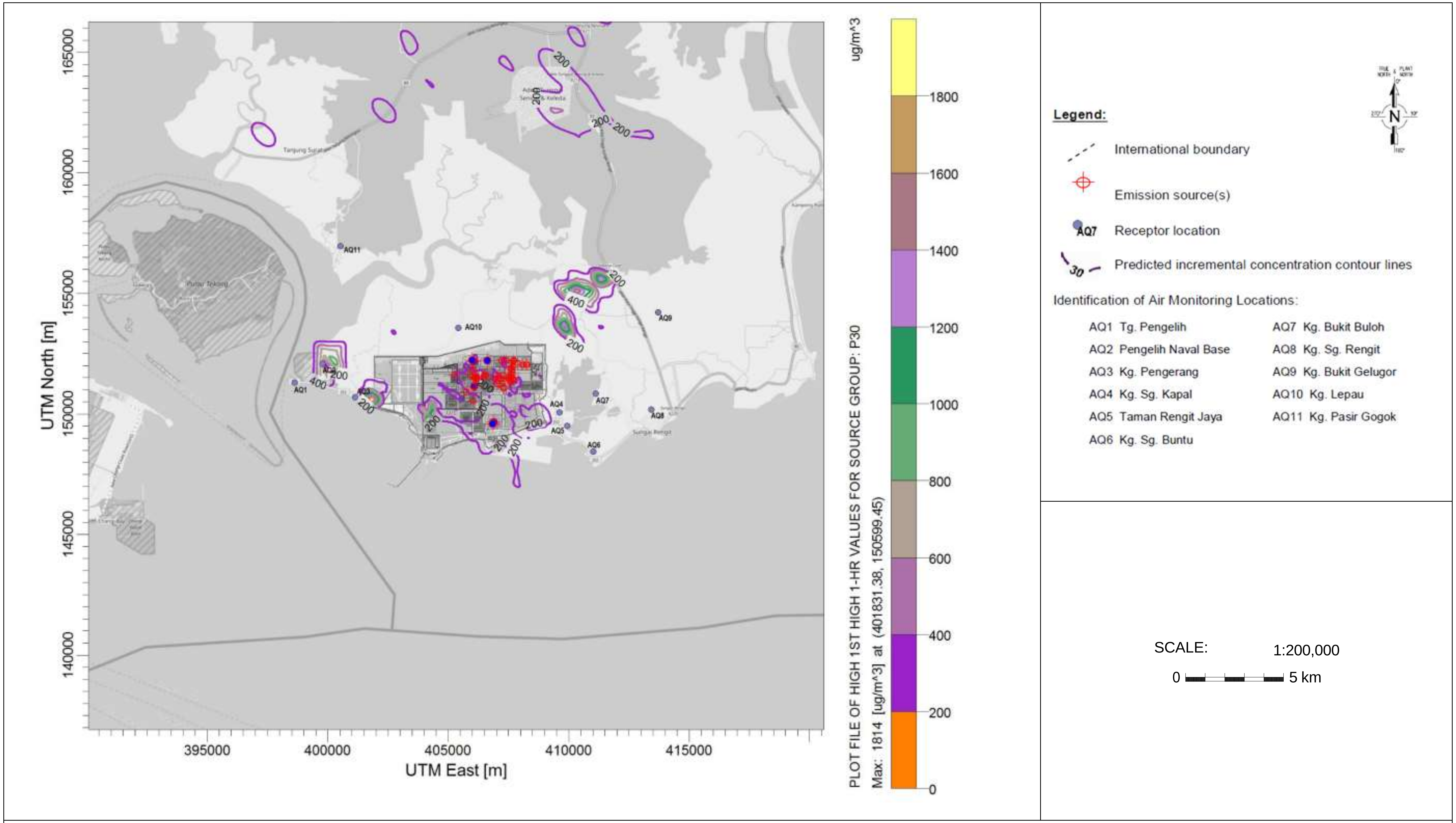


Figure 28: Predicted Incremental Ground Level Concentration for CO During Abnormal Operation for Olefin Storage Tankages (Maximum 1 hour Average in μg/m^3)

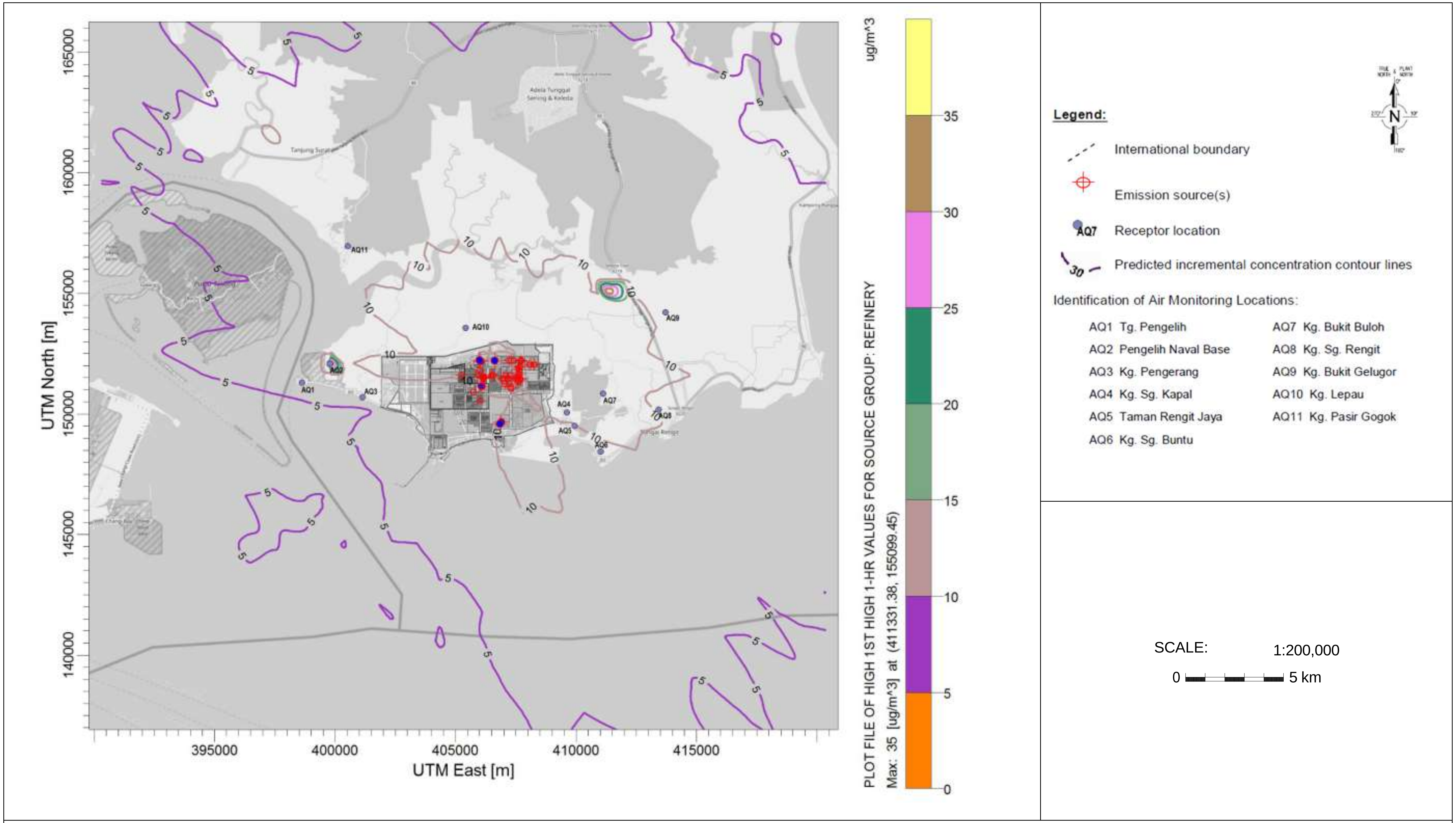


Figure 29: Predicted Incremental Ground Level Concentration for PM_{10} During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

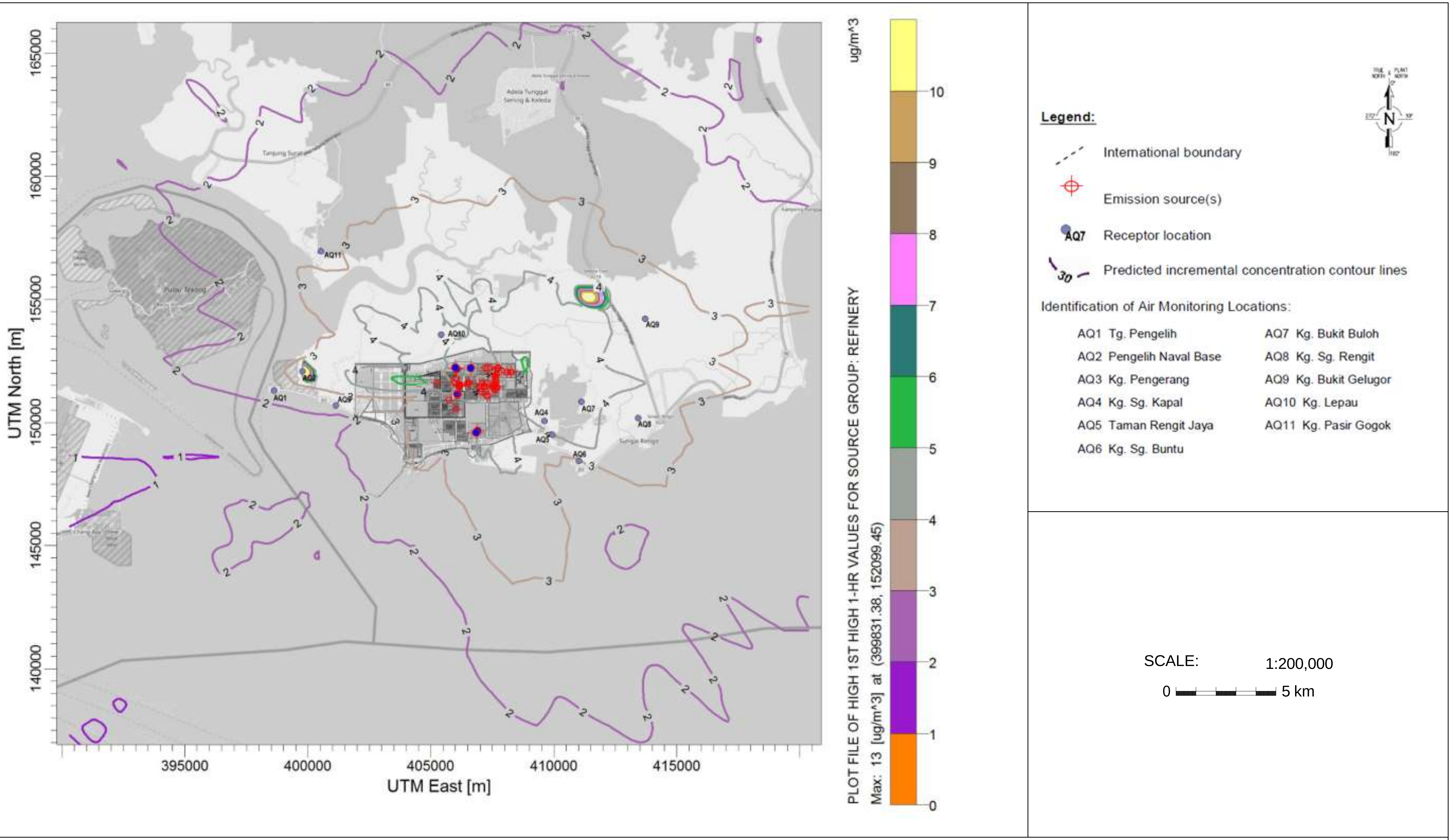


Figure 30: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in μg/m^3)

AERMOD View - Lakes Environmental Software

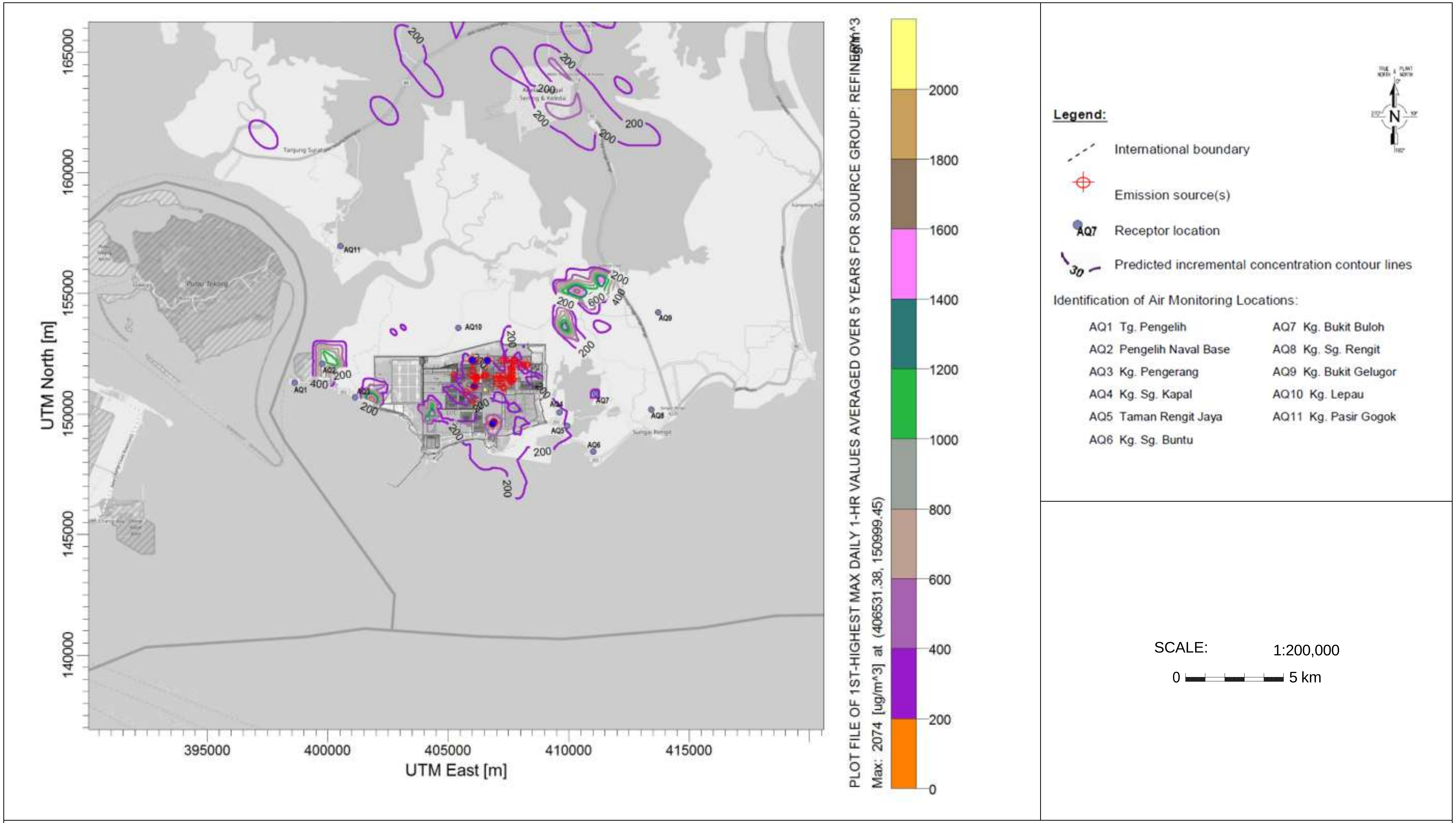


Figure 31: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

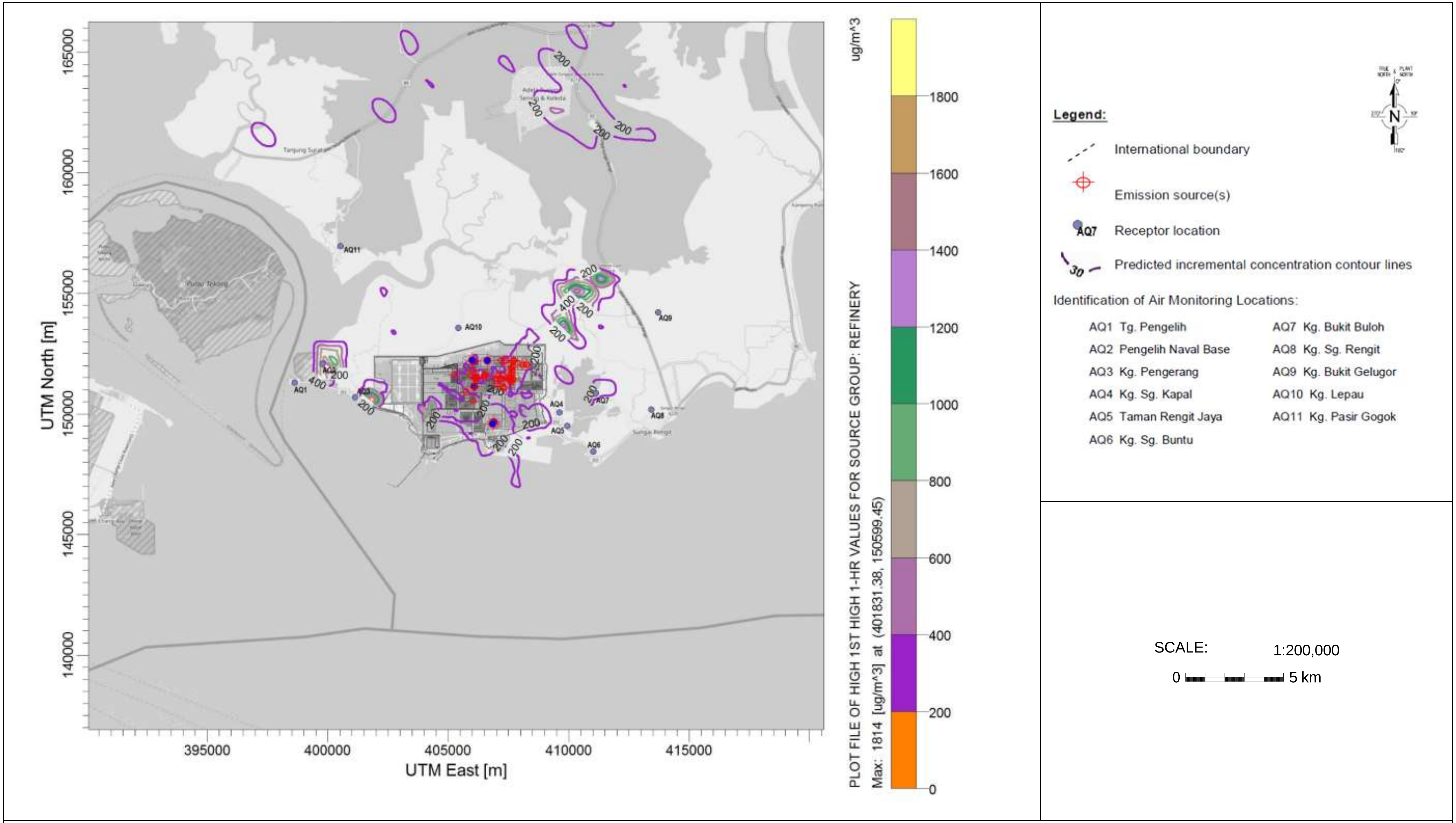


Figure 32: Predicted Incremental Ground Level Concentration for CO During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

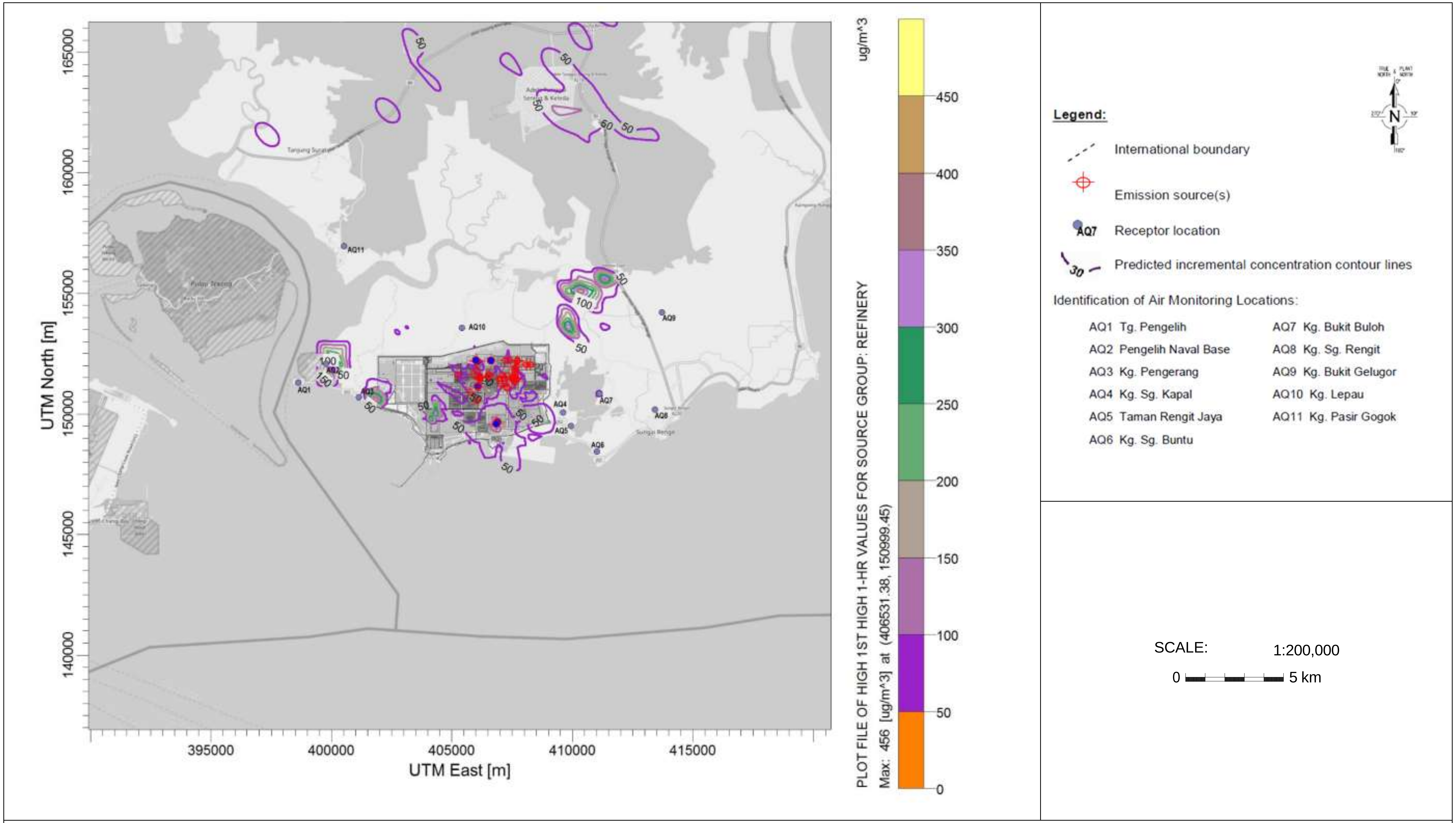


Figure 33: Predicted Incremental Ground Level Concentration for H_2S During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

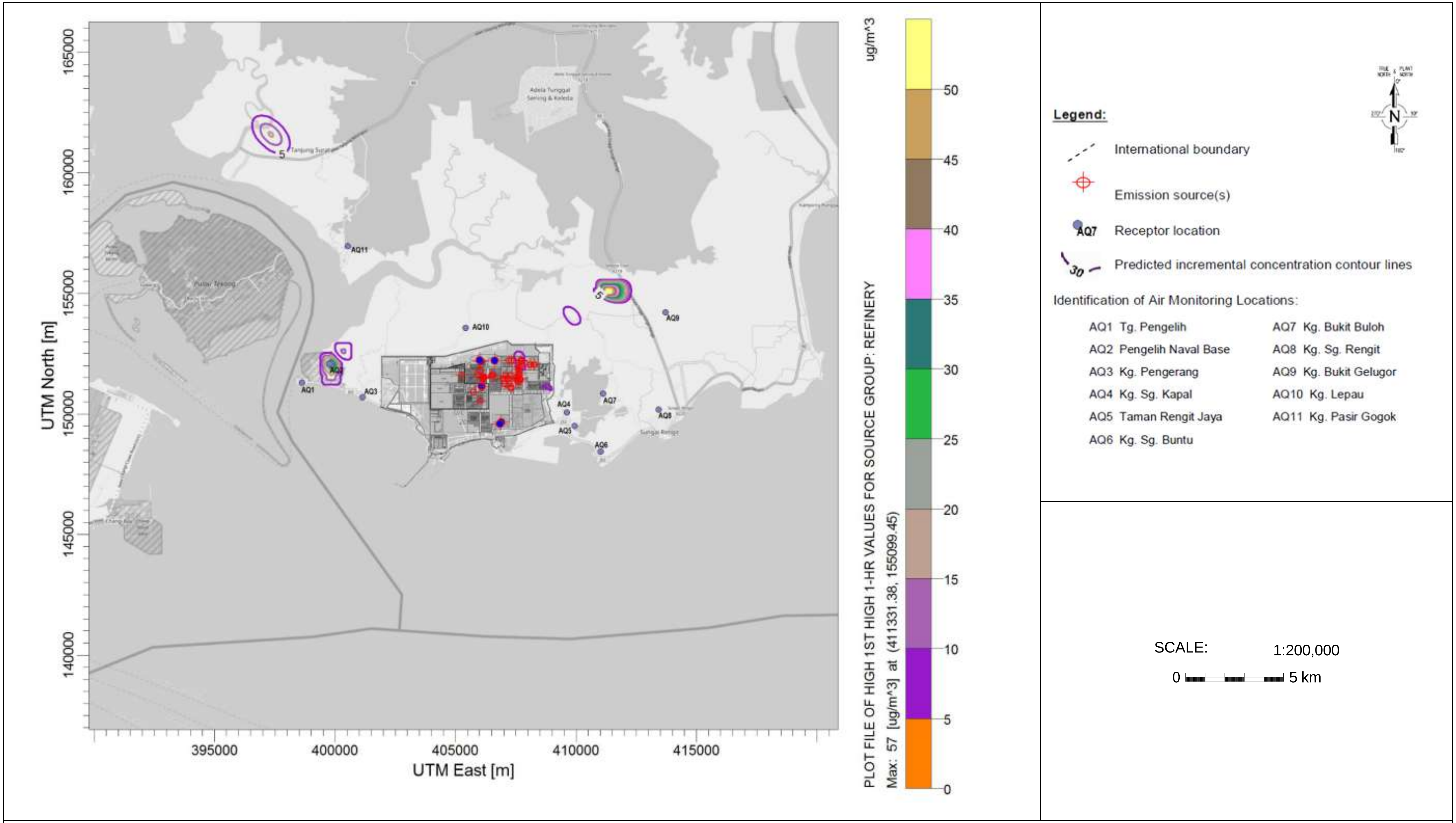


Figure 34: Predicted Incremental Ground Level Concentration for NMVOC During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

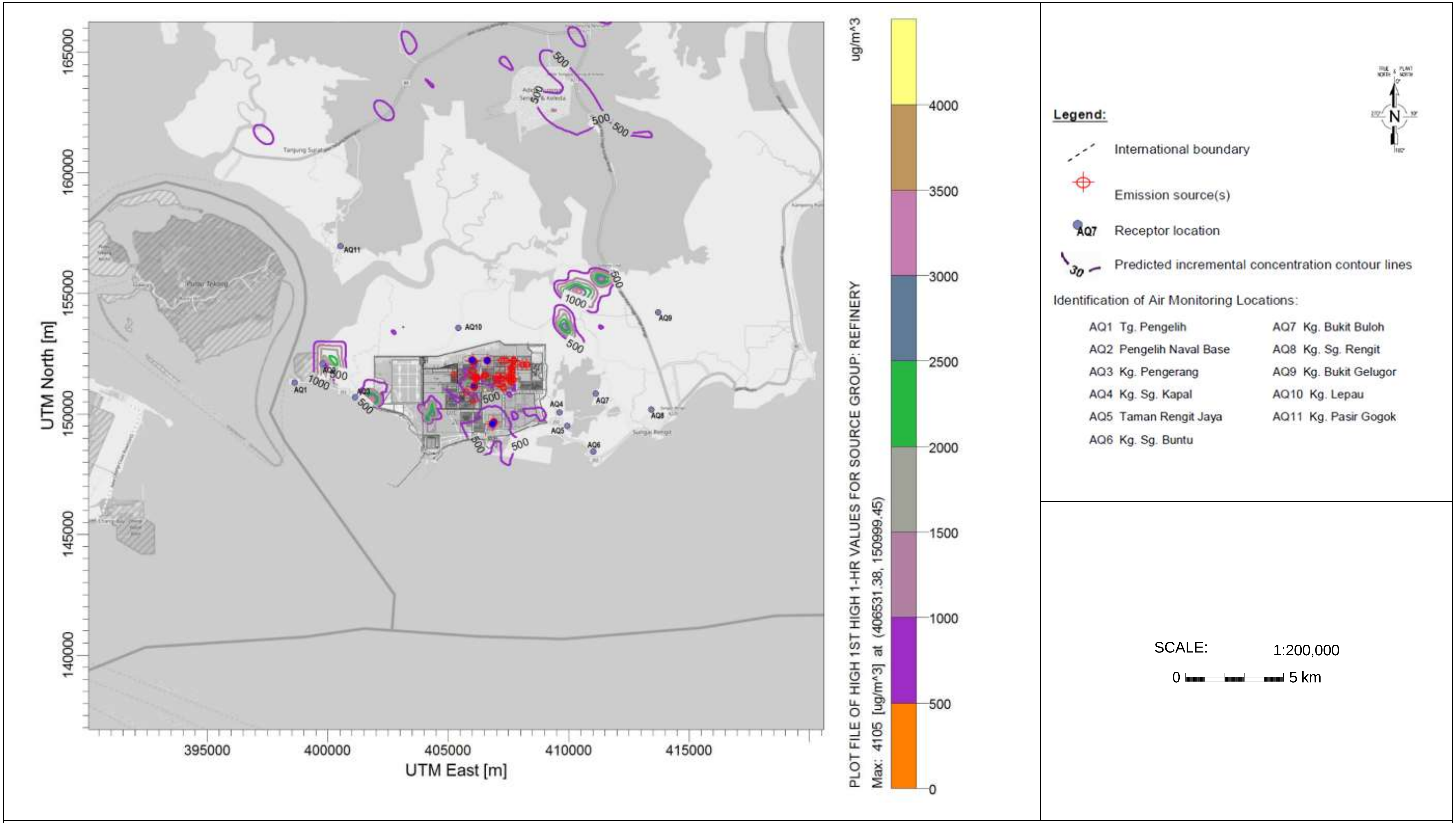


Figure 35: Predicted Incremental Ground Level Concentration for UHC During Abnormal Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

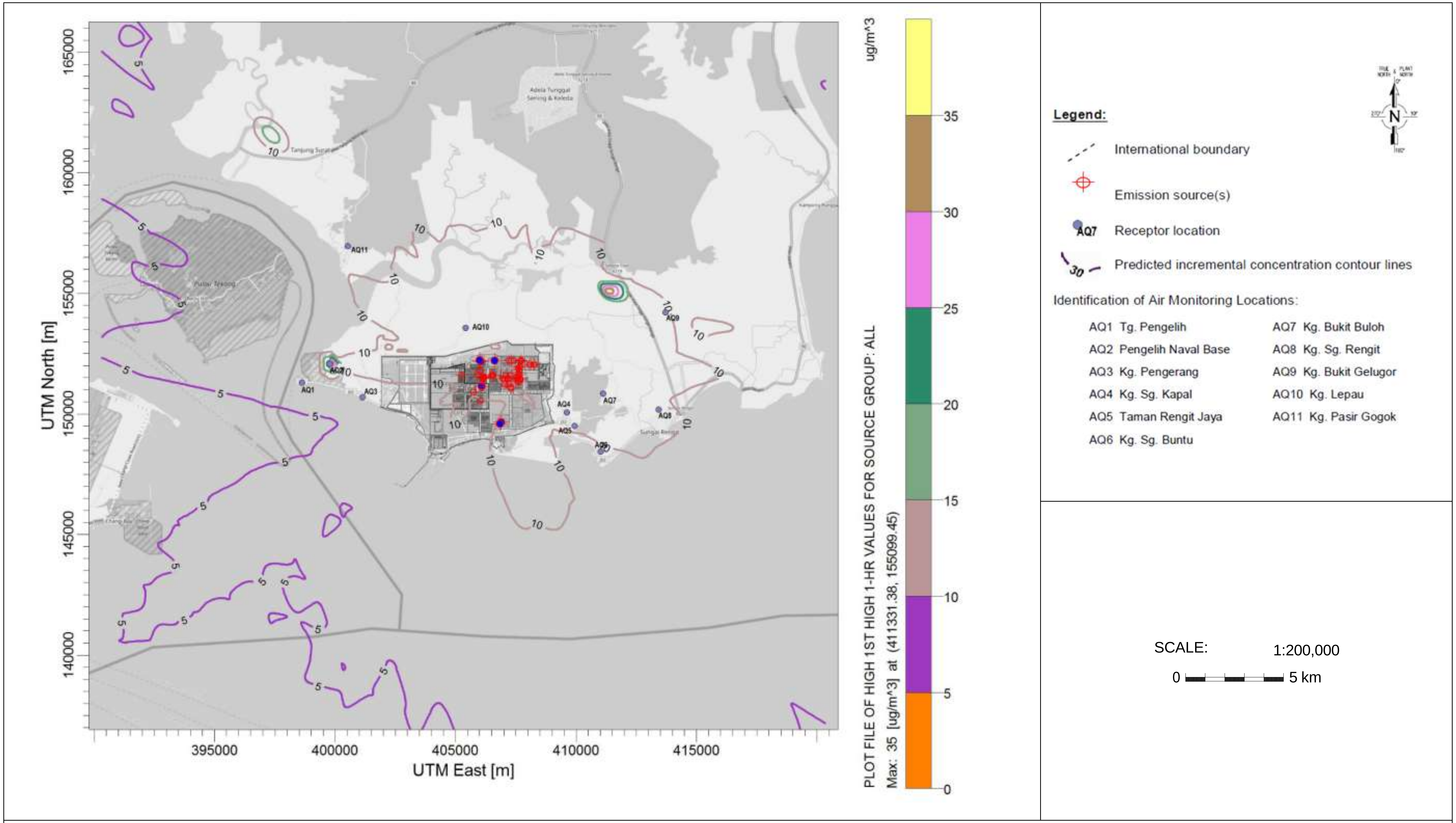


Figure 36: Predicted Incremental Ground Level Concentration for PM_{10} During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

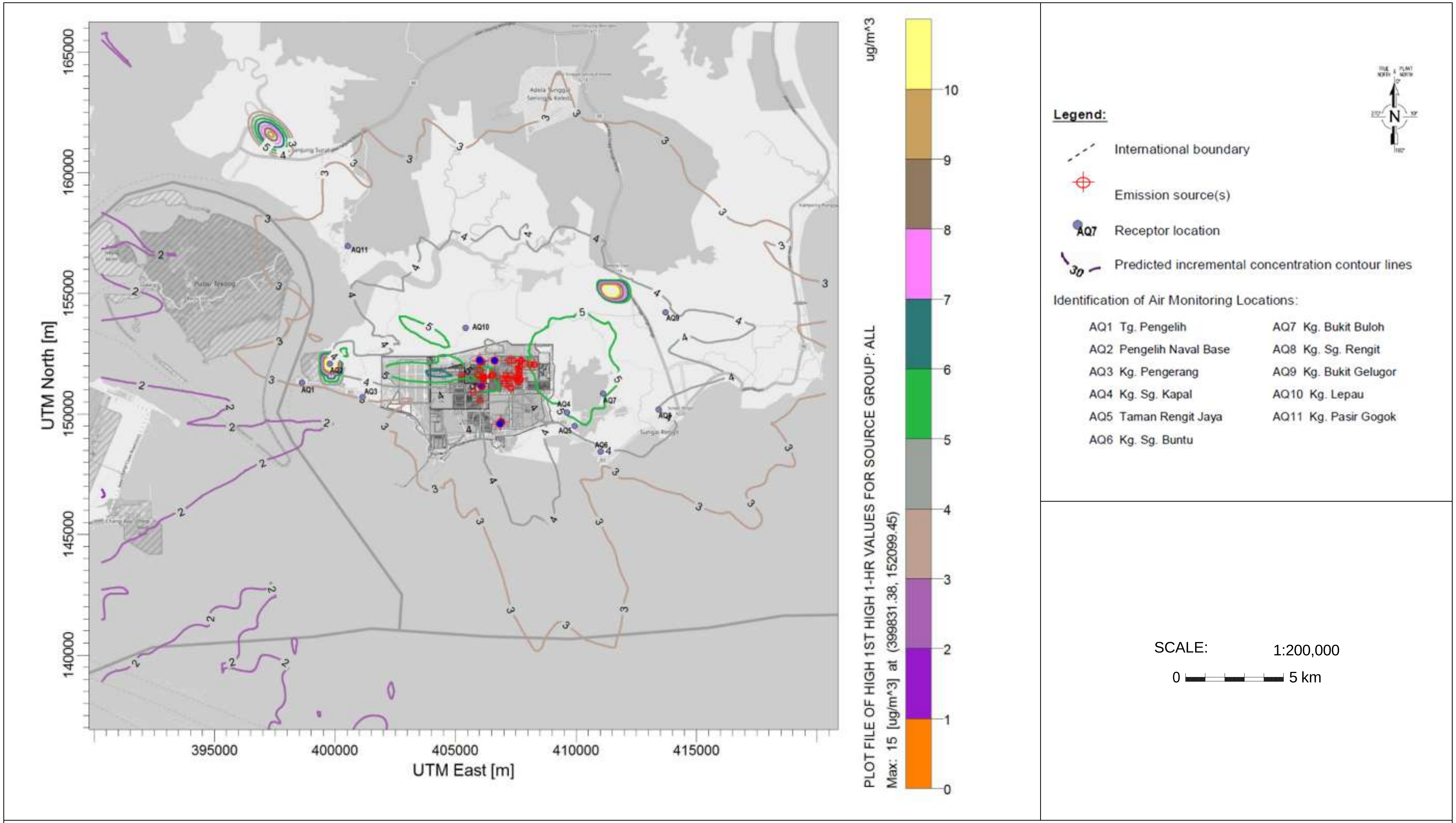


Figure 37: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in $\mu g/m^3$)

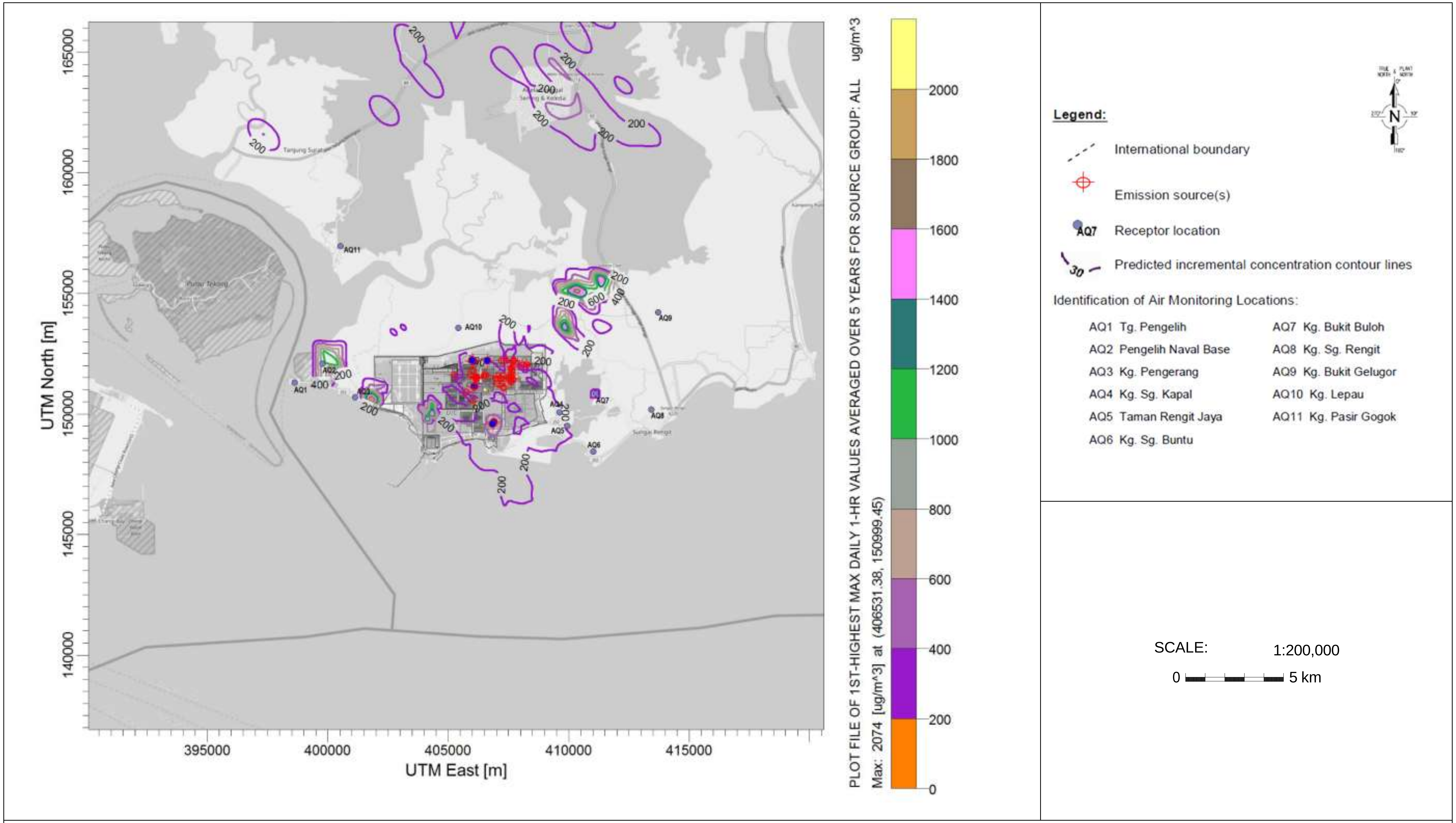


Figure 38: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

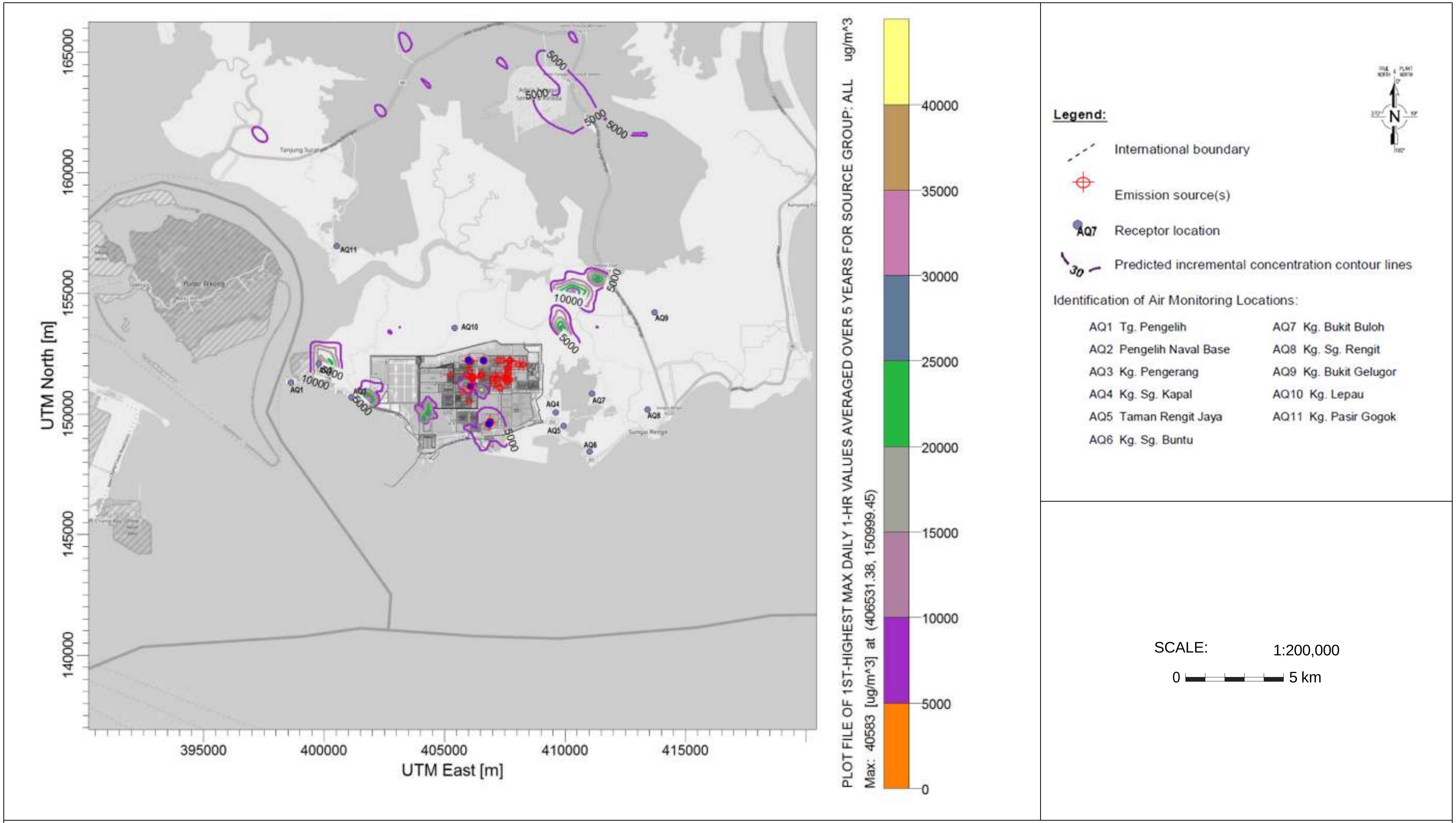


Figure 39: Predicted Incremental Ground Level Concentration for SO_2 During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

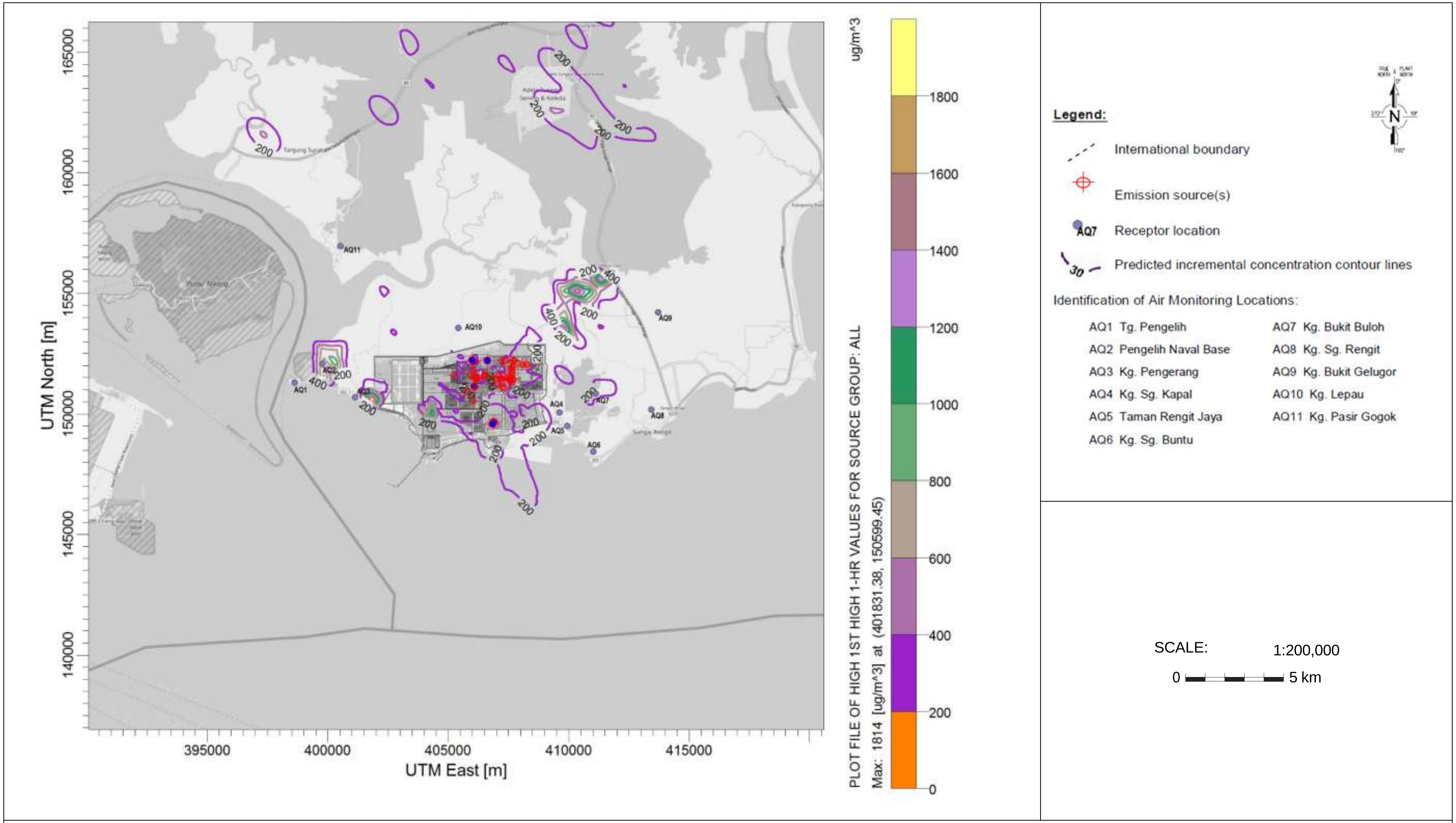


Figure 40: Predicted Incremental Ground Level Concentration for CO During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

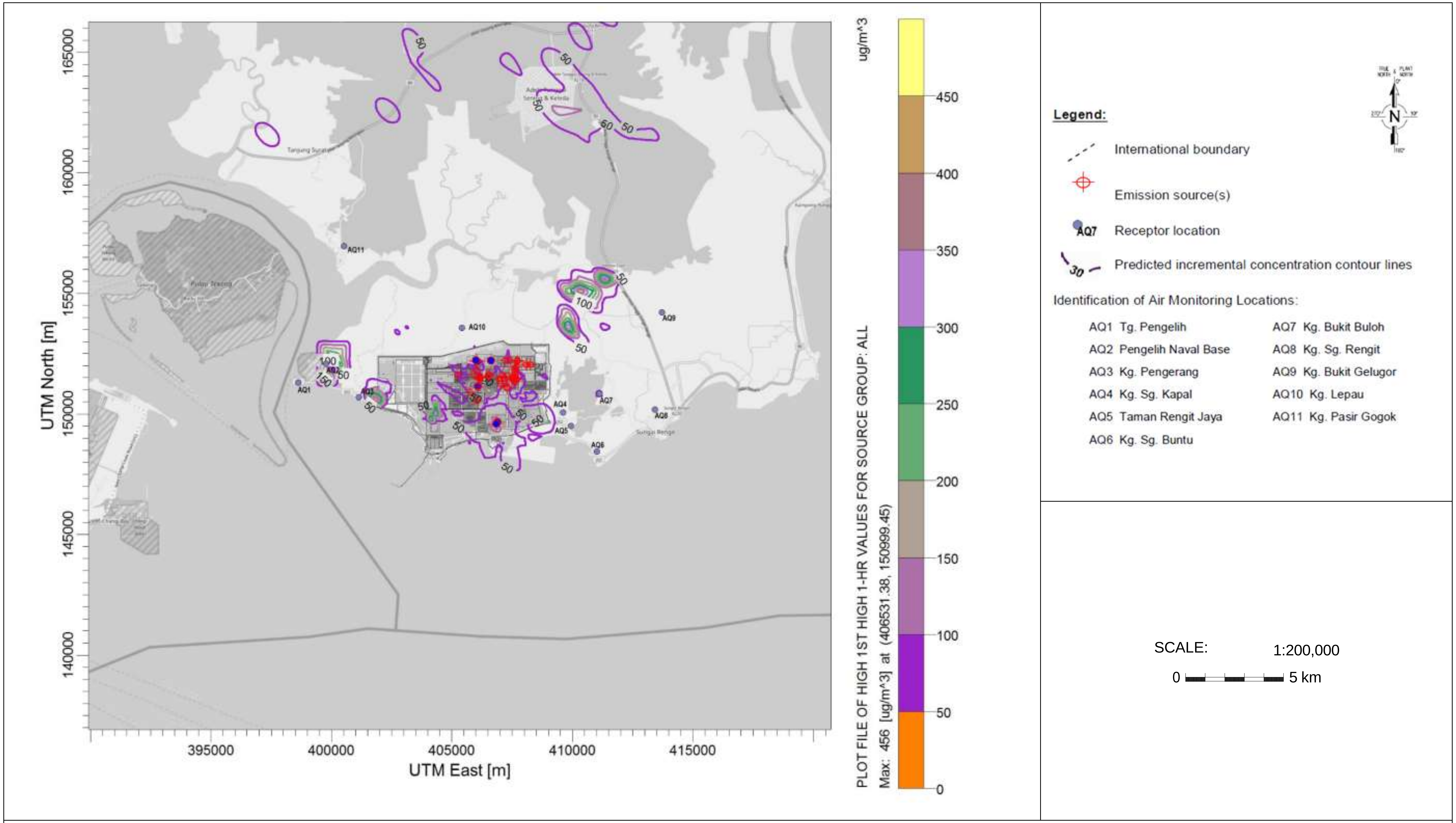


Figure 41: Predicted Incremental Ground Level Concentration for H_2S During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

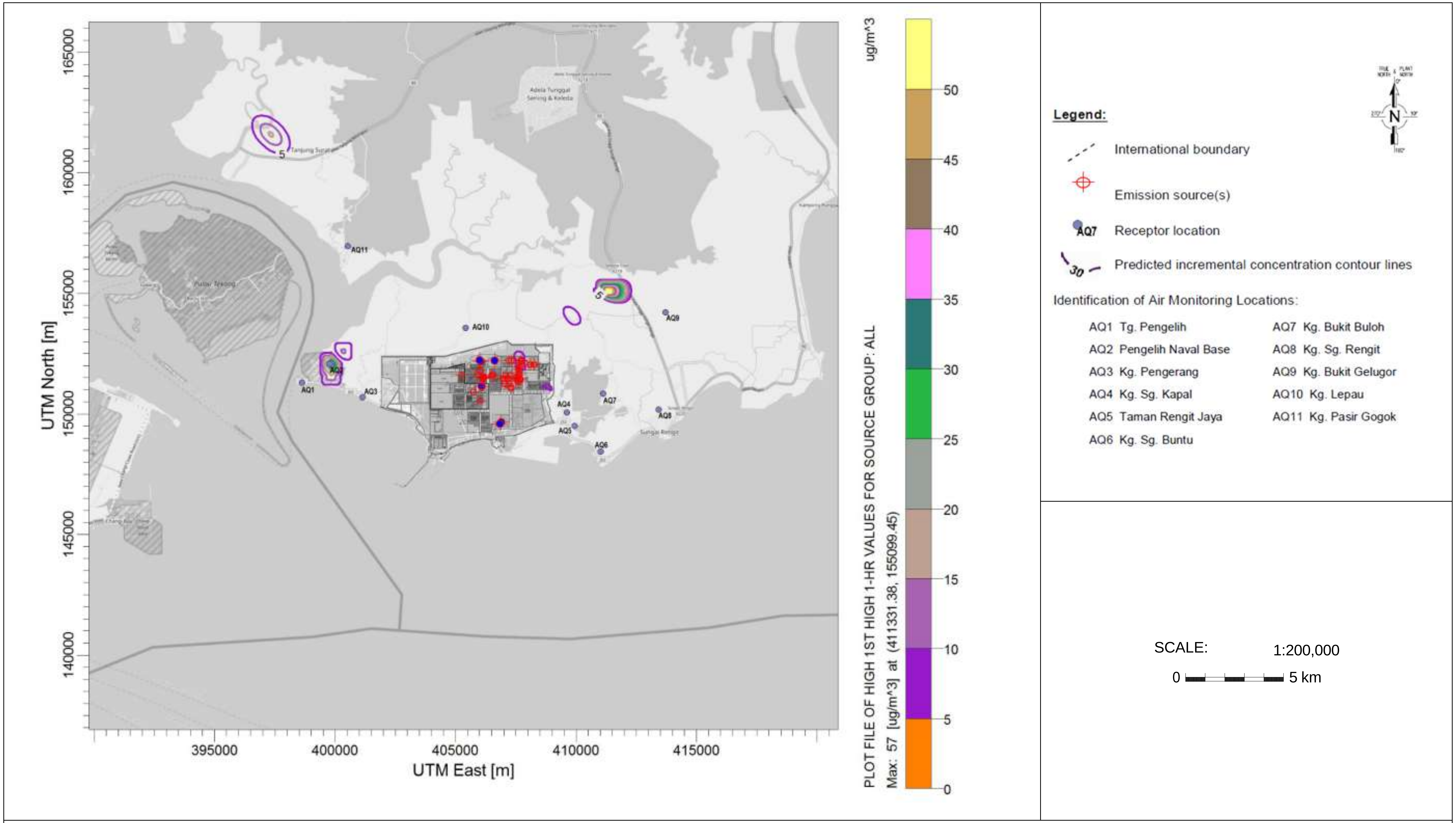


Figure 42: Predicted Incremental Ground Level Concentration for NMVOC During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

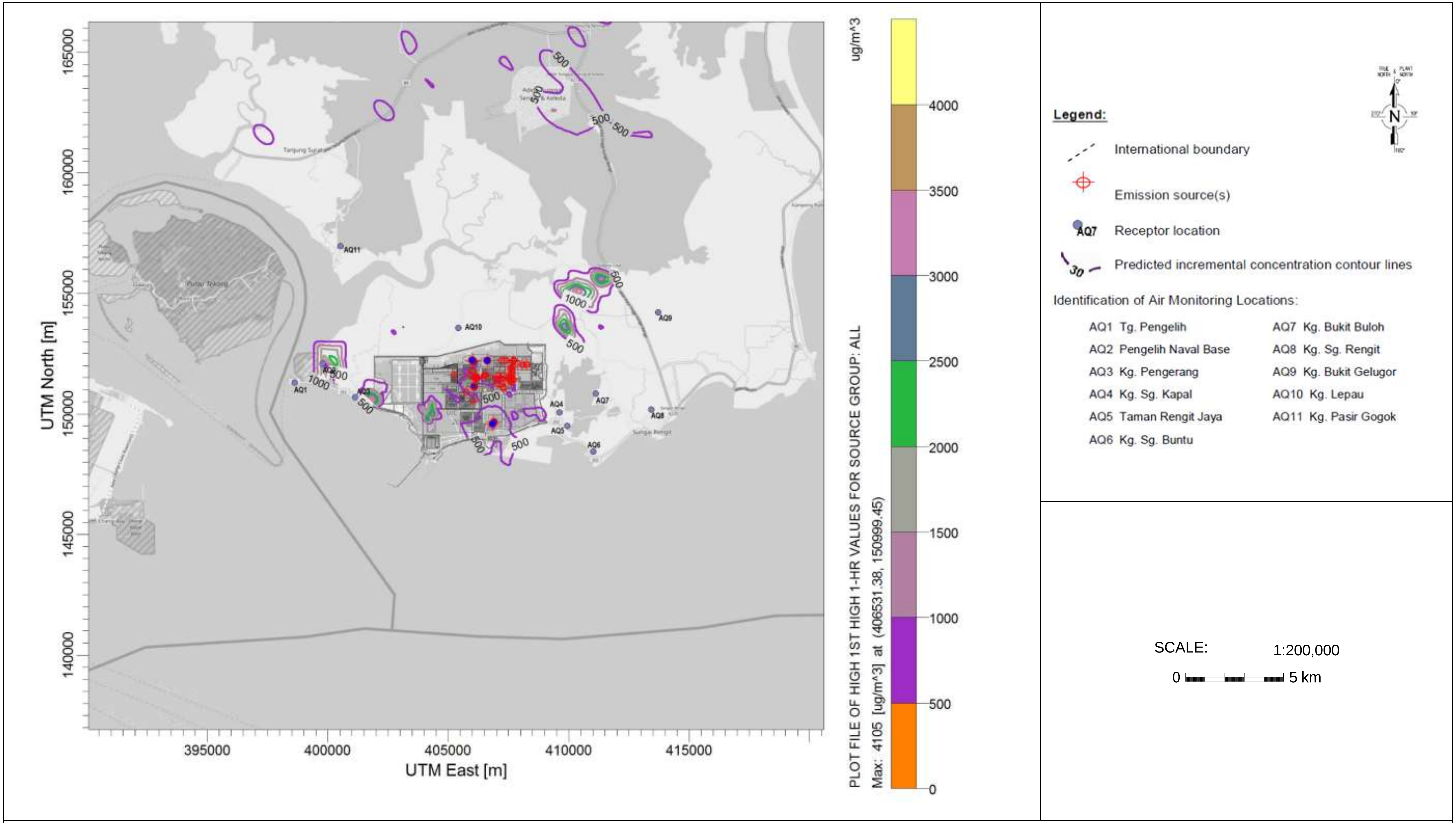


Figure 43: Predicted Incremental Ground Level Concentration for UHC During Abnormal Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

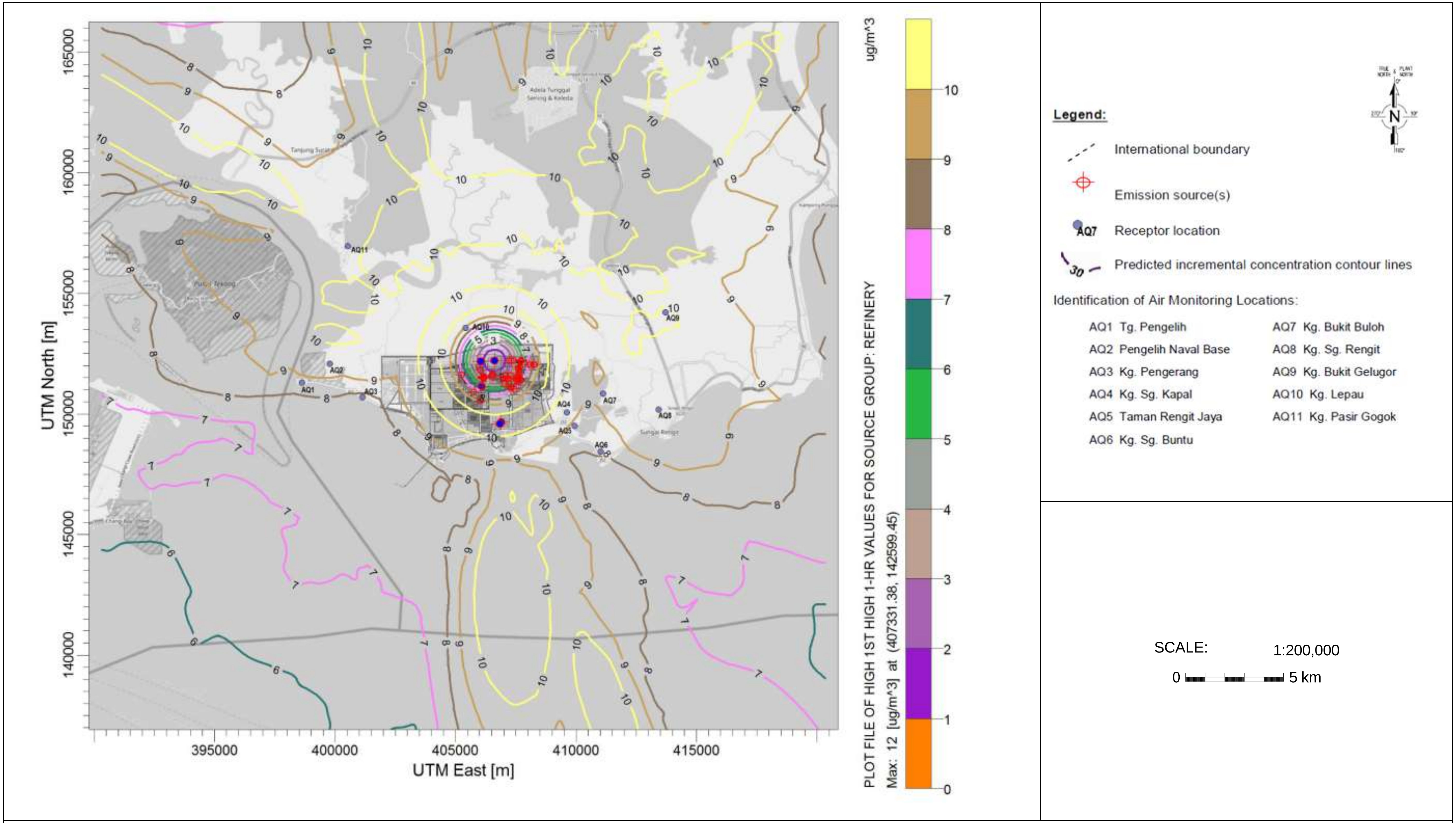


Figure 44: Predicted Incremental Ground Level Concentration for PM_{10} During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in $\mu g/m^3$)

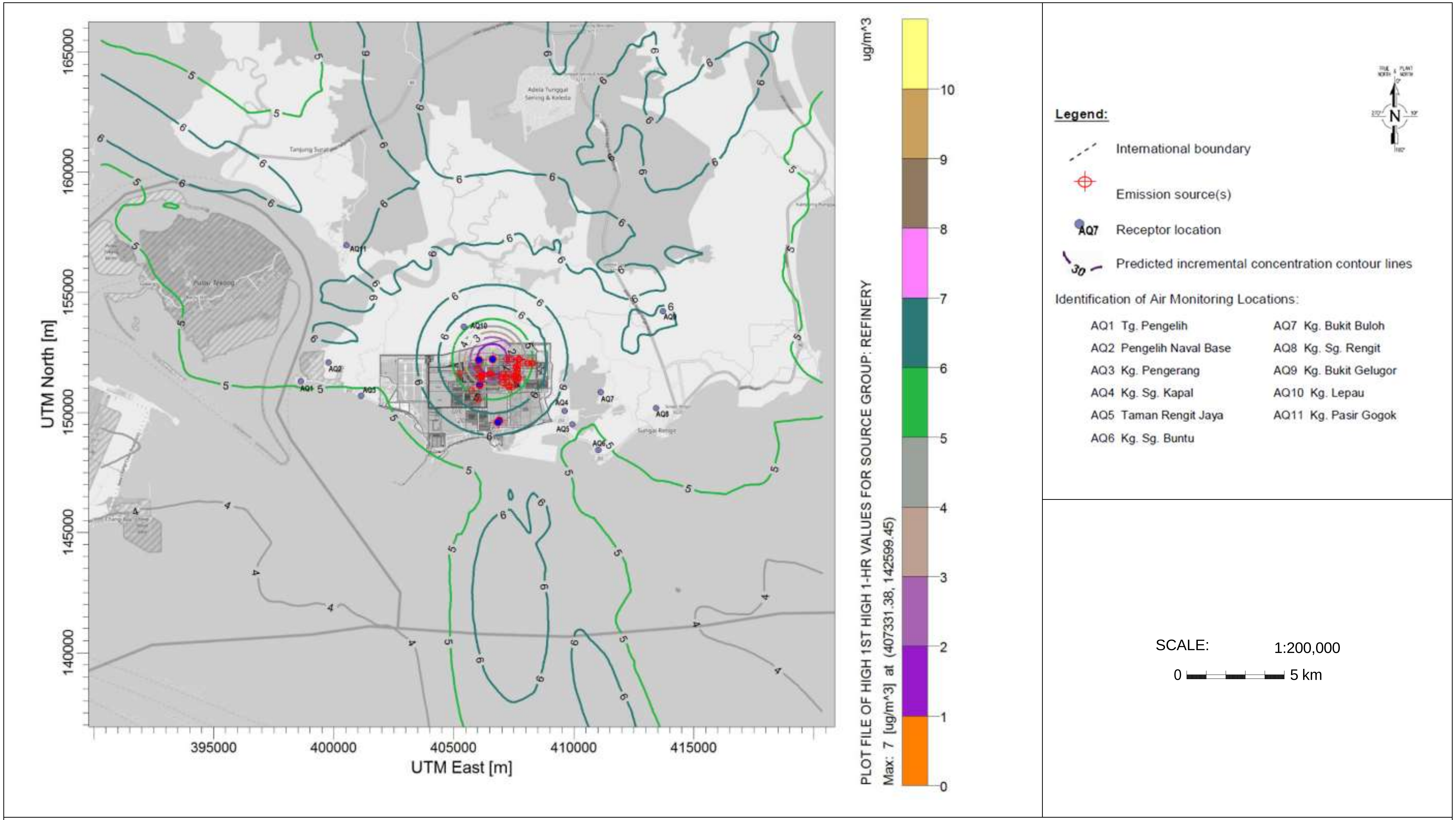


Figure 45: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

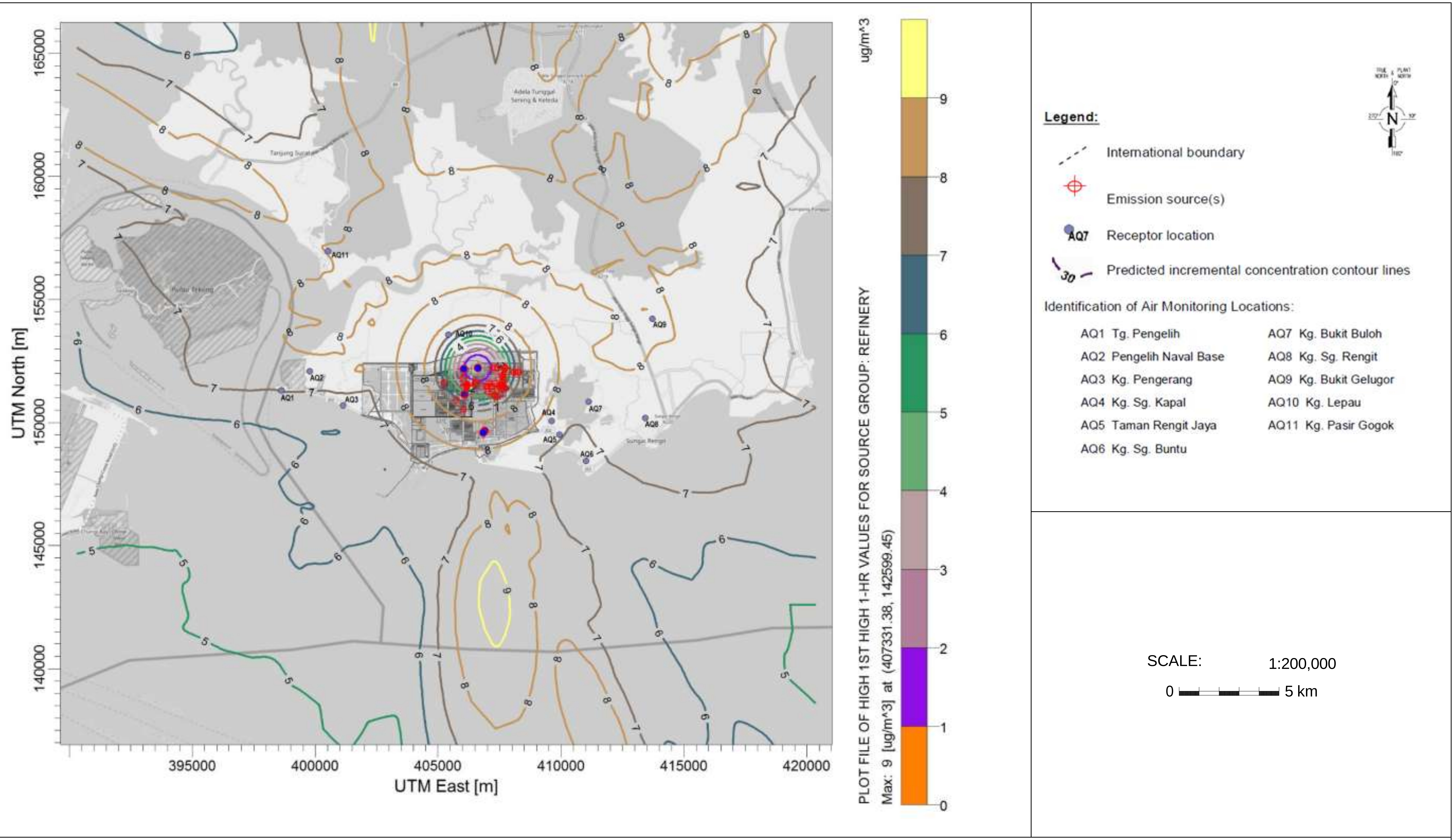


Figure 46: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

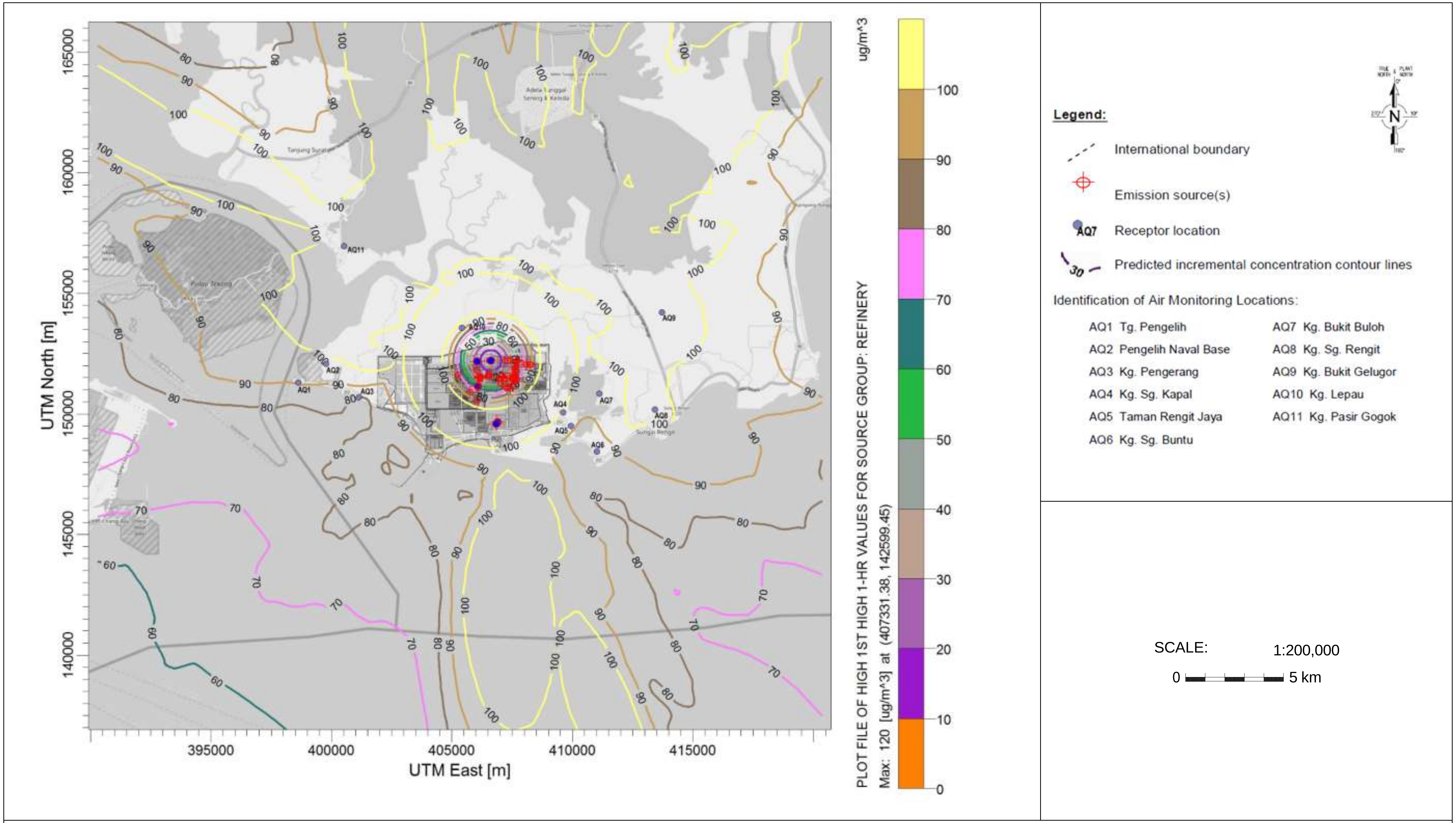


Figure 47: Predicted Incremental Ground Level Concentration for SO_2 During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

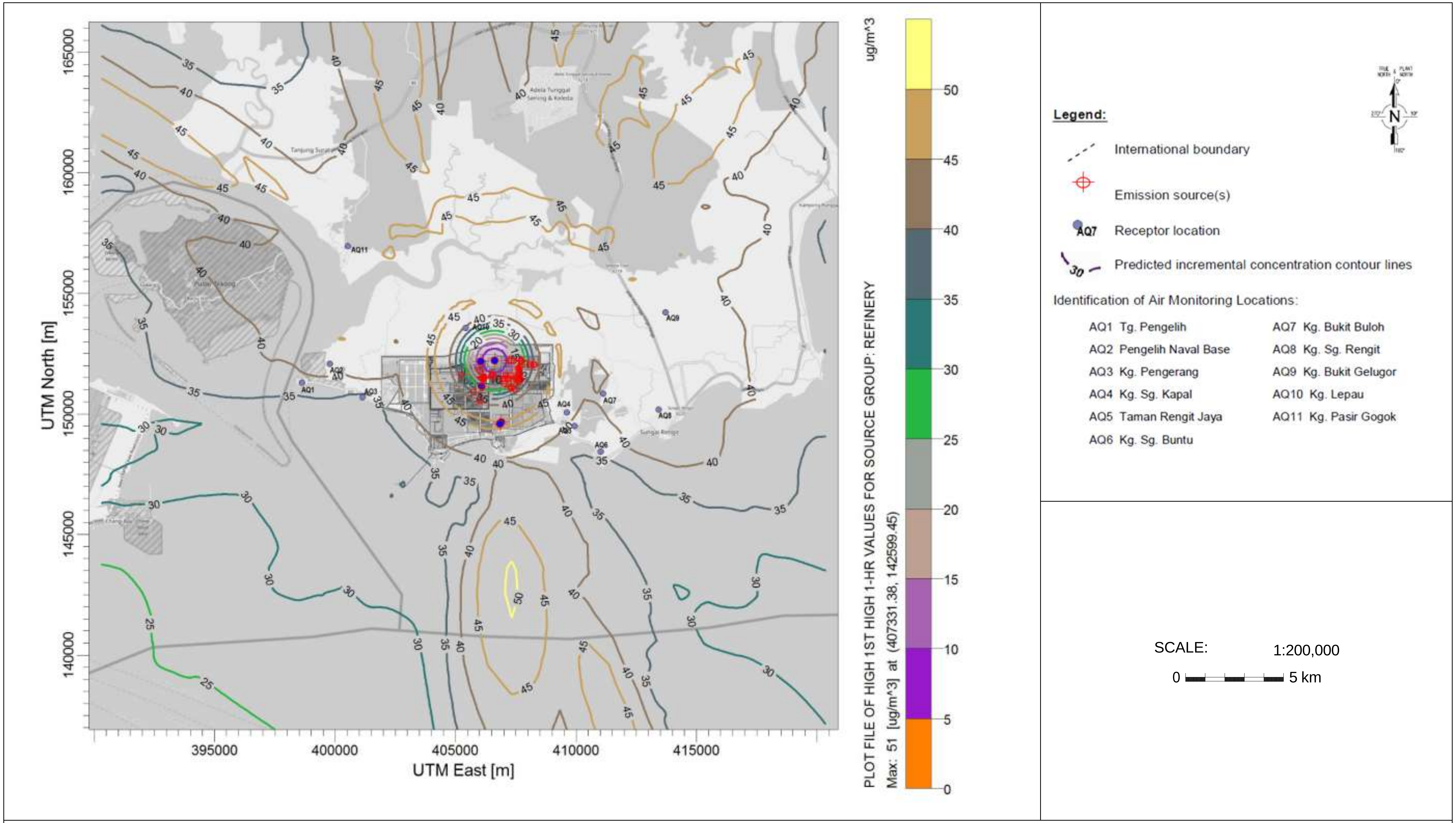


Figure 48: Predicted Incremental Ground Level Concentration for CO During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in μg/m^3)

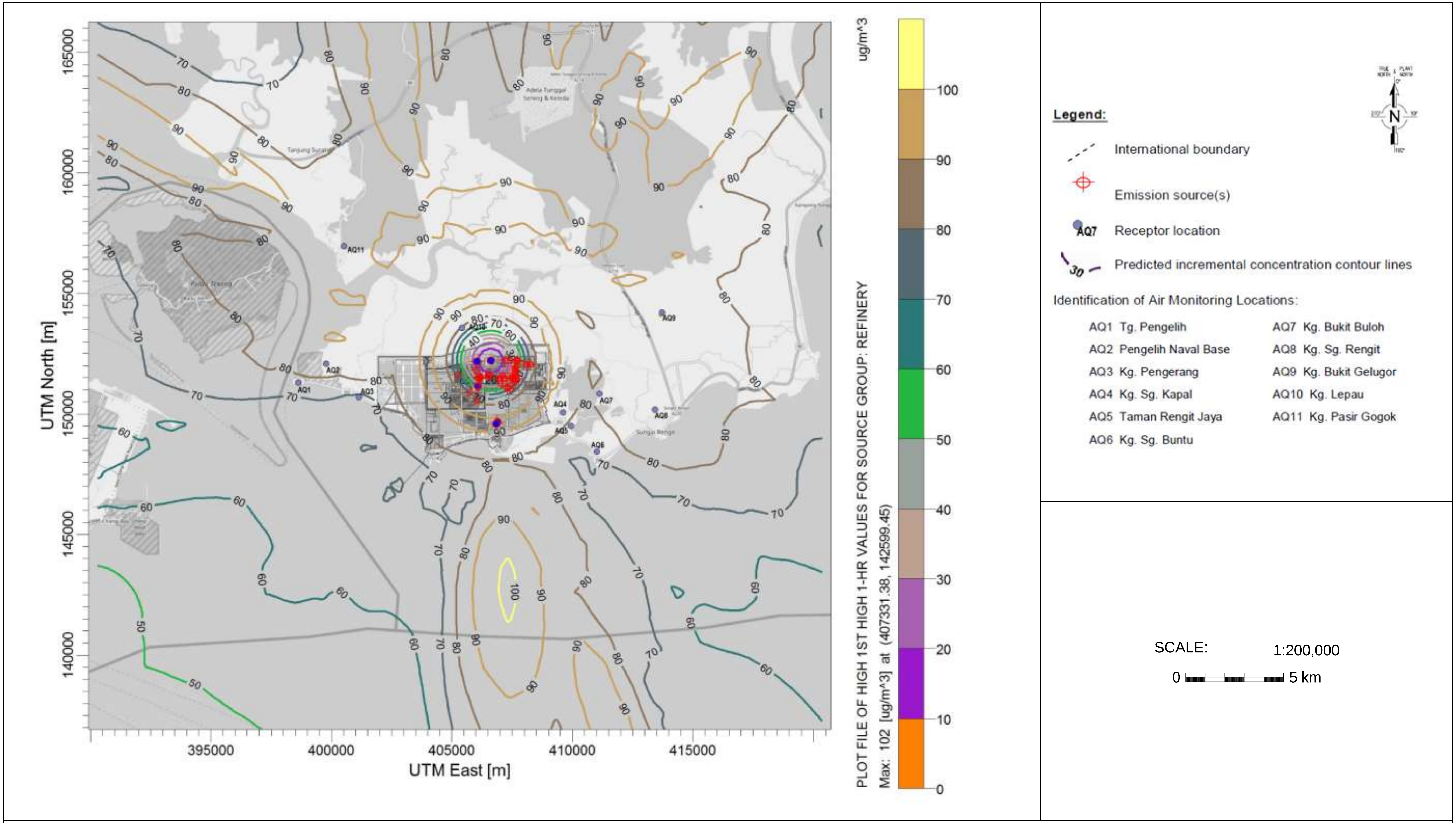


Figure 49: Predicted Incremental Ground Level Concentration for NMVOC During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m³)

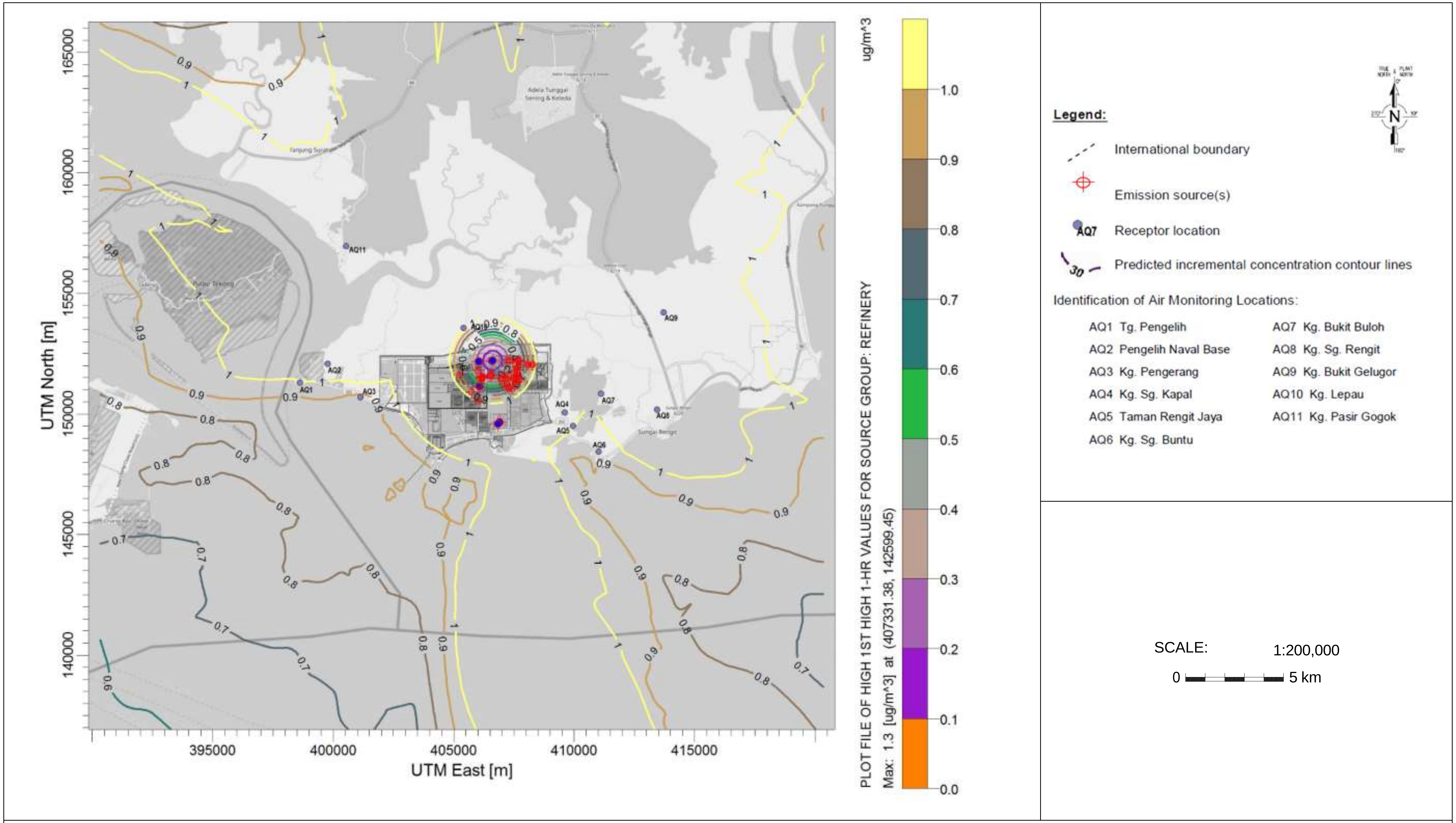


Figure 50: Predicted Incremental Ground Level Concentration for H_2S During Emergency Operation for Cumulative Refinery Cracker Complex (Maximum 1 hour Average in µg/m^3)

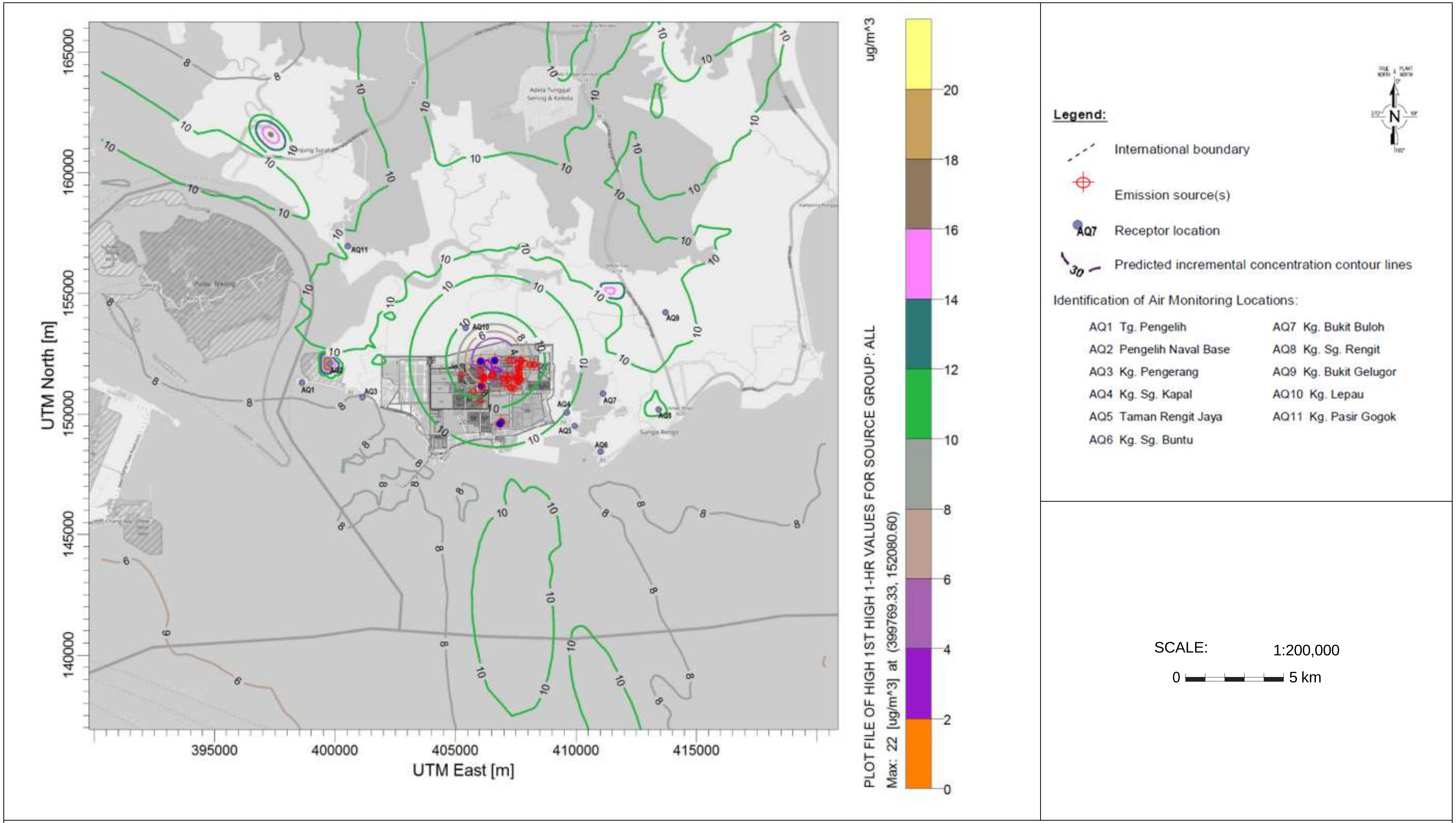


Figure 51: Predicted Incremental Ground Level Concentration for PM_{10} During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

AERMOD View - Lakes Environmental Software

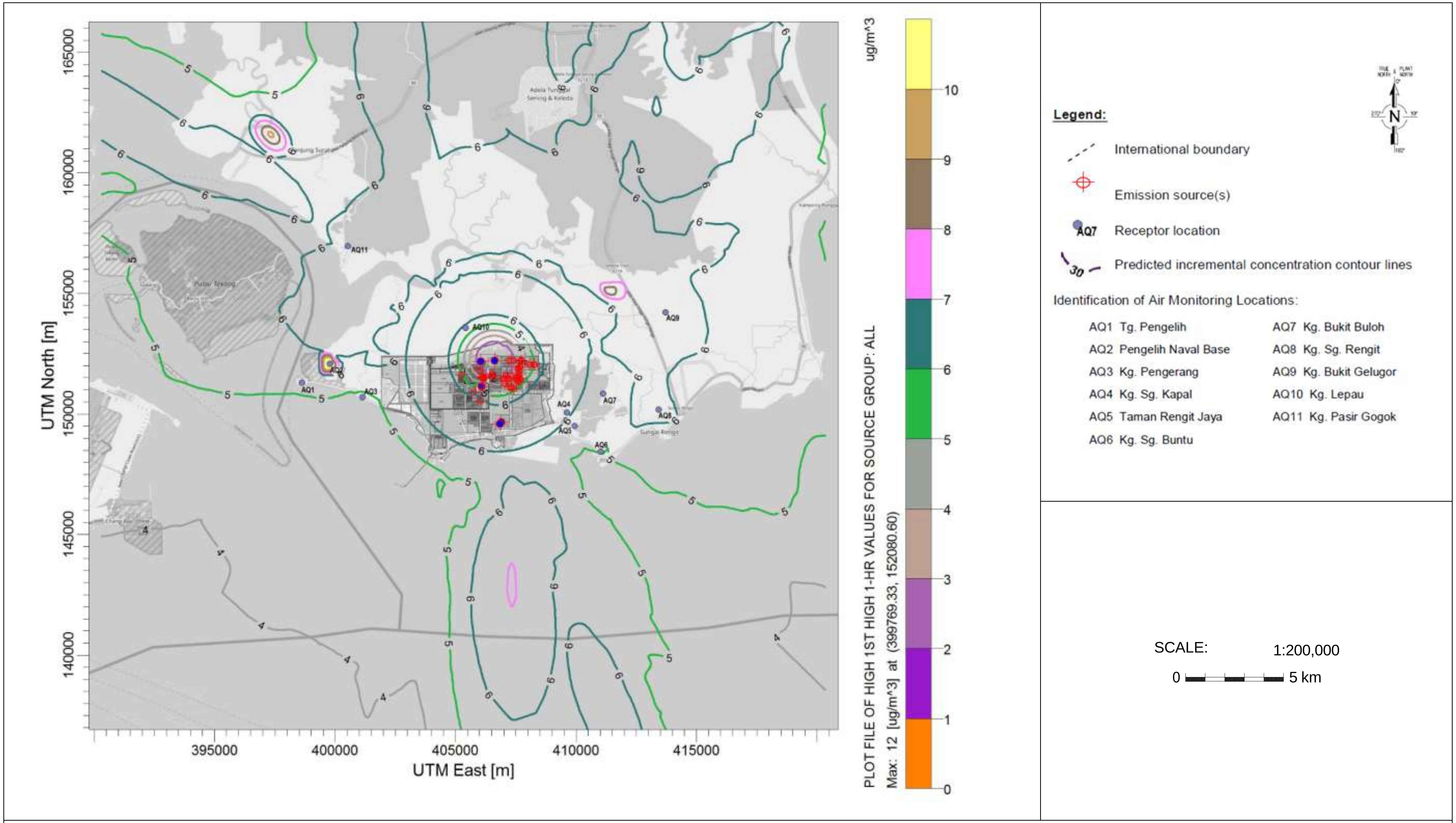


Figure 52: Predicted Incremental Ground Level Concentration for $PM_{2.5}$ During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

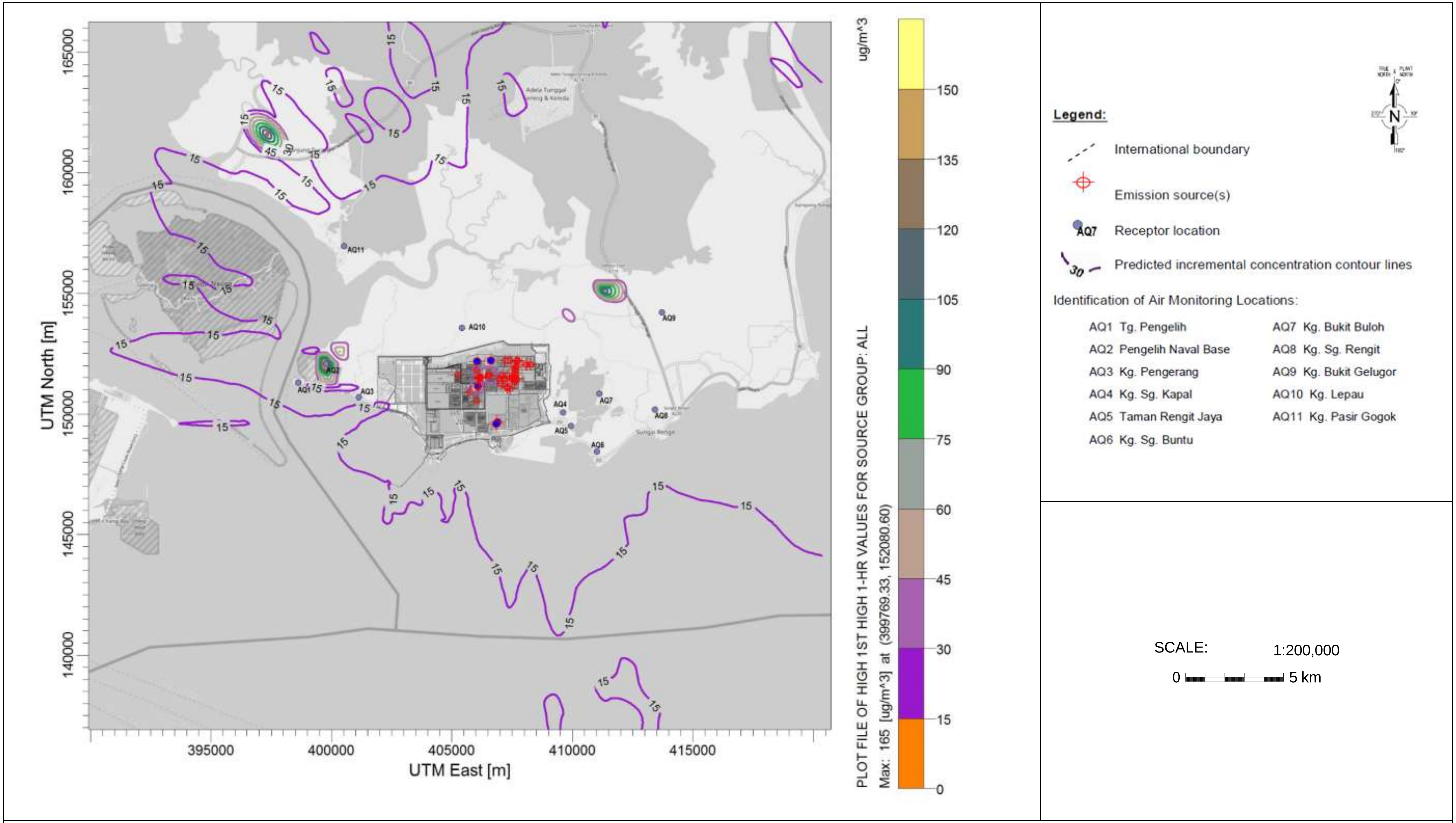


Figure 53: Predicted Incremental Ground Level Concentration for NO_2 Tier1 During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

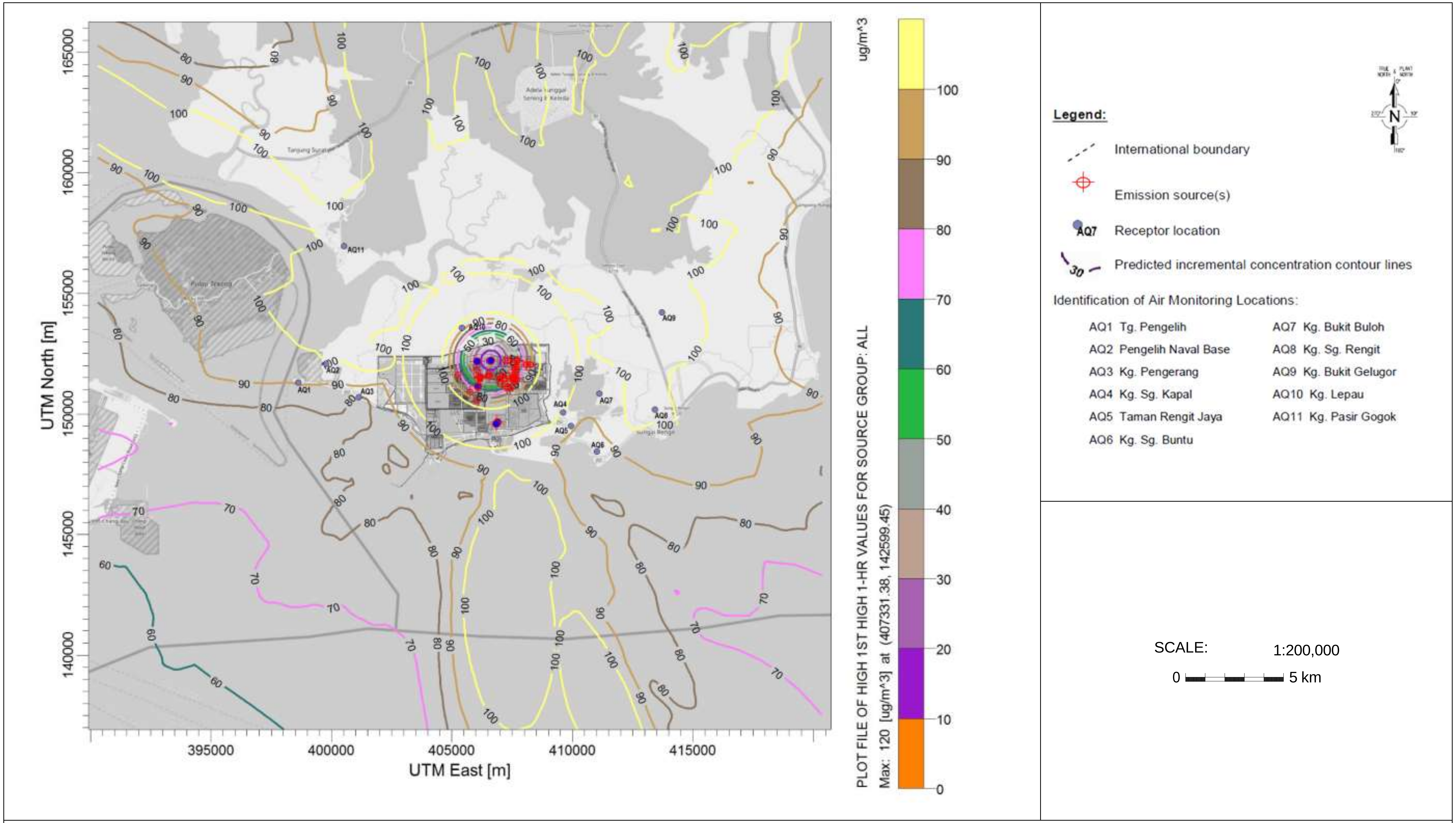


Figure 54: Predicted Incremental Ground Level Concentration for SO_2 During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

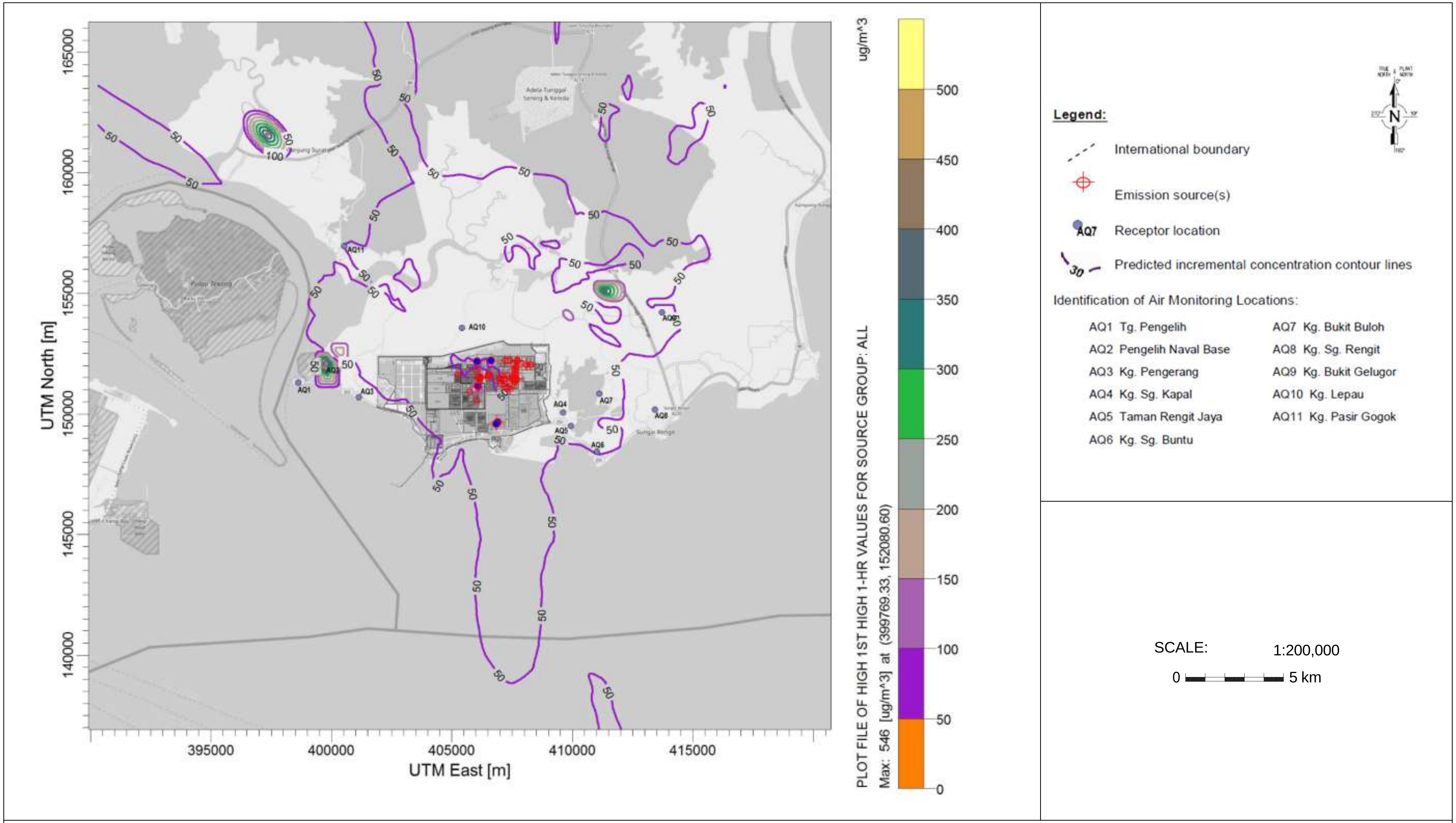


Figure 55: Predicted Incremental Ground Level Concentration for CO During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m³)

AERMOD View - Lakes Environmental Software

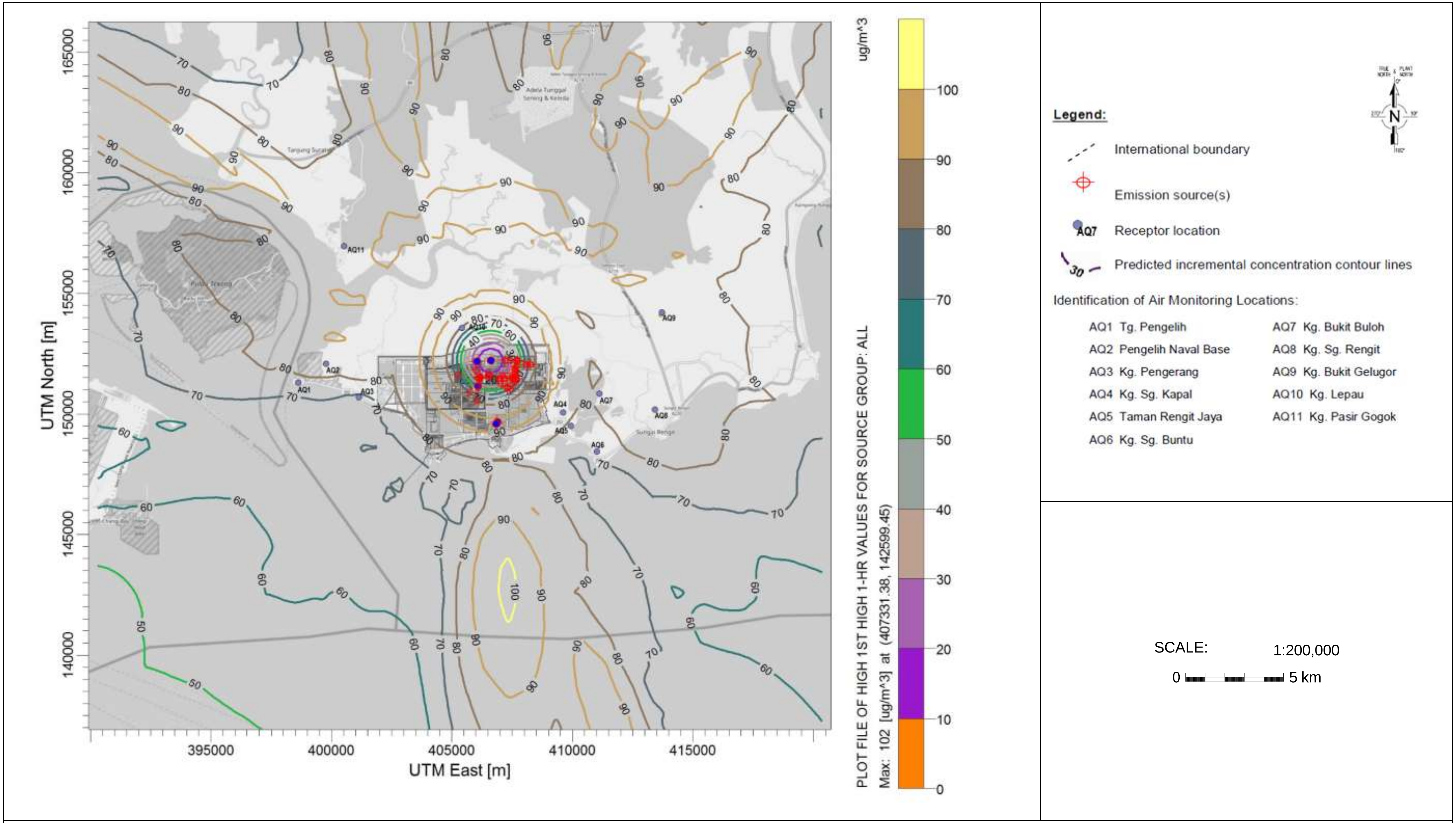


Figure 56: Predicted Incremental Ground Level Concentration for NMVOC During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in µg/m^3)

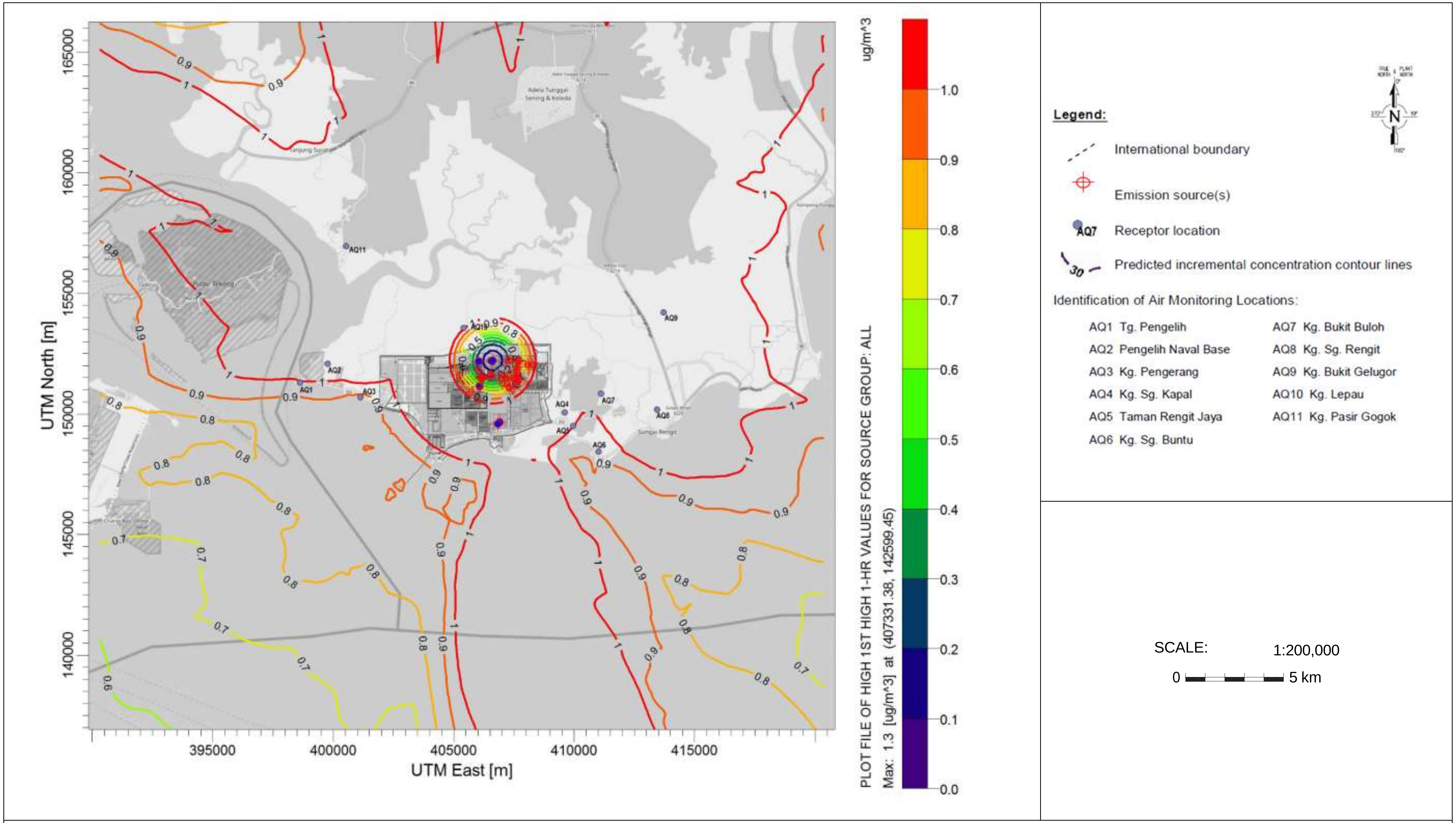


Figure 57: Predicted Incremental Ground Level Concentration for H_2S During Emergency Operation for Cumulative RAPID Complex (Maximum 1 hour Average in $\mu g/m^3$)

AERMOD View - Lakes Environmental Software

Health Impact Assessment

ADDITIONAL INFORMATION TO THE DEIA REFINERY AND PETROCHEMICAL INTEGRATED DEVELOPMENT (RAPID) PROJECT, PENGERANG JOHOR, 2012 TO INCLUDE EURO 5 MOGAS AND OLEFIN TANK UNITS

Prepared For:

PETRONAS REFINERY AND PETROCHEMICAL CORPORATION SDN. BHD.

Prepared By:

INTEGRATED ENVIROTECH SDN. BHD. (650387-K)

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1 INTRODUCTION

The units within Refinery & the Cracker Complex as in DEIA RAPID 2012 are maintained. The RAPID Refinery Cracker Complex was originally designed to produce diesel that meets the EURO 5 specifications and MOGAS (motor gasoline) that meet EURO 4 specifications. To upgrade and meet the EURO 5 MOGAS specifications, Refinery Cracker Complex has been expanded to include additional units as listed below:

1. 2nd Stage Cracked Naphtha Hydrotreating (CNHT 2) Unit
2. Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME) Unit
3. Isomerisation Unit
4. Additional Storage Tanks which consist of:

    i. Two Tertiary-Armyl-Methyl-Ether (TAME) storage tanks
    ii. Two Isomerate storage tanks
    iii. One Medium Cracked Naptha (MCN) Storage Tank

Besides that, there will be new olefin storage tankages located in the current refinery tank farms which consists of:

1. Four mounded bullets for Butadiene Storage
2. One Ethylene Tank
3. Four spheres for Propylene Storage

Details of the additional units are described in **Volume 1, Chapter 2**. This additional information report conducted studies to assess the impacts from these new process units and tank farms in the Refinery and Cracker Complex.

2 HEALTH RISK ASSESSMENT APPROACH

The health impact assessment (HIA) study will focus on the existing disease burden of the sensitive communities and on any potential impacts from the new units for EURO 5 MOGAS production and additional olefins storage.

The sensitive receptors are those people staying or institution located within the zone of impact (ZOI) of 5km radius from RAPID project boundaries. The current disease pattern among community members is very important as a baseline to ensure the health of present and future generations is secured and protected. Qualitative assessment is on the readiness of existing health facilities near the project site for a disaster management.

The scope of this HIA shall include:

i. The assessment of the disease burden of the affected communities residing nearby to the proposed project site.
ii. The estimation of the cumulative health risk status of the affected communities that based on the air dispersion modelling findings.

2.1 Applicable Regulatory Framework

In assessing the potential health impacts of the project, reference will be made to the following standards and guidelines.

i. Guidance Document on Health Impact Assessment (HIA) in Environmental Impact Assessment (EIA) 2012.
ii. Malaysian Ambient Air Quality Standard (2015).
iii. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment) USEPA 2009).

2.2 Pollutants Assessed

The pollutants assessed were particulates and gaseous emission parameters from the identified sources as adopted in the Air Emission Dispersion Study:

a) Simulation for air pollutant dispersion from the identified sources was conducted for:
   i. Emission from Olefin Storage Tanks,
   ii. The cumulative Refinery and Cracker Complex, and
   iii. The cumulative RAPID Complex.

b) The air pollutants that will be assessed for their health effects will be:
   i. Fine particulate ($PM_{2.5}$)
   ii. Respirable particulate (PM_{10})
   iii. Nitrogen dioxide (NO_2)
   iv. Sulphur dioxide (SO_2)
   v. Carbon monoxide (CO)
   vi. Ammonia (NH_3)
   vii. Methanol
   viii. Hydrogen sulphide (H_2S)

For non-methane volatile organic compounds (NMVOCs), it was not being assessed since there is no standard or guideline on its health effects. Similarly for unburned hydrocarbon (UH) that normally contain hydrogen and carbon, which collectively unhazardous to human being.

For the ambient air health risk exposure, three scenarios have been considered during the assessment based on air dispersion modelling that include:

i. Normal operation scenario with cumulative emissions from Refinery Complex and other RAPID components in normal operation mode,

ii. Abnormal operation scenario with unmitigated emissions from selected sources in the Refinery Complex including Olefin Storage Tanks with cumulative emissions from other RAPID components in normal operation mode, and

iii. Emergency operation scenario with unmitigated emissions from selected sources in the Refinery Complex with cumulative emissions from other RAPID components in normal operation mode.

Further details of the emission sources are shown in Volume 2, Appendix 1.

2.3 Identification of the Receptors

The identified sensitive receptors are shown in **Volume 1**, **Chapter 3** and **Chapter 4**.

2.4 Health Impact Assessment

The assessment will employ the approach adopted in the Guidance Document which comprises six basic steps, namely screening, scoping, hazard identification, dose-response assessment, exposure assessment, and risk characterization. For the characterization of the health risk, non-carcinogenic substances will be assessed as a hazard quotient (HQ) and their cumulative hazard index (HI). The cumulative HI should not more than one as representing a low risk condition with insignificant health adverse effects on the receptors. Since non of the potential pollutants behave as a carcinogen, the lifetime cancer risk is not being computed.

Table 2-1 shows the health effects of the particulate and gaseous air pollutants being considered in the HRA.

Further details of the approach and methodology for this study are shown in **Volume 1**, **Chapter 3**.

Table 2-1: Air Pollutant Health Impact

No.	Pollutant	Pollutant concentration (µg/m3) for ambient air		Health Impact
		Reference Limit	Health Exposure Limit Reference	
1	Nitrogen dioxide	280 (1-hour average)	Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020)	• Acute exposure to NO_2 cause pulmonary edema, pneumonitis, bronchitis, and bronchiolitis obliterans. • It's considered as relatively insoluble, reactive gas, such as phosgene and ozone. Once inhaled, it reaches the lower respiratory tract, affecting the bronchioles and the adjacent alveolar spaces, where it produces pulmonary edema within hours. • Many deaths from pulmonary oedema have been induced by acute inhalation of high concentrations of NO_2.
2	Carbon monoxide	30000 (1-hour average) 10000 (8-hours average)	Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020)	• Exposure to carbon monoxide can occur through inhalation of the gas and eye or skin contact with the liquid. • Inhalation of this asphyxiant gas causes tissue hypoxia by preventing the blood from carrying sufficient oxygen. Carbon monoxide combines reversibly with haemoglobin to form carboxyhemoglobin. The reduction in oxygen-carrying capacity of the blood is proportional to the amount of carboxyhemoglobin formed.
3	Sulphur Dioxide (SO_2)	250 (1-hour average)	Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020)	• Studies have shown that inhalation of SO_2 by asthmatics can cause a significant degree of wheezing at concentrations considerably lower than those which affect non-asthmatics. • Concentrations as low as 0.2 ppm have a significant effect, especially in subjects who are mouth breathing or undergoing heavy exercise. The effects appear to be short-lived and not increased by more prolonged exposure. • The effects on moderate or severe asthmatics, or those with marked liability of their asthma, could conceivably be seen at much lower concentrations of SO_2
4	Ammonia (NH_3)	130 (24-hours average)	Arizona Ambient Air Quality Guideline (This guideline is made as reference due to no reference limit for Ammonia (NH_3) in Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020))	• Ammonia is a colourless gas with a very sharp irritating odour. • Human water taste and odour thresholds for ammonia gas are at about 35 and 50 ppm concentrations, respectively. • It is a non-carcinogen corrosive substance that affects skin and mucous membrane in eyes, respiratory tract, mouth, and digestive tract. There is no evidence that its exposure causes birth defects or other developmental effects.

No.	Pollutant	Pollutant concentration (μg/m3) for ambient air		Health Impact
		Reference Limit	Health Exposure Limit Reference	
5	Methanol	4000 (24-hours average)	Canadian Ambient Air Quality Guideline (This guideline is made as reference due to no reference limit for Methanol in Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020))	• Methanol is a skin and eye irritant. It causes irritation, but only minor residual injury, including those requiring the use of an approved air-purifying respirator. • These materials are only slightly hazardous to health and only breathing protection is needed. • Acute poisoning causes initial drowsiness, confusion and ataxia. Then the patient may experience nonspecific malaise, headache, vomiting, abdominal pain, nausea, vomiting, and visual changes. • If untreated, central nervous system depression progresses to encephalopathy, rapid respirations, metabolic acidosis with hypokalemia. • Visual defects are described as blurred or "snowfield" like vision. If untreated, methanol poisoning progresses to coma, metabolic acidosis, and finally respiratory or circulatory arrest. • The minimum lethal dose of methanol in the absence of medical treatment is between 0.3 and 1 g/kg body weight. • The immediately dangerous dose of life or health is 6000 ppm, equal to $8X10^6$ mg/m^3. • At this moment, no studies were found on the possible carcinogenic activity of methanol in humans or experimental animals.
6	Hydrogen sulphide (H_2S)	270 (24-hours average)	Arizona Ambient Air Quality Guideline (This guideline is made as reference due to no reference limit for Hydrogen Sulphide (H_2S) in Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020))	• Exposure to low concentrations of hydrogen sulphide may cause irritation to the eyes, nose, or throat. It may also cause difficulty in breathing for some asthmatics. • High concentrations of hydrogen sulphide (greater than 500 ppm) may cause loss of consciousness. • The inhalation reference limit for hydrogen sulphide according to the Arizona Ambient Air Quality is $270ug/m^3$ for 24 hours exposure.
7	PM10	100.0 (24-hours average)	Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020)	• Particulate matters and total suspended solids are capable of provoking respiratory system irritation, with the release of mediators causing exacerbations of lung disease and increasing blood coagulability in susceptible individuals. • This ultra-fine particulate with a mass median aerodynamic diameter less than 10 microns (PM_{10}) may mediate some of the adverse health effects reported in which there is toxicologic evidence to support this contention. • The health effects for $PM_{2.5}$ is considered worst than PM_{10} in general since it's capable of entering the systemic circulation more easy. These particles are able to enhance calcium influx on contact with macrophages.
8	PM2.5	35 (24-hour average)	Malaysian Ambient Air Quality Standards 2013 (Interim Target 2020)	

No.	Pollutant	Pollutant concentration (µg/m3) for ambient air		Health Impact
		Reference Limit	Health Exposure Limit Reference	
				• Oxidative stress is also to be anticipated, which augmented by oxidants generated by recruiting inflammatory leukocytes producing atheromatous plaques form in the coronary arteries, which one of the causes of morbidity and death associated epidemiologically with particulate air pollution.

3 IMPACTS AND MITIGATION MEASURES

This section details the public health impact assessment of the air pollutant emission from the Cumulative Refinery & Cracker Complex and Cumulative RAPID Complex during the operation phase based on the findings from the Air Dispersion Modeling Study (**Volume 2, Appendix 1**).

3.1 Existing Public Health

This described the present health status of the population residing nearby to the project's site. It will involve the secondary data on disease morbidity, particularly on communicable and non-communicable diseases that will be requested from the District Health Office of Kota Tinggi. These tasks had already been completed in the approved Overall RAPID DEIA, 2012 submitted to the DOE. However, this report will add more data up to 2015.

3.1.1 Existing Public Health Status

Health Impact Assessment (HIA) is one of the important components in Environmental Impact Assessment (EIA) in safeguarding the health of apparently exposed communities to potential pollutants arose from the proposed project.

The aim of this section of health impact assessment (HIA) was to study the current local health care system and to evaluate their capability of providing services to the local population. Next aim was to determine the present burden of diseases among the communities, particularly for people staying in the district of Kota Tinggi, Johor. It's also include communities within the zone of impact of 5km radius that similar to other existing previous health impact assessment for RAPID. The burden of diseases consists of both communicable and non-communicable diseases.

The district of Kota Tinggi is most probably will gain more job opportunities for local people, which indirectly boost up its domestic trading and district income from various taxes. Until the smallest stage of mukim, both Sungai Rengit and Pengerang will be in advantage than other mukims.

More physical developments like roads, small cities and housing area's construction will rise tremendously around this proposed project. Those positive developments normally increase per capita income of local people due to the influx of workers from neighbouring states and countries that increase market demand for goods, foods, shelter and transportation. On the other hand, health problems may become more prominent that granted for an effective prevention and tight surveillance measures.

Kota Tinggi is one of the districts in the State of Johor located in the southeast part of the Peninsular Malaysia with an estimated midyear total population of 238,130 in 2015. It is managed by a local district council manned by a district officer. The main development mukims in the district are the town of Kota Tinggi itself, and Pengerang. The district has 100% coverage of sanitary latrines, safe drinking water supply and electrical power. All townships are readily connected with available good tarred road all over the areas.

3.1.2 Health care services in Kota Tinggi

The district area is served by the Kota Tinggi Hospital since 1913. Started with 60 beds, but now it has a total of 158 beds with a complete range of medical care facilities (**Figure** 3-1). The average number of admissions per day is about 36 cases. With expert medical attention and treatment, most of the patients only stay for an average of 1.7 days. There are about nine doctors with 14 staff nurses. Its emergency unit has four ambulances partially equipped with acute treatment.

Figure 3-1: Hospital Kota Tinggi

There are three health care centres for outpatient treatment. One placed at the Outpatient Department at Hospital Kota Tinggi it, Sungai Rengit Health Centre and Bandar Penawar Health Centre. Sungai Rengit Health Centre is overseen by two medical doctors, two medical assistants, five staff nurses, six community nurses, and two drivers. The centre had received another ambulance for acute emergency transportation from RAPID Petronas as one of their corporate social responsibility (CSR). The clinic is still under renovation and will provide an 24-emergency service for acute cases. Complicated cases usually been transferred to Kota Tinggi Hospital, which is about 65 km away to the north but with good wide tarred roads.

Another health centre is at Bandar Penawar, which also going to be upgraded and expended for the incoming number of workers and communities. One rural clinic at Telok Ramunia focuses on antenatal and child health. There are a few private clinics around Sungai Rengit township that provide a general physician care.

3.1.3 Burden of Diseases

3.1.3.1 Respiratory tract diseases

Acute respiratory infection is the most common lung's problem among communities in Kota Tinggi (**Table** 3-1). Influenza virus infection was the second common respiratory diseases followed by bronchial asthma and pneumonia. These followed by pulmonary tuberculosis. All these respiratory diseases increased in the number of cases compared to the year 2014, except for influenza and pneumonia. The excessive burden might due to unhygienic conditions, overcrowded and poor ventilation of the housing areas.

3.1.3.2 Vector-borne diseases

Table 3-2 shows the number of dengue fever and leptospirosis cases last year was nearly double the number of cases in 2014. The district was not spared from filariasis and malaria, but in minimal number of cases. Still, the area was free from chikungunya, plague, typhus, and yellow fever.

Table 3-1: The number of respiratory diseases in Kota Tinggi, 2014 and 2015

Disease	Year	
	2014	2015
Acute respiratory infection	39136	46726
Bronchial asthma	921	1324
Influenza	2080	2004
Pneumonia	62	0
Tuberculosis	158	162

Source: The Health District of Kota Tinggi (2016)

Table 3-2: The number of vector-borne diseases in Kota Tinggi, 2014 and 2015

Disease	Year	
	2014	2015
Chikungunya	0	0
Dengue Fever	234	592
Dengue Haemorrhage Fever	2	1
Leptospirosis	10	22
Lymphatic Filariasis	6	4
Malaria	5	6
Plague	0	0
Typhus	0	0
Yellow Fever	0	0

Source: The Health District of Kota Tinggi (2016)

3.1.3.3 Food and Water-borne Diseases

Food poisoning is one example of food and water-borne diseases that present in this area. The trend showed a decreasing pattern in the last year compared to numerous number of cases in 2014 (**Table** 3-3). The district also has recorded a few numbers of typhoid cases in 2015. These isolated cases might be due to improper food preparation and handling. Other diseases like cholera, dysentery, and hepatitis A infection, giardiasis and helminths manifestation were absent from the district.

Table 3-3: The number of food and water-borne diseases in Kota Tinggi, 2014 and 2015

Disease	Year	
	2014	2015
Cholera	0	0
Dysentery	0	0
Food Poisoning	121	80
Giardiasis	0	0
Helminths	0	0
Hepatitis A	0	0
Typhoid	0	2

Source: The Health District of Kota Tinggi (2016)

3.1.3.4 Sexually Transmitted Infections (STIs)

Pertaining to sexual related diseases, the district has only few reported cases of all STIs (**Table** 3-4). These diseases are the proxy for blood exposure either through the genital tract bleeds or contaminated needle in the study area, which still under controlled.

However, based on the trend of those diseases, both HIV and hepatitis B were found to be consistently present until last year in 2015. This indicated the availability of exposure and poor sexual behaviour among the communities, but solely by a little group of citizenry. Other STIs like syphilis and gonorrhoea were reduced and well contained. The district has been free from Chlamydia and AIDS.

Table 3-4: The number of sexually transmitted infections in Kota Tinggi, 2014 and 2015

Disease	Year	
	2014	2015
AIDS	0	0
Chlamydia	0	0
Gonorrhoea	4	2
Hepatitis B	13	14
HIV	21	26
Syphilis	3	2

Source: The Health District of Kota Tinggi (2016)

3.1.3.5 Accidents and Injury

There were a significant number of injuries due to road traffic accidents among the local people staying around the Kota Tinggi areas (**Table** 3-5). There were about 5600 and 3452 accidents in Kota Tinggi, 2014 and 2015 respectively. Even though the two-year trend showed improvement in road safety in the area, it’s still among the top causes of admission and death cases at Hospital Kota Tinggi.

Table 3-5: The number of road traffic accidents in Kota Tinggi, 2014 and 2015

Problem	Year	
	2014	2015
Road traffic accident	5600	3452

Source: The Health District of Kota Tinggi (2016)

3.1.4 Summary on Existing Public Health

In summary, the district of Kota Tinggi, where the proposed project will be built, was not free from certain common diseases such as acute respiratory infection, tuberculosis, dengue fever, leptospirosis, malaria, food poisoning, HIV and road traffic accidents were found to be present in quite a significant number of cases.

Most of the diseases seen in the area are preventable and manageable. The health authorities need to carefully monitor their surveillance system. The respiratory diseases may due to poor sanitation and bad air quality that required better ventilation and strengthening of legislation towards good air quality status and housekeeping.

With the presence of huge workforce around the area, the health authorities have to monitor it closely and proactively. They should be monitored for the presence of certain diseases like malaria and STIs. Limitation of movement and contact with surrounding communities should be able to prevent any spread of the disease. The health care system in the area was fully accepted. However, the present staffs need further training to strengthen their acute care knowledge.

In general, the existing burden of diseases of the communities near the proposed project posed certain level of health risk to both workers and the communities. Medical precaution is needed, especially for workers' health and disease prevention.

3.2 Impact from emission from the Individual Units

3.2.1 EURO 5 MOGAS Unit

a) Normal Operation Scenario

During this scenario, the EURO 5 MOGAS vent is routed to CHNT2 Unit to be treated before discharged to atmosphere. Data from the air dispersion modellinig showed that:

- All sensitive receptors have hazard index (HI) of not more than one. These indicate that all locations are predicted to have a good ambient air quality during normal release from the EURO 5 MOGAS unit (**Table 3-6**).
- The maximum point for PM_{10} is expected to occurred at Bukit Penggerang with concentration of 36.034 µg/m^3. This give rise the HQ value of 0.4, which is not more than one. Therefore, in normal scenario, the new unit wont poses any significant health risk to all receptors.
- For $PM_{2.5}$, its maximum ground concentration is also predicted to happened at Bukit Penggerang with estimated incremental of 0.034 µg/m^3. This give rise the HQ of less than one (0.001), which indicate the unit is expected not to createany substantial health hazard to all surrounding receptors.
- Pertaining to SO_2 emission from the new unit, the highest point is expected also at the Bukit Penggerang with concentration of 1.1 µg/m^3. The HQ is only 0.004 that indicate no significant health risk to all identified receptors.
- The highest concentration of NO2 (tier-1) is also been predicted to occur at the Bukit Penggerang with the 30.8 µg/m^3. This give the HQ of 0.1, which indicates of no significant health risk will be impose during normal operation of the new EURO 5 MOGAS unit.

- Specific on CO, its maximum point is predicted to be occurred at Bukit Penggerang with concentration of 101.1 µg/m^3 that gives the value of HQ of 0.01. All receptors are free from any health risk of CO emission.

In summary, the new EURO 5 MOGAS unit is found to have no significant health impact to all receptors during normal operating condition.

b) Abnormal Operation Scenario

Emission from this unit during abnormal scenario is as per normal operating condition.

c) Emergency Operating Scenario

No emergency operating scenario modelling is done for this system as the waste gasses are flared and this is expected to be temporary less than 1 hour.

3.2.2 Olefins Storage Tankages

a) Normal Operation Scenario

No air dispersion modeling was done for the Olefin Storage Tanks since there is no continuous emission.

b) Abnormal Operation Scenario

Intermittent emission from Olefin storage tanks is routed to the Cold Flare located within the Olefin Storage Tank. In this scenario, only NO_2 (tier-1) and CO are being assessed and computed as other pollutants are not relevant.

- All sensitive receptors have hazard index (HI) of not more than one. These indicate that all receptors are predicted to have a clean and good quality of air during intermittent release from the Olefin Storage Tanks (**Table 3-7**).

- However, the maximum point for NO2 (tier-1) is predicted to occur at RAPID complex with concentration of 308.1 µg/m^3. This give the hazard quotient (HQ) of 1.1, which indicates of no significant health risk will be impose if abnormal operation occured.
- Pertaining to CO, its maximum concentration is predicted to be at 1814.0 µg/m^3 that gives the value of HQ of 0.1. The value means that during abnormal scenario, its predicted to have no substantial health risk.

In conclusion, for the Olefin Storage Tanks air emission have no significant health impact to all sensitive receptors and people working within RAPID complex itself during abnormal operating scenario.

c) Emergency Operating Scenario

No emergency operating scenario modelling is done for this system as the waste gasses are flared and this is expected to be temporary less than 1 hour.

Table 3-6: Predicted Concentration, Hazard Quotient and Hazard Index for the EURO 5 MOGAS Unit (Normal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	PM_{10} (24 hours average)		$PM_{2.5}$ (24 hours average)		SO_2 (1 hour average)		NO_2 (Tier 1) (1 hour average)		CO (8 hours average)		Hazard Index
	Conc. (µg/m^3)	HQ	Conc. (µg/m^3)	HQ	Conc. (µg/m^3)	HQ	Conc. (µg/m^3)	HQ	Conc. (µg/m^3)	HQ	
Tg. Pengelih	24.0	0.24	0.0012	0.00003	5.0	0.07143	5.8	0.0232	100.0	0.01	0.3
Pengelih Naval Base	24.0	0.24	0.0339	0.00097	6.1	0.08714	30.8	0.1232	101.1	0.01011	0.5
Kg. Penggerang	36.0	0.36	0.0019	0.00005	5.1	0.07286	6.2	0.0248	100.1	0.01001	0.5
Kg. Sg. Kapal	25.0	0.25	0.0068	0.00019	5.1	0.07286	6.7	0.0268	100.1	0.01001	0.4
Taman Rengit Jaya	38.0	0.38	0.0050	0.00014	5.1	0.07286	7.0	0.028	100.1	0.01001	0.5
Kg. Sg. Buntu	28.0	0.28	0.0039	0.00011	5.1	0.07286	6.8	0.0272	100.1	0.01001	0.4
Kg. Bukit Buloh	31.0	0.31	0.0017	0.00004	5.1	0.07286	6.8	0.0272	100.0	0.01	0.4
Kg. Sg. Rengit	20.0	0.2	0.0014	0.00004	0.1	0.00143	1.6	0.0064	0.0	0.000	0.2
Kg. Bukit Gelugor	22.0	0.22	0.0015	0.00004	5.1	0.07286	6.6	0.0264	100.0	0.01	0.3
Kg. Lepau	35.0	0.35	0.0017	0.00005	5.1	0.07286	6.9	0.0276	100.1	0.01001	0.5
Kg. Pasir Gogok	20.0	0.20	0.0011	0.00003	0.0	0.00000	1.1	0.0044	0.0	0.00000	0.2

Table 3-7: Predicted Concentration, Hazard Quotient and Hazard Index for the Olefin Storage Tanks (Abnormal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	NO_2 (Tier 1) (1 hour average)		CO (8 hours average)		Hazard Index
	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	
Tg. Pengelih	14.7	0.0	99.1	0.0	0.0
Pengelih Naval Base	133.7	0.5	714.3	0.0	0.5
Kg. Penggerang	17.0	0.1	112.1	0.0	0.1
Kg. Sg. Kapal	35.0	0.1	172.8	0.0	0.1
Taman Rengit Jaya	30.4	0.1	160.9	0.0	0.1
Kg. Sg. Buntu	26.5	0.1	132.1	0.0	0.1
Kg. Bukit Buloh	43.6	0.2	222.2	0.0	0.2
Kg. Sg. Rengit	16.2	0.1	111.3	0.0	0.1
Kg. Bukit Gelugor	18.5	0.1	87.7	0.0	0.1
Kg. Lepau	29.4	0.1	147.5	0.0	0.1
Kg. Pasir Gogok	14.1	0.0	84.8	0.0	0.0

3.3 Impact from Cumulative Refinery & Cracker Complex

a) Normal Operation Scenario

For this normal operation scenario, the available baseline concentrations were only for PM_{10}, SO_2, NO_2, and CO. Others are not detected during the baseline study. Therefore, for particular pollutants like NH_3, methanol, and H_2S, their respective maximum incremental limits were used as a proxy for their ground concentrations.

- As for the health risk characterisation, none of the receptors have hazard index (HI) of more than one (**Table 3-8**). This means that for this refinery cracker complex, the ambient air quality is predicted to pose a low risk to health and will not cause any excess of health problems among the exposed receptors or population.
- However, in assessing for the individual pollutants, the highest point of incremental of PM_{10} is predicted to occur at Bukit Penggerang that's quite far away from those sensitive receptors. The maximum cumulative ground concentration is about 1.8 µg/m^3 with a HQ value of 0.2 that not more than one. The condition itself is safe with low health risk.
- For SO_2, the highest point is within the RAPID complex of 90.5 µg/m^3 that give rise to HQ value of 0.36, which it's health risk is not significant. All sensitive receptors are secured.
- For NO_2 (tier 3), the maximum predicted concentration is at Bukit Pelali with 479.5 µg/m^3 predicted concentration. Its HQ is 1.7, which still not more than one indicating of no substantial health hazard. The hilly area is actually far away from any sensitive receptors in the study.
- For CO, it's maximum ground concentration is predicted to occur within the RAPID complex with a value of 204.8 µg/m^3 that give HQ of 0.02, it is no significant health implication.

- Pertaining to NH_3, it is predicted to reach the maximum incremental limit of 0.302 µg/m^3, also within RAPID complex. Its HQ is about 0.001, which significantly no excess of health hazard.
- For methanol, it is predicted to increase at the maximum limit up to 6.2 µg/m^3 that found within RAPID complex. The HQ is 0.05, which is low risk of adverse health effects.
- The next pollutant is H_2S that predicted to have highest concentration of 0.907 µg/m^3 that located within RAPID complex. Its HQ is 0.003, which has no significant health danger.

b) Abnormal Operation Scenario

This scenario is based on only one emission control failure event at a time or based on the worst-case pollutant load released from a selected failure event. Once more, most of the potential pollutants are not detected as for their baseline concentration except for SO2 and NO2. For other pollutants, their maximum incremental concentrations are applied to assess their health risk. Unburned hydrocarbon (UHC) is not being assessed as it’s not risky to health. Pollutants like PM_{10} and $PM_{2.5}$ are not included since there is no standard for a 1-hour exposure. And methanol is not being modelled in this scenario.

- During abnormal operation, the waste gasses are released to the atmosphere and this is expected to be temporary, less than one hour for all parameters.
- All sensitive receptors within 0 to 5 km radius from the complex are predicted to have the HI of more than one in this abnormal scenario (**Table 3-9**). It means the ambient air is polluted and not safe for all receptors. However, it's only temporarily and less for one hour.

- Among those sensitive receptors, the highest risk area in this condition is the Pengelih Naval Base with HI of 70.5 mainly due to emission of SO_2. However, for this to occur is very unlikely because of other emission control that's available to take care the load released. Its for the short time that less than one hour.
- On the other hand, looking at individual pollutants, most of them concentrated within RAPID complex itself. The highest point for SO_2 is within RAPID complex itself, with 40582.8 µg/m^3 that give HQ of 162.33. It is a very hazardous condition that required prompt use of respirators if happened. Without any personal protective equipments, a person may develop respiratory problem and trouble in breathing after 10 minutes of exposure. Again, this is expected to be temporary that less than one hour. With good wind blow and dilution, the pollutant is no more at dangerous concentration.
- For NO_2, the highest point is also within the RAPID complex with concentration of 2073.8 µg/m^3. The HQ for this point is 7.4, which very hazardous to human being. At this concentration, workers without any respirator may develop sneezing, shortness of breath and coughing after 2-hour exposure. However, from the modelling result, its occurrence is predicted only at the 0.5 percentile, which the probability to occur is only nine days in every five years of operating period.
- Again RAPID complex is predicted to have the highest concentration point for CO with 1814.0 µg/m3 (HQ of 0.1). Nevertheless, it is safe and predicted not to induce any substantial health problems.
- And for H_2S, the highest level is also predicted to be inside RAPID complex with concentration of 456.1 µg/m3 and HQ of 1.7, which is unhealthy and may cause respiratory problems among exposed person.

In conclusion, in this abnormal operating scenario, all identified sensitive receptors are exposed to high health risk mainly due to high emission of SO_2. It may trigger sudden sneezing, difficulty in breathing and chest discomfort. However, it is predicted not to claim any fatality cases since its only temporarily and less than one hour.

c) Emergency Operation Scenario

For the emergency operation scenario, most of the pollutants are not detected as for their baseline concentrations except for SO_2 and NO_2. Since there is no standard limit for 1-hour PM_{10} and $PM_{2.5}$, both are not being assessed in this scenario. Similarly for NH_3 and methanol because they are not being modelled in this exercise.

- The modelling results showed that none of the sensitive receptors have hazard index (HI) of more than one (**Table 3-10**). All identified receptors are not exposed to any health risk due to the emission.
- Most of the predicted pollutants are found to be concentrated at the ocean, south of the RAPID complex site, but at lower concentrations that far below the allowable limits.
- For SO_2, its maximum incremental of 120.4 µg/m^3 gave rise to the value of 0.5 HQ. The situation is safe and no significant risk to health.
- For NO_2, its maximum incremental value of 9.3 µg/m^3 is equivalent with 0.03 HQ. The circumstance causes no substantial danger to health.
- And for CO, the maximum incremental of 50.7 µg/m^3 that equal to HQ of 0.002. The condition is very safe with low risk of hazard to receptors.
- For H2S, the highest level was 1.3 µg/m3 that give HQ value of 0.02.

In general, for the emergency operations scenario, the Refinery Cracker Complex is predicted not to create any extra health adverse effects in the exposed communities surrounding the proposed project site.

Table 3-8: Predicted Concentration, Hazard Quotient and Hazard Index for Cumulative Refinery & Cracker Complex (Normal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	PM_{10} (24 hours average)		$PM_{2.5}$ (24 hours average)		SO_2 (1 hour average)		NO_2 (Tier 3) (1 hour average)		CO (8 hours average)		NH_3 (24 hours average)		Methanol (24 hours average)		H_2S (24 hours average)		Hazard Index
	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	Conc. ($\mu g/m^3$)	Hazard Quotient	
Tg. Pengelih	24.2	0.2	0.1	0.0	21.5	0.1	19.1	0.1	109.6	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.4
Pengelih Naval Base	24.4	0.2	0.3	0.0	34.8	0.1	116.4	0.4	125.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.8
Kg. Penggerang	36.2	0.4	0.2	0.0	22.6	0.1	25.4	0.1	108.5	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.6
Kg. Sg. Kapal	25.4	0.3	0.2	0.0	53.7	0.2	83.4	0.3	121.4	0.0	0.0	0.0	0.6	0.0	0.2	0.0	0.8
Taman Rengit Jaya	38.4	0.4	0.3	0.0	39.1	0.2	75.4	0.3	141.5	0.0	0.0	0.0	0.9	0.0	0.1	0.0	0.9
Kg. Sg. Buntu	28.4	0.3	0.2	0.0	28.9	0.1	67.3	0.2	120.6	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.6
Kg. Bukit Buloh	31.4	0.3	0.2	0.0	47	0.2	96.5	0.3	304.8	0.0	0.2	0.0	3.8	0.0	0.2	0.0	0.8
Kg. Sg. Rengit	20.3	0.2	0.2	0.0	30.4	0.1	68	0.2	11.5	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.5
Kg. Bukit Gelugor	22.2	0.2	0.1	0.0	33	0.1	68.5	0.2	109.9	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.5
Kg. Lepau	35.4	0.4	0.3	0.0	51	0.2	72.9	0.3	122.3	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.8
Kg. Pasir Gogok	20.3	0.2	0.2	0.0	20.5	0.1	31.9	0.1	10.6	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.4

Table 3-9: Predicted Cumulative GLC, Hazard Quotient and Hazard Index for Cumulative Refinery & Cracker Complex (Abnormal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	SO_2 (1 hour average)		NO_2 (1 hour average)		CO (1 hours average)		H_2S (1 hour average)		Hazard Index
	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	
Tg. Pengelih	1303.9	5.2	86.6	0.3	99.1	0.0	24.5	0.1	5.6
Pengelih Naval Base	16625.7	66.5	928.3	3.3	714.3	0.0	182.3	0.7	70.5
Kg. Penggerang	1547.3	6.2	95.4	0.3	112.1	0.0	31.3	0.1	6.6
Kg. Sg. Kapal	3745.9	15.0	213.6	0.8	172.8	0.0	45.8	0.2	16.5
Taman Rengit Jaya	3441.2	13.8	192.7	0.7	160.9	0.0	50.1	0.2	14.7
Kg. Sg. Buntu	2870	11.5	162.1	0.6	132.1	0.0	39.9	0.1	12.2
Kg. Bukit Buloh	5402.5	21.6	300.3	1.1	222.2	0.0	62.8	0.2	22.9
Kg. Sg. Rengit	2051.7	8.2	118.8	0.4	111.3	0.0	29.1	0.1	8.7
Kg. Bukit Gelugor	1705.7	6.8	117.3	0.4	87.7	0.0	22.1	0.1	7.3
Kg. Lepau	3061.3	12.2	175.2	0.6	147.5	0.0	38.4	0.1	12.9
Kg. Pasir Gogok	1890.4	7.6	106.8	0.4	84.8	0.0	22.0	0.1	8.1

Table 3-10: Predicted Concentration, Hazard Quotient and Hazard Index for Cumulative Refinery & Cracker Complex (Emergency Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	SO_2 (1 hour average)		NO_2 (1 hour average)		CO (1 hour average)		H_2S (1 hour average)		Hazard Index
	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	
Tg. Pengelih	96.1	0.4	12.1	0.0	38.4	0.0	1.0	0.0	0.4
Pengelih Naval Base	104.7	0.4	12.7	0.0	42	0.0	1.1	0.0	0.4
Kg. Penggerang	85.0	0.3	11.2	0.0	33.7	0.0	0.9	0.0	0.3
Kg. Sg. Kapal	104.3	0.4	12.7	0.0	41.8	0.0	1.1	0.0	0.4
Taman Rengit Jaya	97.2	0.4	12.1	0.0	38.9	0.0	1.0	0.0	0.4
Kg. Sg. Buntu	89.7	0.4	11.6	0.0	35.7	0.0	0.9	0.0	0.4
Kg. Bukit Buloh	100.5	0.4	12.4	0.0	40.3	0.0	1.0	0.0	0.4
Kg. Sg. Rengit	103.3	0.4	8.0	0.0	43.5	0.0	1.1	0.0	0.4
Kg. Bukit Gelugor	111.5	0.4	13.2	0.0	44.9	0.0	1.2	0.0	0.4
Kg. Lepau	98.8	0.4	12.3	0.0	39.5	0.0	1.0	0.0	0.4
Kg. Pasir Gogok	104.1	0.4	8.1	0.0	43.8	0.0	1.1	0.0	0.4

3.4 Impact from Cumulative RAPID Complex

a) Normal Operation Scenario

The predicted concentration of identified pollutants for Cumulative RAPID Complex during this normal operation scenario and their hazard quotient and hazard index are shown in **Table 3-11**. The baseline concentrations for $PM_{2.5}$, methanol, NH_3, and H_2S are not detected. Thus, their maximum incremental concentrations are applied to calculate their risks.

- For this normal operation scenario, none of the sensitive receptors around the proposed project area have the HI of more than one. All locations are predicted to have clean and safe ambient air without any significant potential of health effects due to exposure among the receptors.
- For PM_{10}, the highest point was at Bukit Penggerang with maximum increments of only 3.2 µg/m^3 concentration. The location is clean and has low health risk with HQ of 0.03.
- For SO_2, the highest concentration was within the RAPID complex itself, with maximum incremental of 91.0 µg/m^3 that gave the HQ value of 0.4, which is also clean with insignificant health risk.
- For NO_2, the most concentrated point by air dispersion modelling was at Bukit Pelali with maximum incremental value of 523.0 µg/m^3 that equivalent to 1.87 points of HQ. The condition is unhealthy especially among asthmatic patients and lung diseases like chronic bronchitis. Fortunately, the area is a hilly area with no regular inhabitant. Nevertheless, from the modelling, its occurrence is predicted approximately 0.5 percentile, which the probability to occur is only nine days in every five years of operating period.

- And as for CO, the highest point with maximum incremental concentration of 205.0 µg/m^3 that detected within RAPID complex itself. The HQ is 0.02 only, which indicates clean air quality without any substantial health danger.
- The maximum incremental concentration of NH_3 is predicted to occur within the RAPID complex with a value of 0.3 µg/m^3 that give HQ of 0.001, which safe and no health risk.
- The high point for methanol is also within the RAPID complex (6.2 µg/m^3 = HQ of 0.05). The point is spare from any health risk.
- For H_2S, the highest level was 0.907 µg/m3 within RAPID complex that give HQ value of 0.003. Again, it's safe and no risk to health.

These bring a conclusion that during normal operation of the proposed project as a cumulative effect with other units, there won't be any extra or excess of health risks toward the identified sensitive receptors. Only a spot of high concentration of NO_2 is predicted to occur at Bukit Pelali, which is predicted to occur only nine days in five years of operation. In summation, the region is actually a hill and its not an attractive site to be seen by anybody.

b) Abnormal Operation Scenario

In this scenario, most of the potential pollutants don't have their baseline concentration except for SO_2 and NO_2 (**Table 3-12**). Unburned hydrocarbon (UHC) is not being assessed as it's not risky to health. Pollutants like PM_{10} and $PM_{2.5}$ are not included since there is no standard for a 1-hour exposure. And methanol is not being modelled in this scenario.

- During abnormal operation of Refinery Cracker Complex, the waste gasses are released to the atmosphere and this is expected to be temporary, thus the modelling shall be modelled for 1 hour averaging time for all parameters.

- All identified sensitive receptors within 5 kilometre radius from RAPID complex boundaries have HI of more than one. The highest is the Pengelih Naval Base (HI of 71.5). Fortunately, it is very unlikely because of other emission control systems in Rapid Complex that available to take care the temporarily stack release within one hour.
- The highest point for SO_2 is within RAPID complex itself, with 40582.8 µg/m^3 that give HQ of 162.33, which is a very hazardous that required the use of respirators. However, it won't cause any fatality since the value is far below than the limit set by NIOSH (262,000 µg/m^3) as the immediately dangerous to life or health (IDLH). In addition, its only temporary and less than one hour.
- For NO_2, the highest point is also within the RAPID complex with concentration of 2073.8 µg/m^3. The HQ for this point is 7.4, which very hazardous to human being. At this concentration, anybody healthy without any PPEs may develop respiratory problems like shortness of breath and coughing only after 2-hour of exposure. However, from the modelling results, the occurrence is very low as predicted, to happen in nine days within five years of operation. On the other hand, the value is very low compared to the IDHL for NO2 (190,000 µg/m3).
- For CO, the highest point with maximum incremental concentration of 1814.1 µg/m^3 that detected within RAPID complex itself. The HQ is 0.06, which is clean and no significant health risk.
- For H2S, the highest level was 456.1 µg/m3 within RAPID complex that give HQ value of 1.7, which is not healthy and poses significant risk to site workers' health.

In conclusion, the abnormal operation of the proposed project is predicted to pose a significant health effect to all identified sensitive receptors and workers within RAPID complex itself.

c) Emergency Operation Scenario

Once more, most of the pollutants for this modelling exercise don't have their baseline concentrations except for both SO_2 and NO_2 (**Table 3-13**). However, the maximum incremental concentrations are used to predict the health risks for other pollutants like CO, and H_2S.

There is no limit for 1-hour PM_{10} and $PM_{2.5}$. Thus, both of the parameters are not being appraised in the study. There is also no prediction for NH_3 and methanol in this scenario. During this emergency operation, the waste gasses are flared. The health impact is expected to be minimal and temporary that less than 1 hour of exposure.

- In this circumstance, none of sensitive receptors have the HI of more than one. All locations are predicted to have clean and safe air during this scenario without any potential of health risk among receptors.
- For SO_2, the highest concentration is predicted to be at the ocean, south of the RAPID complex with maximum incremental of 120.5 µg/m^3 that gave the HQ value of 0.48. The HQ indicates no excess of health risk at the location due to SO_2.
- For NO_2, the highest incremental point was at Bukit Penggerang with a value of 165.0 µg/m^3 that equivalent to value of HQ of 0.59. Again, the location has no substantial health hazard due to NO_2 exposure.
- And for CO, the highest point with maximum incremental concentration of 546.4 µg/m^3 that detected at Bukit Penggerang. The HQ is 0.02, which indicates of no present of health hazard at the location.
- For H_2S, the highest point was 1.3 µg/m^3 detected at the ocean, south of the RAPID complex that give HQ value of 0.02. The point has low health risk.

In conclusion, in this emergency operation scenario of the proposed cumulative RAPID complex project, it doesn't pose any significant health effect to all sensitive receptors.

Table 3-11: Predicted Concentration, Hazard Quotient and Hazard Index for Cumulative RAPID Complex (Normal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	PM_{10} (24 hours average)		$PM_{2.5}$ (24 hours average)		SO_2 (1 hour average)		NO_2 (Tier 3) (1 hour average)		CO (8 hours average)		NH_3 (24 hours average)		Methanol (24 hours average)		H_2S (24 hours average)		Hazard Index
	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	Conc. (μg/m^3)	Hazard Quotient	
Tg. Pengelih	24.3	0.2	0.2	0.0	22.0	0.1	23.3	0.1	109.6	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.4
Pengelih Naval Base	26.4	0.3	1.5	0.0	34.8	0.1	180.2	0.6	125.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.1
Kg. Penggerang	36.5	0.4	0.3	0.0	23.1	0.1	29.8	0.1	108.5	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.6
Kg. Sg. Kapal	25.5	0.3	0.4	0.0	54.6	0.2	91.3	0.3	121.4	0.0	0.0	0.0	0.6	0.0	0.2	0.0	0.8
Taman Rengit Jaya	38.5	0.4	0.4	0.0	39.7	0.2	82.1	0.3	141.5	0.0	0.0	0.0	0.9	0.0	0.1	0.0	0.9
Kg. Sg. Buntu	28.5	0.3	0.3	0.0	29.2	0.1	76.0	0.3	120.6	0.0	0.0	0.0	0.4	0.0	0.1	0.0	0.7
Kg. Bukit Buloh	31.5	0.3	0.3	0.0	47.6	0.2	105.0	0.4	304.8	0.0	0.2	0.0	3.8	0.0	0.2	0.0	0.9
Kg. Sg. Rengit	20.4	0.2	0.3	0.0	30.9	0.1	77.1	0.3	11.5	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.6
Kg. Bukit Gelugor	22.4	0.2	0.2	0.0	33.5	0.1	80.2	0.3	109.9	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.7
Kg. Lepau	35.7	0.4	0.6	0.0	51.4	0.2	77.7	0.3	122.3	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.8
Kg. Pasir Gogok	20.4	0.2	0.3	0.0	21.0	0.1	41.0	0.1	10.6	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.4

Table 3-12: Predicted Concentration, Hazard Quotient and Hazard Index for Cumulative RAPID Complex (Abnormal Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	SO_2 (1 hour average)		NO_2 (1 hour average)		CO (1 hours average)		H_2S (1 hour average)		Hazard Index
	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	
Tg. Pengelih	1303.9	5.2	92.2	0.3	99.5	0.0	24.5	0.1	5.6
Pengelih Naval Base	16626	66.5	936.0	3.3	744.4	0.0	182.3	0.7	71.5
Kg. Penggerang	1547.3	6.2	99.9	0.4	112.1	0.0	31.3	0.1	6.7
Kg. Sg. Kapal	3745.9	15.0	213.7	0.8	174.5	0.0	45.8	0.2	16.0
Taman Rengit Jaya	3441.2	13.8	193.0	0.7	160.9	0.0	50.1	0.2	14.7
Kg. Sg. Buntu	2870	11.5	163.5	0.6	142.3	0.0	39.9	0.1	12.2
Kg. Bukit Buloh	5402.5	21.6	300.3	1.1	455.6	0.0	62.8	0.2	22.9
Kg. Sg. Rengit	2051.7	8.2	126.7	0.5	111.3	0.0	29.1	0.1	8.8
Kg. Bukit Gelugor	1705.7	6.8	126.0	0.5	93.5	0.0	22.1	0.1	7.3
Kg. Lepau	3061.3	12.2	180.8	0.6	184.9	0.0	38.4	0.1	12.9
Kg. Pasir Gogok	1890.4	7.6	112.1	0.4	107.1	0.0	22.0	0.1	8.1

Table 3-13: Predicted Concentration, Hazard Quotient and Hazard Index for Cumulative RAPID Complex (Emergency Operation Scenario) at Sensitive Receptor Locations

Location (Sensitive Receptors)	SO_2 (1 hour average)		NO_2 (1 hour average)		CO (1 hour average)		H_2S (1 hour average)		Hazard Index
	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	Conc. (µg/m^3)	Hazard Quotient	
Tg. Pengelih	96.2	0.4	20.7	0.1	42.7	0.0	1.0	0.0	0.5
Pengelih Naval Base	104.8	0.4	170.0	0.6	546.4	0.0	1.1	0.0	1.0
Kg. Penggerang	85.1	0.3	22.0	0.1	47.3	0.0	0.9	0.0	0.4
Kg. Sg. Kapal	104.5	0.4	23.1	0.1	57.7	0.0	1.1	0.0	0.5
Taman Rengit Jaya	97.4	0.4	24.8	0.1	65.8	0.0	1.0	0.0	0.5
Kg. Sg. Buntu	89.8	0.4	21.2	0.1	52.3	0.0	0.9	0.0	0.5
Kg. Bukit Buloh	100.6	0.4	25.3	0.1	53.2	0.0	1.0	0.0	0.5
Kg. Sg. Rengit	103.5	0.4	19.4	0.1	49.8	0.0	1.1	0.0	0.5
Kg. Bukit Gelugor	111.7	0.4	26.0	0.1	51.3	0.0	1.2	0.0	0.5
Kg. Lepau	99.1	0.4	29.5	0.1	82.4	0.0	1.0	0.0	0.5
Kg. Pasir Gogok	104.2	0.4	15.8	0.1	50.1	0.0	1.1	0.0	0.5

3.5 Mitigation Measures

<u>During the construction phase</u>

a) Potential of communicable and non-communicable diseases

From the existing health status of the communities surrounding the proposed project site, the area is found to have a significant burden of diseases like acute respiratory infection, tuberculosis, dengue fever, leptospirosis, food poisoning, sexually transmitted infections and road traffic accidents. The influx of workers (both foreign and local) may worsen the current health condition.

The proposed mitigation measures are as follows:

- **Workers' health monitoring**

i. Any workers with health symptoms such as chronic cough, fever, headache, chest discomfort or eye redness should be brought to a medical attention for further investigation and treatment. Anyone with chronic cough more than two weeks and bloody sputum, should be quarantined and investigated for pulmonary tuberculosis. All contacts among his college should be screen if he found to be positive with tuberculosis. Any positive cases should be notified to the Kota Tinggi health office as required by the law.

ii. Regularly, each worker is required to undergo medical check-up to detect any possibility of sexually transmitted infections (STIs). Anybody with symptoms like penile discharge or pain must be screened and treated for STIs accordingly.

- **Sanitation monitoring**

i. Proper housekeeping and good sanitation of the project site is important to be maintained all time. Any base camp should not crowded, have a good and effective ventilation system, clean toilets, and canteen. The camp should have a good solid waste system with regular collection by the authority or appointed agency. No empty containers that have a potential to collect water should be discarded or buried. Leftover foods should be collected in a container or plastic bag for disposal with other solid wastes.

ii. No open burning should be allowed and no open ground type of disposal for any waste. Regular inspection by the workers themselves should be scheduled accordingly to detect and destroy any potential breeding sites.

- **Prevention of food poisoning**

i. In order to prevent any food poisoning occurrence among workers, especially those staying in the camp, all food handlers should be vaccinated with typhoid vaccine regularly, and should have clean and hygiene body conditions.

ii. Any canteen or cooking area should be built in an area or space that far away from toilet or waste collection sites. There should be no storage room for raw foods, especially for those temporary base camps. All cooked food should be eaten immediately and no over night foods should be taken in the early morning.

- **Reduction of road traffic accident**

i. No workers are allowed to drive any vehicle, except for those with a valid international license. They should attend a regular briefing on safe driving and road safety with exposure to local laws and cultures.

ii. All vehicles provided are only for work related tasks and should be maintained regularly at selected approved workshops.

<u>During operation phase</u>

a) Potential of communicable diseases due to unmanage housekeeping and sanitation of the environment.

The proposed mitigation measures are as follows:

- **Reduction of breeding sites**

i. Regular surveillance and monitoring of the ground for any potential of vector breeding sites by workers and inspectorate appointed.

ii. All potential breeding sites should be covered from rainwater collection, or demolished.

- **Reduction of vector attraction factors**

i. All wastes, especially food based should be collected in a covered bin and disposed accordingly.

ii. All solid wastes should be picked up and disposed accordingly by the appointed waste collector.

b) Potential of health risks due to poor air quality

From the risk characterisation, the cumulative Refinery & Cracker Complex is predicted to cause poor air quality in abnormal operating scenario. Pertaining to cumulative RAPID complex, it's found to cause air pollution during the normal and abnormal operating scenario. For emergency scenario, both Refinery & Cracker Complex and RAPID complex are predicted not to have any health impact.

The proposed health mitigation measures are as follows:

- **Awareness and education programs among community members.**

i. To ensure that individuals, communities, and agencies are familiar with their roles and responsibilities during normal, abnormal or emergency situation. It's beneficial for those involved as first responders to feel competent and comfortable with their roles, especially for health care workers and fire and rescue department. These also include their roles in giving advices about PPE, when to stay indoor and what is a good ventilation of a house for community members.

- **Continuous monitoring for air quality.**

i. To have an installation of indoor gas monitoring for at least three important pollutants, i.e. NO_2, SO_2 and H_2S within RAPID complex. All workers should wear their respirator once the siren is heard. Health and safety officer should continue monitoring the health of workers together in ensuring a good air exchange rate and ventilation at the site.

ii. To installed few gas detectors at the nearest sensitive communities, particularly the Pengelih Naval Base. With the cooperation of the Naval Base Rumah Sakit Angkatan Tentera (RSAT), the cases of respiratory illnesses should be monitored. Any incremental trend should be informed to the Kota Tinggi Health Office.

- **Emergency Management Plan**

i. The release should not exceed more than 30 minutes, if it's occurred. The proposed plant should have an emergency system to stop the plant to continue emitting SO_2 and NO_2 into the ambient air. This should be monitored by the proposed plant Emergency Management Coordinator under supervision of a council or company board.

- **Emergency Planning Committee.**

i. May comprise of Plant Emergency Management Coordinator, representatives from the Municipal department, Fire and Rescue department, Health office, and police. These agencies could be called upon for planning and programs related or during an emergency to advise and assist the Committee.

4 CONCLUSION

In summary, the proposed project is basically has no significant health risk to the sensitive receptors within 5km radius from RAPID complex boundaries. Minimally, it may relate to certain communicable and non-communicable diseases, especially due to the influx of workers and current disease burden of the communities. From the air dispersion exercise, the proposed plant is predicted to pose the acceptable hazard index during normal, and emergency operation scenarios for all sensitive receptors. However, in the abnormal operating scenario, all sensitive receptors may exposed to minimal health risk, but its temporarily and predicted to occur in low probability that less than nine days within five years of operation.

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1.0 INTRODUCTION

The units within Refinery & Cracker Complex as in DEIA RAPID 2012 are maintained. The RAPID Refinery Cracker Complex was originally designed to produce diesel that meet the EURO 5 specifications and MOGAS (motor gasoline) that meet EURO 4 specifications. To upgrade and meet the EURO 5 MOGAS specifications, Refinery Cracker Complex has been expanded to include additional units as listed below:

1. 2nd Stage Cracked Naphta Hydrotreating (CNHT 2) Unit
2. Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME) Unit
3. Isomerization Unit
4. Additional Storage Tanks which consist of:

    i. Two Tertiary-Armyl-Methyl-Ether (TAME) storage tanks
    ii. Two Isomerate storage tanks
    iii. One Medium Cracked Naptha (MCN) Storage Tank

Besides that, there will be new olefin storage tankages located in the current refinery tank farms which consists of:

1. Four mounded bullets for Butadiene Storage
2. One Ethylene Tank
3. Four sphere for Propylene Storage

Details of the additional units are described in **Volume 1, Chapter 2**. This additional information report conducted studies to assess the impacts from these new process units and tank farms in the Refinery and Cracker Complex.

1.1 Objectives

The objectives of the QRA study are to identify and quantify the probability and consequences of the possible accidents that may escalate from the proposed MOGAS units and its associated tank farm to the surrounding offsite areas; to calculate the level of risk; and to suggest measures to reduce the level of risk if higher than the allowable level in compliance with DOE's risk criteria stipulated in the Environmental Impact Assessment Guidelines for Risk Assessment, December 2004, EG 1/04.

1.2 Scope of Study

The scope of work for this study comprises of the following:

- Hazard Identification – Qualitative review of possible accidents that may occur (based on previous accident experience or professional judgement where necessary) for the proposed unit;
- Determination of failure scenarios;
- Determination of probability of occurrence for each failure scenario;
- Determination of consequences hazard distances of each identified hazard scenario;
- Combination of failure frequencies and all consequences in order to determine the individual risk levels posed by the operation of the proposed facility; and
- Comparison of the risk results against DOE risk criteria.

1.3 Project Background

1.3.1 Site Location

The project location are described in **Volume 1, Chapter 1 and 2**.

1.3.2 Layout Plan

The layout plan of EURO 5 MOGAS Units and Olefins Storage Tankages are described in **Volume 1, Chapter 1 and 2**.

1.3.3 Process Description

The details of process description for the EURO 5 MOGAS Units and Olefins Storage Tankages are shown in **Volume 1, Chapter 2**.

1.4 Meteorological Data

The following sections present the meteorological data used for the consequence analysis (modeling) of the Quantitative Risk Assessment.

1.4.1 Annual Mean Air Temperature

The annual mean air temperature was assumed as 33°C in the consequence modeling.

1.4.2 Annual Mean % Humidity

The annual mean percentage humidity was assumed as 85%.

1.4.3 Atmospheric Pressure

The atmospheric pressure for Pengerang area was assumed at sea level.

1.4.4 Wind Speed

As per DOE risk criteria, the following meteorological conditions have been referenced for conducting consequence analysis. Wind speed affects radiation distances hence different wind speeds have been identified for consequence modeling purposes. Based on the Changi wind direction data (from year 1999 to 2012) obtained from the Changi Meteorological Station, the following wind data were applied in the QRA model.

Table 1-1: Changi Meteorological Data

Prevailing Wind Direction and Mean speed (m/s) (Station time)

Station : Changi Airport

Year: 1999 TO 2012

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed
1999	NNE	1.7	NNE	2.5	N	0.9	S	0.9	SSW	1.2	S	1.5	S	1.9	S	1.7	S	1.6	W	0.9	W	0.7	NNE	1.7
2000	NNE	1.8	NNE	1.6	NNE	1.3	ENE	1.0	S	1.1	S	1.1	S	2.1	S	2.1	S	1.9	W	1.4	NNE	1.5	N	1.4
2001	N	1.6	N	2.2	NNE	1.4	S	1.0	S	1.6	SSW	1.6	S	2.2	S	1.9	S	1.9	W	1.3	N	1.6	N	1.9
2002	NNE	3.1	NNE	3.3	NNE	2.7	NNE	1.7	S	2.2	S	2	S	2.9	S	3.0	S	2.2	ESE	1.6	NW	1.2	NNE	1.3
2003	N	2.5	NNE	2.7	NNE	1.9	NE	1.1	S	1.7	S	2.5	S	2.7	S	2.5	S	1.8	S	1.7	N	1.0	N	2.1
2004	NNE	2.8	N	3.3	N	1.8	E	1.7	S	1.1	S	2.4	S	1.7	S	3.1	SE	2.1	S	1.5	NNE	1.3	NNE	2.1
2005	NNE	2.7	NNE	2.7	NNE	2.4	NNE	1.6	S	1.5	S	1.6	S	1.4	S	2.0	S	1.8	S	1.2	W	1.0	N	1.6
2006	N	2.0	NNE	2.7	NNE	2.2	NNE	.9	S	1.1	S	1.5	S	2.7	SSE	2.7	SE	2.0	E	1.4	NNE	1.0	NNE	1.8
2007	N	2.0	NNE	2.4	NNE	1.2	NNE	1.1	S	1.4	S	1.3	S	1.5	S	1.8	S	1.9	S	1.3	NNE	1.0	NNE	1.3
2008	NNE	1.8	NNE	2.1	NNE	1.5	E	1.2	S	1.8	S	1.7	S	2.0	S	2.0	S	1.6	S	0.9	W	1.0	N	1.7
2009	NNE	2.8	NNE	2.1	NNE	2.0	W	2.0	S	1.8	S	1.7	S	1.9	S	2.0	S	1.8	S	1.7	N	2.5	NNE	3.3
2010	NNE	2.9	NNE	3.6	NE	2.8	N	2.1	NW	2.1	S	2.0	SSW	2.0	S	2.3	SSW	2.1	SSW	1.9	NNW	1.9	N	1.9
2011	NNE	2.9	NNE	3.2	N	2	NNE	2.4	S	1.9	S	2.3	S	3.1	SSE	2.8	SSE	2.6	NW	2	N	1.8	N	2.3
2012	N	2.5	NE	2.7	N	1.9	VAR	1.8	SSW	2	S	2.5	S	2.6	SSE	3.1	SSW	2.3	NNW	1.8	NNW	1.6	N	1.8

1.4.5 Atmospheric Stability Classification

Generally, the prevailing wind speeds are within the range of 1 m/s and 3 m/s. The corresponding atmospheric stability class for the most prevailing wind speeds is defined as A, B and C in the Pasquill-Turner Atmospheric Stability Classification scheme, which is shown in **Table 1-2**. The atmospheric stability class F is used for the 1 m/s wind speed for the the consequence modeling to address the worst case scenario.

Table 1-2: Pasquill-Turner Atmospheric Stability Classification

Atmospheric Stability Categories					
Surface Wind Speed (elevation of 10 meters) (m/s)	Day			Night	
	Incoming Solar Radiation			Thinly Overcast or > ½ Cloud Cover	< ½ Cloud Cover
	Strong	Moderate	Slight		
< 2	A	A – B	B	—	—
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	E

2.0 QRA METHODOLOGY

Further details of methodology of Quantitative Risk Assessment of this study is shown in **Volume 1, Chapter 3**.

2.1 Definitions

The risk assessment of the project has been conducted in accordance with the elements described in the following sections. The main stages of the QRA study are as follows:

- **Stage 1** Hazard Identification: Identification of initiating release events and major hazards that require further evaluation;
- **Stage 2** Frequency Analysis: Determination of the frequency of initiating events and the frequency of hazardous event outcomes;
- **Stage 3** Consequence Analysis: Determination of the consequences of hazardous events;
- **Stage 4** Event Tree Analysis: Representation of how the initiating event may develop and the resulting likelihood of the hazardous outcome;
- **Stage 5** Risk Summation: Calculation of individual risk level and Evaluation as well as comparison against the risk criteria established for the study; and
- **Stage 6** Risk Mitigation: Recommendation of risk mitigation measures, as required.

The methodology adopted for the study is further discussed in the following sections.

2.2 Hazard Identification

The first step in the QRA involves identifying physical situations (failure modes or initiating events) that may lead to a major accident with the potential for personnel injury or fatality, such as fire, explosion or the release of a dangerous substance. A representative set of discrete initiating events was short listed after a full review of the process and hazardous substances present onsite. The consequences of these scenarios were further evaluated and their risk was quantified in the study.

2.3 Frequency Analysis

Frequency analysis involves estimating the likelihood of each of the representative release events highlighted in the hazard identification exercise. Frequency analysis involves the following steps:

- Quantification of the frequency of initiating events (such as vessel rupture, leakage, etc.) based on historical data; and
- Quantification of the frequency of various hazardous outcomes (such as fire, explosion) through Event Tree Analysis, which is used to describe and analyse how, an initiating event can lead to various outcomes, depending upon the nature and type of the release.

2.4 Consequence Analysis

This stage of the QRA involves the determination of the impact of each of the identified hazardous outcomes on the surrounding population. **Section 3.3** of this report summarises the assessment of release consequences. The hazardous outcomes that were evaluated in this study were Pool Fire, Jet Fire, Flash Fire, Explosion and Boiling Liquid Expanding Vapour Explosion (BLEVE).

The Software package Phast developed by DNV GL has been used for the consequence analysis modeling.

2.5 Event Tree Analysis

Event tree analysis involves taking each initiating event through a defined sequence of events to determine the likelihood that an associated hazardous outcome will occur. Such event trees will take into account the necessary conditions for the hazardous outcome to occur, such as ignition. By assigning probabilities to each branch of the event tree, the final frequency of each outcome can then be established. The frequency of occurrence and probabilities of the initiating events develops to that outcome. The consequences associated with each of the hazardous outcomes can then be evaluated.

2.6 Risk Summation

Risk summation involves combining the frequency of a given event outcome with its associated consequences to determine the individual risk levels associated with the facility. For the purpose of this study, risks evaluated are reported in terms of Individual Risk (IR). Individual risk may be defined as the frequency of fatality per individual per year due to the realisation of specified hazards.

2.7 Risk Mitigation Measures

Based on the risk assessment results, risk mitigation measures will be identified, as required, to reduce the risks to levels that are As Low As Reasonably Practicable (ALARP).

2.8 Risk Criteria

This section presents the risk tolerability criteria used in this study as stated in the Risk Assessment Guidelines from DOE.

- The 1×10^{-5} fatalities/ person per year individual risk contour should not extend beyond industrial developments; and

- The 1 x 10^{-6} fatalities/ person per year individual risk contour should not encompass involuntary recipients of industrial risks such as residential areas, schools, hospitals and places of continuous occupancy.

3.0 ASSESSMENT AND FINDINGS

3.1 EURO MOGAS and Olefin Storage Tank

3.1.1 Hazard Identification and Scenario Selection

The identification of possible major accident hazard in the EURO 5 MOGAS Units and Olefins Storage Tankages is based on the physical and chemical properties (i.e. flash point, boiling point, heat of combustion, and toxicity data) of substances stored and handled in this plant. Other than that, the design parameter of the vessels which store the hazardous substance has also been considered as one of the factor in deciding the possible scenario of major accident hazard.

3.1.2 Occupational Health Hazards

The impact of other hazards, such as occupational hazards which are limited to personnel working within the EURO 5 MOGAS and olefin storage tank units and external hazards (earthquake, air plane crash etc.) have not been reported as these hazards are not within the scope of this QRA.

3.1.3 Hazardous Substances

The hazardous substances that have been assessed in this QRA for the MOGAS EURO 5 units and olefin tanks are as summarized in **Table 3-1**. The materials are chosen based on high mass percentage in each unit (equipment) and its physical and chemical properties (explosive, flammability and toxicity).

It should be noted that maximum quantities/ inventories and worst case operating/ processing conditions are used in the QRA to ensure conservatism.

Table 3-1: Characterization of Hazardous Material

Unit	Hazardous Material	Characterization
EURO 5 MOGAS	Naphtha	Fire, Explosion
	Hydrogen	Fire, Explosion
	Methyl Diethanolamine (MDEA)	Fire
	Methanol	Fire, Explosion
	Tertiary-Amyl-Methyl-Ether (TAME)	Fire
	Hydrocarbon	Fire
	Isomerate	Fire
	LPG	Fire, Explosion
Olefin Tank Farm	Ethylene	Fire, Explosion
	Propylene	Fire, Explosion
	Butadiene	Fire, Explosion

3.1.4 Representative Release Scenario

Leaks can range in size from a pinhole leak to a catastrophic failure. In general smaller leaks have higher accident likelihood but lower consequence distances. On the other hand larger releases have lower accident likelihood but longer consequence distance. The representative scenarios considered in this study are [1]:

Pressure Vessels;

- Minor leak (5mm);
- Small leak (15mm);
- Medium leak (50mm);
- Large leak (100mm); and
- Catastrophic failure.

Compressor;

- Minor leak (5mm);
- Small leak (15mm);
- Medium leak (50mm);
- Large leak (100mm); and
- Catastrophic failure.

Pressurized Storage;

- Minor leak (5mm);
- Small leak (15mm);
- Medium leak (50mm);
- Large leak (100mm); and
- Catastrophic failure.

Pipeline;

- Minor leak (5mm);
- Small leak (15mm);
- Medium leak (50mm);
- Large leak (100mm); and
- Catastrophic failure

The events identified for further analysis in this study has been divided into isolatable section (which represent sections of the process that have various hold up inventory, pressure and temperature) as tabulated in **Sub-Appendix 3A**.

3.1.4.1 Release Frequencies for Equipment in the Plant

Generic failure rate data for equipment item have been taken from Offshore Hydrocarbon Release Database [1]. **Table 3-2** summarizes the generic equipment failure data used in this study.

Table 3-2: Equipment Failure Rates

Equipment Item	Failure Size	Failure Frequency
Pressure vessel* (> 3 ft)	Minor	3.71 x 10^{-4} per vessel per year
	Small	4.32 x 10^{-4} per vessel per year
	Medium	2.54 x 10^{-4} per vessel per year
	Large	2.87 x 10^{-5} per vessel per year
	Catastrophic	1.43 x 10^{-5} per vessel per year
Compressor Reciprocating (> 3 ft)	Minor	3.79 x 10^{-2} per vessel per year
	Small	1.09 x 10^{-2} per vessel per year
	Medium	5.25 x 10^{-4} per vessel per year
	Large	2.34 x 10^{-4} per vessel per year
	Catastrophic	2.37 x 10^{-4} per vessel per year
Filter (> 3 ft)	Minor	1.50 x 10^{-3} per vessel per year
	Small	2.22 x 10^{-4} per vessel per year
	Medium	1.56 x 10^{-4} per vessel per year
	Large	6.13 x 10^{-5} per vessel per year
	Catastrophic	3.29 x 10^{-5} per vessel per year
Centrifugal Pump (> 3 ft)	Minor	2.02 x 10^{-3} per pump per year
	Small	5.81 x 10^{-4} per pump per year
	Medium	2.79 x 10^{-5} per pump per year
	Large	1.20 x 10^{-5} per pump per year
	Catastrophic	1.26 x 10^{-5} per pump per year
Heat Exchanger (> 3 ft)	Minor	2.49 x 10^{-3} per heat exchanger per year
	Small	6.62 x 10^{-4} per heat exchanger per year
	Medium	7.91 x 10^{-5} per heat exchanger per year
	Large	2.23 x 10^{-5} per heat exchanger per year
	Catastrophic	3.29 x 10^{-5} per heat exchanger per year
Pipeline* (< = 3”)	Minor	6.18 x 10^{-5} per m per year
	Small	2.50 x 10^{-5} per m per year
	Medium	4.41 x 10^{-6} per m per year
	Large	-
	Catastrophic	-
Pipeline* (3” < = D < 11”)	Minor	2.39 x 10^{-5} per m per year
	Small	3.55 x 10^{-6} per m per year
	Medium	2.49 x 10^{-6} per m per year
	Large	9.80 x 10^{-7} per m per year
	Catastrophic	5.26 x 10^{-7} per m per year
Pipeline* (> = 11”)	Minor	2.51 x 10^{-5} per m per year
	Small	3.73 x 10^{-6} per m per year
	Medium	2.61 x 10^{-6} per m per year
	Large	1.03 x 10^{-6} per m per year
	Catastrophic	5.52 x 10^{-7} per m per year

Equipment Item	Failure Size	Failure Frequency
Actuated Valve (< = 3")	Minor	2.85×10^{-4} per valve per year
	Small	1.15×10^{-4} per valve per year
	Medium	2.03×10^{-5} per valve per year
	Large	-
	Catastrophic	-
Actuated Valve (3" < = D < 11")	Minor	3.29×10^{-4} per valve per year
	Small	4.89×10^{-5} per valve per year
	Medium	3.43×10^{-5} per valve per year
	Large	1.35×10^{-5} per valve per year
	Catastrophic	7.24×10^{-6} per valve per year
Actuated Valve (> = 11")	Minor	4.39×10^{-4} per valve per year
	Small	6.52×10^{-5} per valve per year
	Medium	4.57×10^{-5} per valve per year
	Large	1.80×10^{-5} per valve per year
	Catastrophic	9.65×10^{-6} per valve per year
Manual Valve (> = 11")	Minor	2.51×10^{-4} per valve per year
	Small	3.73×10^{-5} per valve per year
	Medium	2.62×10^{-5} per valve per year
	Large	1.03×10^{-5} per valve per year
	Catastrophic	5.53×10^{-6} per valve per year
Flange Joint (< = 3")	Minor	2.65×10^{-5} per joint per year
	Small	1.07×10^{-5} per joint per year
	Medium	1.89×10^{-6} per joint per year
	Large	-
	Catastrophic	-
Flange Joint (3" < = D < 11")	Minor	4.55×10^{-5} per joint per year
	Small	6.77×10^{-6} per joint per year
	Medium	4.75×10^{-6} per joint per year
	Large	1.87×10^{-6} per joint per year
	Catastrophic	1.00×10^{-6} per joint per year
Flange Joint (> = 11")	Minor	9.73×10^{-5} per joint per year
	Small	1.45×10^{-5} per joint per year
	Medium	1.01×10^{-5} per joint per year
	Large	3.99×10^{-6} per joint per year
	Catastrophic	2.14×10^{-6} per joint per year

Note: * - the ignition probabilities have been multiplied by the safety factor 0.1

It should be noted that the equipment listed above are not subject to any lifting operations once installed at the plant. Hence the possibility of failures due to lifting operations is deemed not credible.

This generic failure data were derived from statistical analysis of historical accident data from the chemical industry as a whole and take no account of the current safety engineering standards which are generally higher than the historical average. Furthermore, no account was taken of clients' engineering design standards nor safety management systems. The data can be considered as conservative for the purposes of assessment.

3.1.5 Ignition Probabilities

The probability of ignition depends on the availability of a flammable mixture, the flammable mixture reaching an ignition source, and the type of ignition source (energy, etc).The possible ignition sources on the facility include:

- Hot work;
- Faults in electrical equipment;
- Faults in rotating equipment;
- Ignition caused by combustion engines/ hot surfaces;
- Automatic ignition in the event of a fracture/ rupture;
- Static electricity; and
- Lighting.

According to Cox, Lees and Ang [2] (also contained in Frank P. Lee's Loss Prevention in the Process Industries), generic ignition probabilities are given as below:

Table 3-3: Generic Ignition Probabilities

Scenario	Probabilities of Ignition for Release Rate Categories		
	0.1 to 1.0 kg/s	1.0 to 50 kg/s	> 50 kg/s
Gas Leak	0.01	0.07	0.3
Oil/ Condensate Leak	0.01	0.03	0.08

Depending on the time of ignition after release, the ignition can be "immediate ignition" or "delayed ignition". The following assumptions have been made for distribution of overall ignition probability into immediate and delayed ignition:

Table 3-4: Immediate and Delayed Ignition Probability Distributions

Release Rate (kg/s)	Immediate Ignition	Delayed Ignition
0.1 to 1.0	0.1	0.9
1.0 to 50	0.5	0.5
> 50	0.6	0.4

The probability of explosion depends on factors such as location of leak source, gas concentrations (presence of vapour clouds), location and energy of ignition sources, area geometry, and ventilation of the area and equipment congestion. Cox, Lees and Ang [2] provides probabilities for explosion used in the assessment in lieu of the detailed information required for estimation.

Table 3-5: Probability of Explosion Given Gas Cloud Ignition

Release Rate (kg/s)	Probability of Explosion (Given Ignition)
0.1 to 1.0	0.04
1.0 to 50	0.12
> 50	0.3

3.1.6 Event Tree Analysis

The event frequencies can be obtained by applying the ignition probabilities above to event tree as shown in the figures below.

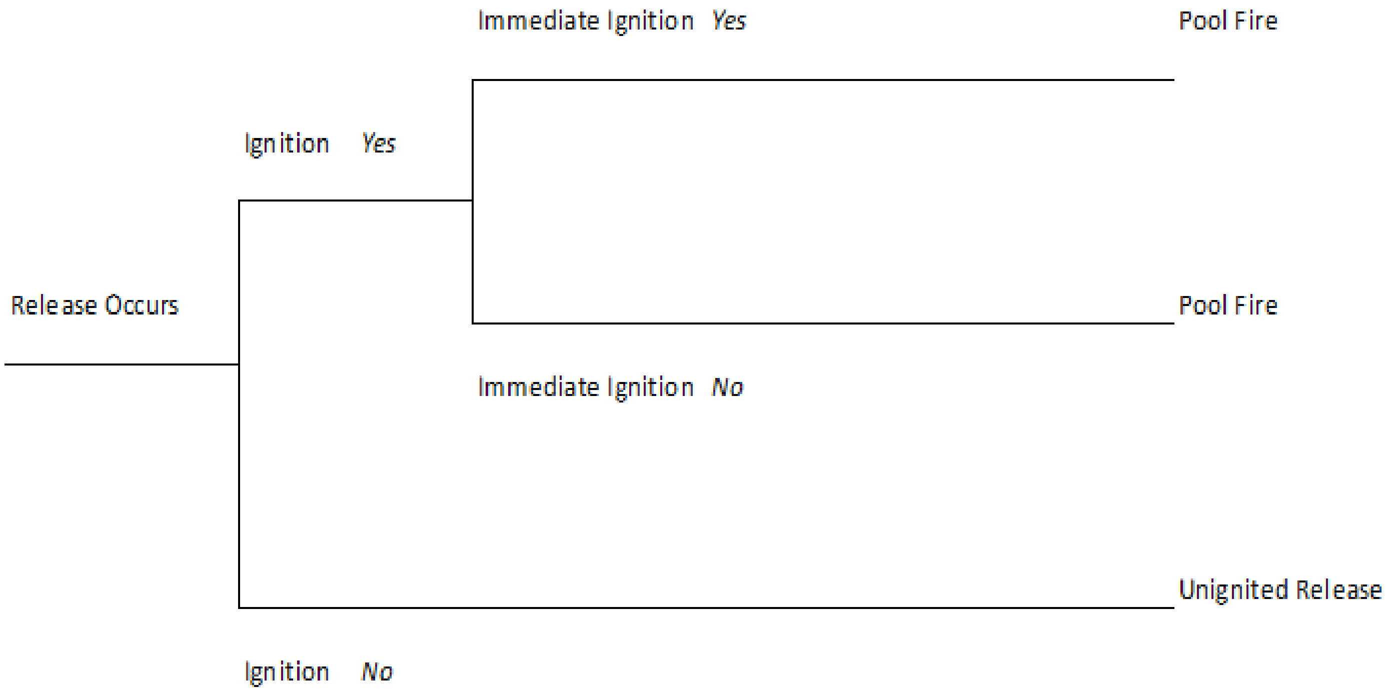

Figure 3-1: Minor, Small, Medium, Large and Catastrophic Release of Flammable Liquid < 2 bar

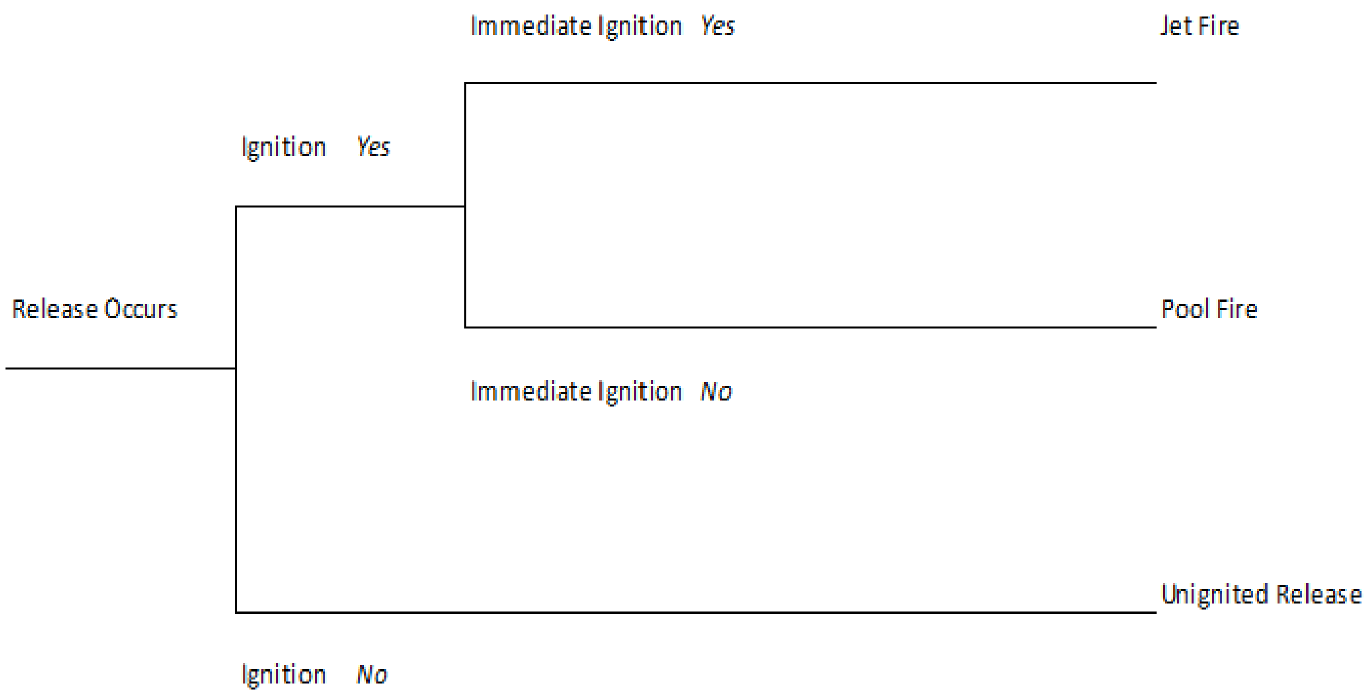

Figure 3-2: Minor, Small, Medium and Large Release of Flammable Liquid ≥ 2 bar

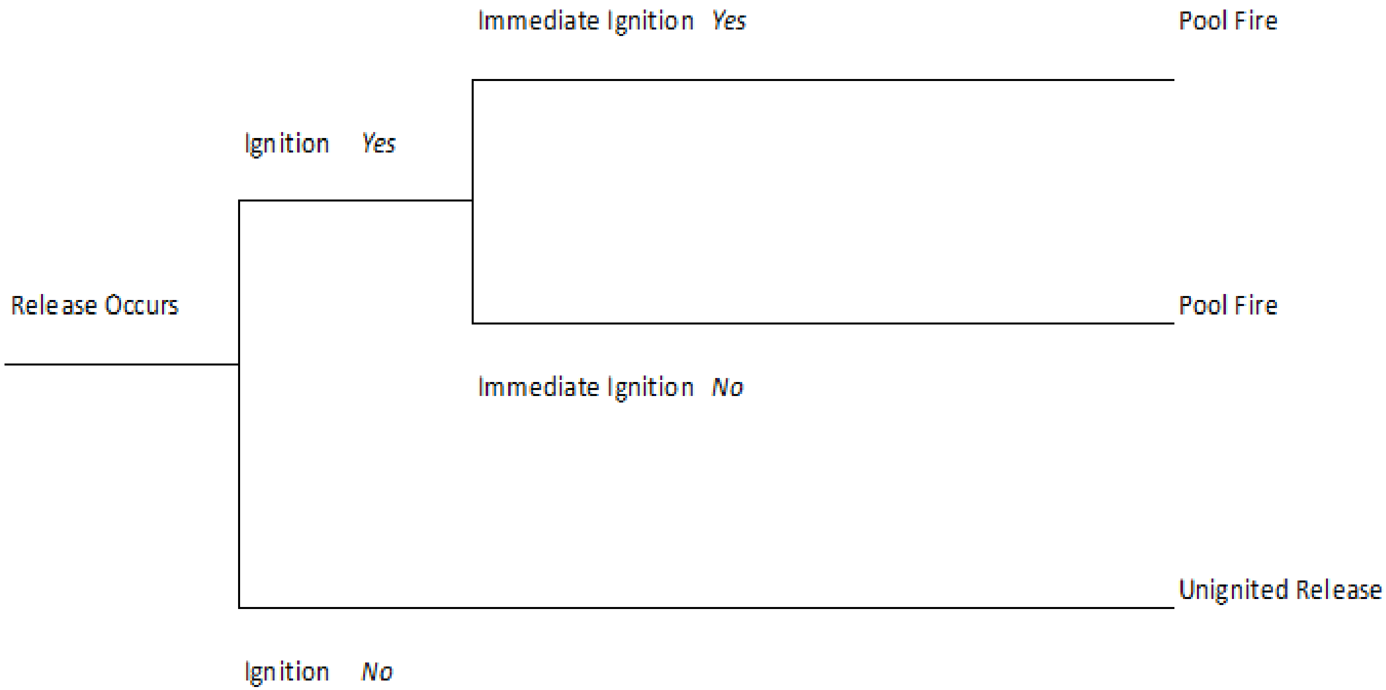

Figure 3-3: Catastrophic Release of Flammable Liquid ≥ 2 bar

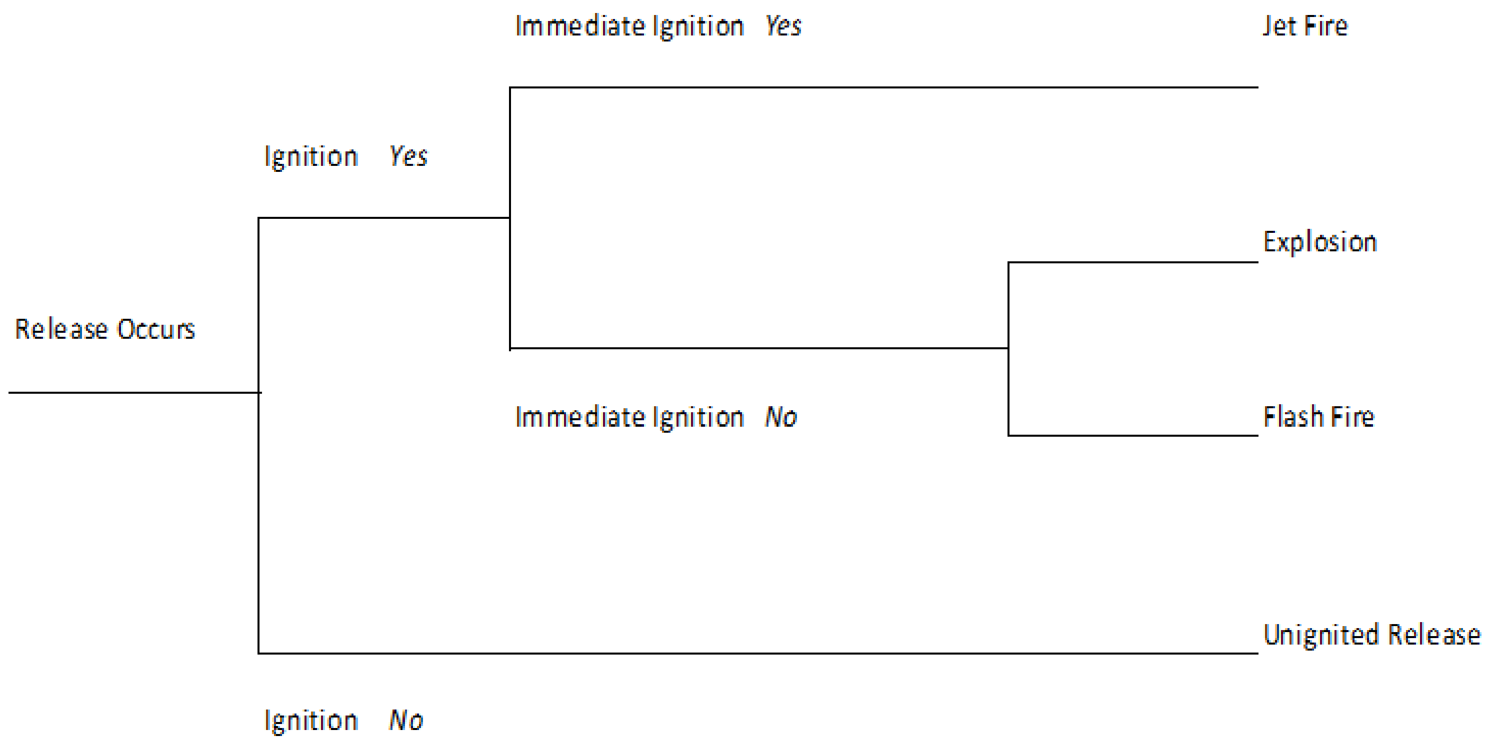

Figure 3-4: Minor, Small, Medium, Large and Catastrophic Release of Flammable Gas

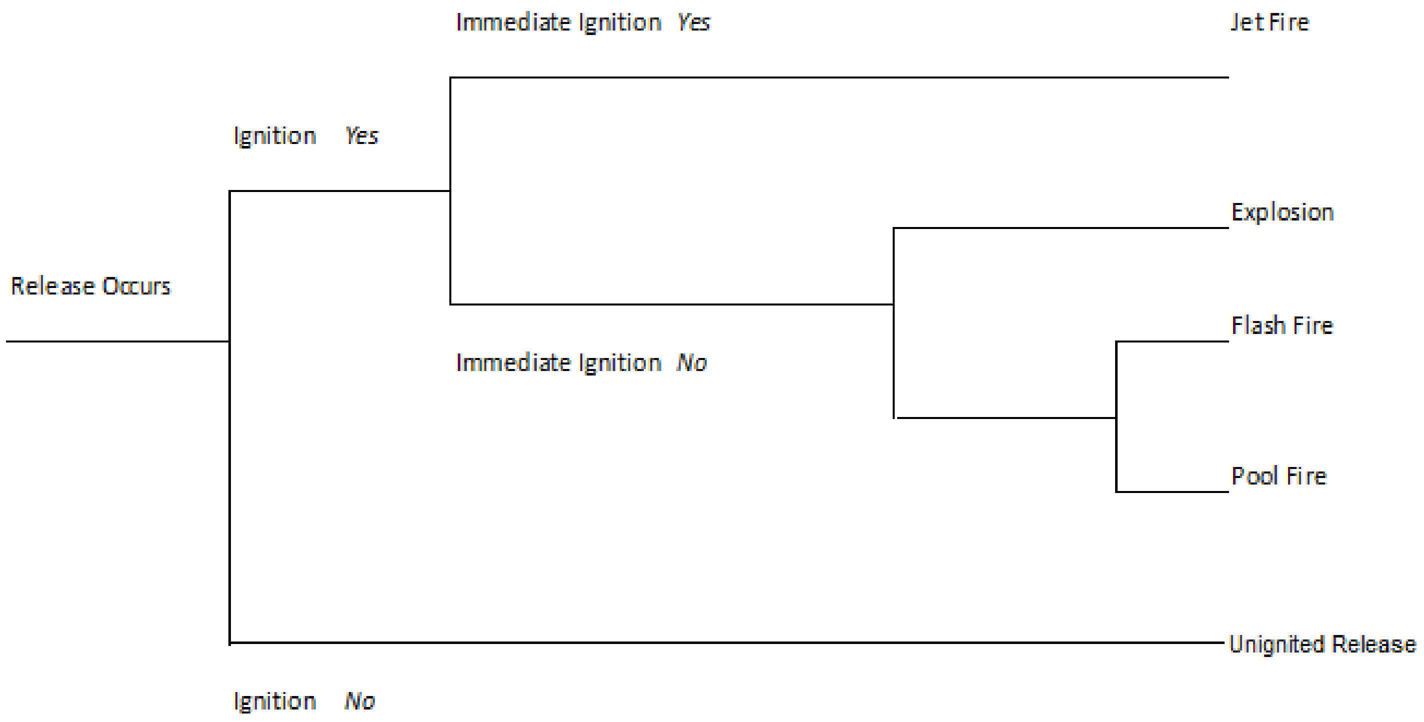

Figure 3-5: Minor, Small, Medium and Large Release of Liquefied Gas from Pressurized Storage

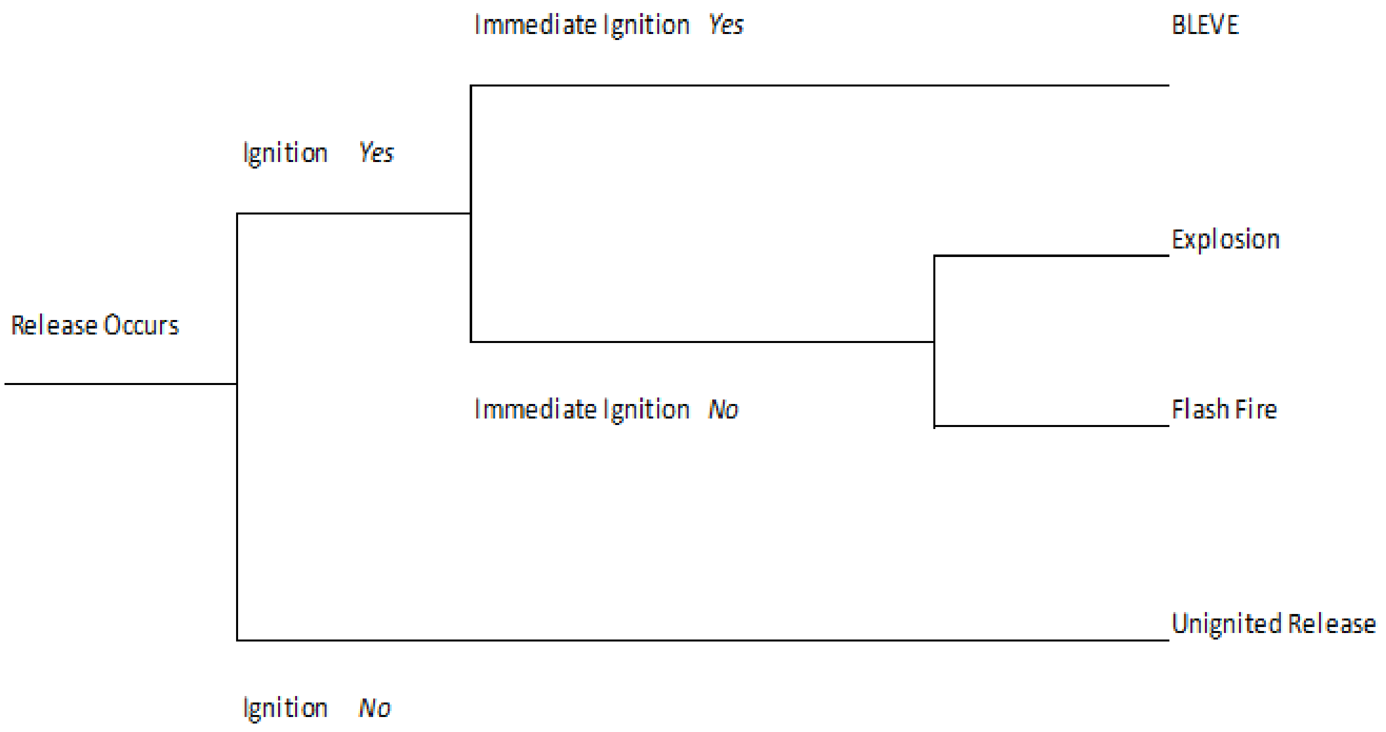

Figure 3-6: Catastrophic Release of Liquefied Gas from Pressurized Storage

3.1.7 Consequence Analysis

3.1.7.1 Hazard Zones

The following hazard zones have been analyzed via consequence modeling. The criteria for each hazard zone are as follows:

Table 3-6: Hazard Zones Criteria

Hazard	Criteria
Thermal (Fire)	37.5 kW/m^2 – This radiation level may result in up to 100% fatalities in the total population exposed and cause significant damage to process equipment
	12 kW/m^2 – This radiation level may result in up to 50% fatalities in the total population exposed and cause damage to process equipment
	4 kW/m^2 – This radiation level may result in up to 3% fatalities in the total population exposed, but below which no injuries or damage would be expected
Explosion (Overpressure)	1.013 bar, 0.9 bar, 0.17 bar

3.1.8 Models Used

Software package Phast developed by DNV GL has been used for the calculation of consequence effects for all events.

Consequence analysis was carried out for identified outcome events, including release rates, characterising flames and thermal radiation ranges, estimate dispersion distances and vapour cloud explosion overpressures.

Events

Fire and explosion events have been considered for further evaluation. Jet fire scenarios (due to immediate ignition) have been modelled (deemed to give greater consequence distance regardless of the total mass released), as a pressurised release may be ignited and hence the consequence of a fire event in this particular scenario is deemed more likely to take place within the confined area of the plant.

The consequence modelling is performed on a conservative basis to ensure risk is not underestimated. For example, the maximum inventories of hazardous substances in vessels, are used together with worst case process conditions, and releases are modelled based on initial maximum (rather than average) release rates; no account taken of site drainage/ emergency spill containment systems to limit the spread of liquid releases etc, using published computer models that are inherently conservative.

Pool Fire

Pool fires are a result from the ignition of flammable liquid spills. Upon spillage, the liquid draws energy from the ground and surrounding air, to form a flammable vapour/ air layer close to the liquid surface. The thickness of this vapour/ air layer is dependent on the flash point of the spilt liquid.

If the spill releases insufficient fuel to fill the bund area or the spill is unbunded, the pool will spread with gravitational forces pushing down on it and forcing it outwards at the edges. Spreading will stop when equilibrium is reached between the gravitational forces, frictional forces and surface tension forces acting on the spreading liquid (the latter two forces resisting pool spread). The pool thickness and hence surface area are therefore dependent on the point at which this equilibrium is reached. For pools that fill the bund or containment area, the pool surface area is fixed, with the depth of liquid varying according to the volume of liquid spilled.

Upon ignition, it is the vapour layer above the liquid pool that burn, generating heat that in turn causes further evaporation of liquid (i.e. the fire becomes self-generating). Since burning only occurs at the surface of the pool, the radiant heat effect of a pool fire is dependent on the volume of fuel spilt, the size of the bund/ containment area and the burning rate of the fuel. Hazards arising from pool fires are primarily due to thermal radiation.

Jet Fire

In the event of a continuous pressurized release of either gas or liquid or two-phase fluid, a jet of fluid will form. A jet or spray fire is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction or directions. Jet fires can arise from releases of gaseous, flashing liquid (two phase) and pure liquid inventories.

The primary concern for jet fires is that of engulfment and high thermal radiation flux. Normally jet fires should be distinguished as being either horizontal or vertical jets. Horizontal jets have the possibility of impacting upon other structures and being deflected. This process gives rise to a loss of momentum and substantial entrainment which enhances the formation of a flammable cloud and hence the potential for an unconfined explosion.

The properties of jet fires depend on the fuel composition, release conditions, release rate, release geometry, direction and ambient wind conditions. Low velocity two-phase releases of condensate material can produce 'lazy', wind affected buoyant, sooty and highly radiative flames similar to pool fires.

Flash Fire

Following a vapour, a gas cloud (which is heavier than air) will form, initially located around the release point. If this cloud is not ignited immediately, it will move with the wind and be diluted as a result of air entrainment.
The principal hazard arising from a cloud of dispersing flammable material is its subsequent (delayed) ignition, resulting in a flash fire or vapour cloud explosion. Large scale experiments on the dispersion and ignition of flammable gas clouds show that ignition is unlikely when the average concentration is below the Lower Flammability Limit (LFL).

Therefore, the following critical hazard distances were calculated to determine the hazardous extent of the clouds:

- Maximum distance to the LFL and ½ LFL of the cloud;
- Maximum crosswind LFL and ½ LFL distance of the cloud; and
- Maximum upwind LFL and ½ LFL distance of the cloud.

It is considered that there is no probability for escape within the flammable limits of a flash fire. Therefore, a fatality probability of 100% of persons present within the flammable cloud (as defined by the distances above) is assumed for flash fires.

Explosion

Explosion occurs when a sufficient amount of flammable material in gas or vapour phase within the explosive limit (LEL, UEL) is ignited. Ignition of vapour cloud with flammable mass less than the threshold value may result in a flash fire and subsequently jet fire for continuous source. The most damaging effects of an explosion come from its blast overpressure. An explosion is the sudden release of tremendous energy. The intensity of explosion depends on the rate of energy release.

Boiling Liquid Expanding Vapour Explosion (BLEVE) and Fireball

A BLEVE (Boiling Liquid Expanding Vapor Explosion) is a sudden release of a large mass of pressurized superheated liquid to the atmosphere. The primary cause is usually an external flame impinging on the shell of a vessel above the liquid level, weakening the container and leading to the sudden shell rupture. BLEVE may occur due to any mechanism that results in a sudden failure of container.

3.1.9 Tabulation of Consequence and Frequency of All Possible Accident Scenarios

This section presents the results of the consequence modelling performed for the failure cases identified in the hazard identification. All consequence results can be found in **Sub-Appendix 3B**, while the frequency results can be found in **Sub-Appendix 3C**.

3.1.10 Risk Summation

The results of risk summation are presented in terms of Individual Risk which, in the context of the DOE Risk Guidelines, is defined as the risk of fatality to a person in the vicinity of a hazard. This includes the nature of the fatality to the individual, the likelihood of the fatality occurring, and the period of time over which the fatality might occur. The individual is assumed to be unprotected and to be present during the total time of exposure (i.e. 24 hours a day, every day of the year). The individual risk value, R_i, at a particular distance, *i,* due to the occurrence of a particular event outcome, *j,* is calculated by the following equation:

$$R_i = \sum f_{eo,j} . P_{fat,i,j} . P_{weather,j},$$

where:

$f_{eo,j}$ is the frequency of event outcome *j* obtained from event tree analysis and historical data;

$P_{fat,i,j}$ is the probability of fatality at distance *i* produced by event outcome *j* from consequence analysis; and

$P_{weather,j}$ is the probability of the weather conditions required to produce the event outcome at *j* (from meteorological data, 1 for weather independent event outcomes).

The individual risk (IR) profile for the site under study is calculated with the Consultant's in-house spreadsheet based on the above equation. It is represented as a function of distance from the source of potential risk upon the surrounding environment. Risk summation involves combining the frequency of a given event outcome *j* with its associated consequences to determine the individual risk levels associated with the site.

3.1.11 Salient Findings of the EURO MOGAS and Olefin Storage Tank QRA Study

The extent of all consequences assessed is limited within the industrial development surrounding the proposed RAPID facilities, which is in compliance with DOE's risk acceptance criteria.

- That the following hazard zones/ IR contour for credible scenarios are within RAPID boundary;
  - 37.5 kW/m^2 heat radiation hazard zone; and
  - The 1.013 bar overpressure contour.
- IR Contours:
  - The 1 x 10^{-5} per year and the 1 x 10^{-6} per year IR contours extends beyond the RAPID Complex development boundary, encroaching the neighboring development on the southern side of the RAPID Complex.

The above results are in compliance of the requirements stipulated by the DOE risk criteria as no sensitive receptors (schools, residential areas) are affected.

Table 3-7: Individual Risk (IR) Contour Findings Summary for EURO 5 MOGAS Units and Olefins Storage Tankages

IR Contours	Max Distance to Contour (m)	Confirmation
1×10^{-5} per year	**703.10**	The contour extends beyond RAPID's site boundary, encroaching the neighboring development on the southern side of the RAPID Complex. However it does not encompass involuntary recipients of industrial risks to sensitive receptors i.e. schools and residential areas.
1×10^{-6} per year	**955.70**	The contour extends beyond RAPID's site boundary, encroaching the neighboring development on the southern side of the RAPID Complex. However it does not encompass involuntary recipients of industrial risks to sensitive receptors i.e. schools and residential areas.

The Individual Risk Contour for the EURO 5 MOGAS Units and Olefins Storage Tankages is attached in **Sub-Appendix 3D**.

It should be noted that the risks have been assessed on a conservative basis, both in terms of consequences(e.g. use of the maximum inventories of hazardous substances in vessels, worst case process conditions, releases are modelled based on initial maximum (rather than average) release rates, no account taken of site drainage/ emergency spill containment systems to limit the spread of liquid releases etc. using published computer models that are inherently conservative), and frequency – i.e. no account has been taken of plant safety systems (e.g. isolation valves, detectors), operator intervention to prevent or minimise releases and no credit has been taken to account for the site Safety Management System.

A worst case scenario (WCS) is the scenario which entails the farthest consequence distance amongst all the scenarios irrespective of the frequency while a worst case credible scenario (WCCS) is a credible scenario (with event frequencies > 1×10^{-6} per year) with furthest consequence distance.

Below explains the WCS and WCCS for each event from the QRA study for the Euro 5 MOGAS Plant and its associated tank farm and Olefin Storage Tank Farm:

- The WCS and WCCS of fire event is a jet fire scenario resulting from the ignited release of Ethylene (at a rate of 2222.85 kg/s) due to a catastrophic release from the HP Ethylene BOG Liquid Receiver (5220-V-102) at -114 °C and 47 barg pressure. This results in the 37.5 kW/m^2 heat radiation hazard zone (that corresponds to a radiation intensity sufficient to cause up to 100% fatalities and damage process equipment) of up to 614.87 m. The 4 kW/m^2 heat radiation hazard zone (that typically corresponds to a radiation intensity to cause up to 3% fatalities and below which no injuries or damage would be expected) extends a maximum of 877.30 m confined within the proposed RAPID project boundary. Refer to **Figure E1** at **Sub-Appendix 3E** for the WCS and WCCS contour of fire event.

- The WCS and WCCS of explosion event originate from the Boiling Liquid Expanding Vapour Explosion (BLEVE) due to a catastrophic release of Propylene from the Propylene Storage Vessel (5220-V-104) which operates at 40 °C and 15.5 barg pressure. This result in the 1.013 bar explosion overpressure hazard zone (where extensive damage and fatalities are to be expected) extends up to 79.95 m which is confined to the RAPID site boundary.Refer to **Figure E2** at **Sub-Appendix 3E** for the WCS and WCCS contour of explosion event.

- The WCS and WCCS of fireball event originate from the Boiling Liquid Expanding Vapour Explosion (BLEVE) due to a catastrophic release of Propylene from the Propylene Storage Vessel (5220-V-104) which operates at 40 °C and 15.5 barg pressure. This result in 100% fatality distance of up to 124.88 m and 3% fatality distance of up to 685.75 m, which remains within the RAPID site. Refer to **Figure E3** at **Sub-Appendix 3E** for the WCS and WCCS contour of fireball event.

3.2 Cumulative Assessment – Refinery Cracker Complex

The cumulative assessment of the entire Refinery Cracker Complex (inclusive of the latest addition of the EURO MOGAS and Olefin Storage Tanks) demonstrates that the individual risk contours for the complex are not in line with DOE's risk acceptance criteria. This is mainly due to the catastrophic failure events within the refinery units which result in offsite consequences and subsequently unacceptable risk towards the surrounding present population.

The contributing events that results in the unacceptable risk are:

1. Flash Fire event due to catastrophic failures of equipment in 2 Trains of Residue Fluid Catalytic Cracking Unit.
2. Fire events related to catastrophic failure of Intermediate LPG storage vessels of the Refinery Storage Tank Farm.

The cumulative individual risk contour for the Refinery Cracker Complex is provided in Appendix 3D. The worst case scenario consequence contours are provided in **Sub-Appendix 3G**. Recommendation for the residual risk is discussed in **Section 4.0**.

3.3 Cumulative Assessment – Refinery Cracker Complex and Petrochemical Complex

The cumulative assessment of the entire RAPID Complex (inclusive of the Refinery Cracker Complex and Petrochemical Complex) demonstrates that the individual risk contours for the complex are not in line with DOE's risk acceptance criteria. The main risk contributor towards the non-compliance are the catastrophic failure events within the refinery units which result in offsite consequences and subsequently unacceptable risk towards the surrounding present population.

Risk from the Petrochemical Complex is deemed not to be the contributing factor in resulting non-compliance of DOE's risk acceptance criteria.

The cumulative individual risk contour for the entire RAPID Complex is provided in Appendix 3D. The worst case scenario consequence contours are provided in **Sub-Appendix 3F**.

4.0 RECOMMENDATIONS

Taking into consideration that the contributing events towards the project's non-compliance in meeting DOE's risk acceptance criteria are due to catastrophic failures, the operators of the refinery shall implement the "Predictive Maintenance" programme to eliminate catastrophic equipment failures.

- The Predictive Maintenance philosophy consists of scheduling maintenance activities only if and when mechanical or operational conditions warrant-by periodically monitoring the machinery for excessive vibration, temperature and/or lubrication degradation, or by observing any other unhealthy trends that occur over time. When the condition gets to a predetermined unacceptable level, the equipment is shut down to repair or replace damaged components so as to prevent a more costly failure from occurring.

  Advantages of this approach are that it works very well if personnel have adequate knowledge, skills, and time to perform the predictive maintenance work, and that it allows equipment repairs to be scheduled in an orderly fashion. It also provides some lead-time to purchase materials for the necessary repairs, reducing the need for a high parts inventory. Since maintenance work is only performed when it is needed, there is likely to be an increase in production capacity. The predictive maintenance programme shall form part of PETRONAS's Process Safety Management Framework.

Other recommendations for the project proponent are as follows:

- Development of a formal framework for managing health, occupational safety, environment and process safety matters. Emphasis should be given to Process safety management as an analytical tool focused on preventing releases of any substance defined as a "highly hazardous chemicals". It is a set of inter-related approaches to manage hazards associated with the process industries and is intended to reduce the frequency and severity of incidents resulting from releases of chemicals and other energy sources.

- Design changes during the subsequent engineering phases post EIA should be analysed to determine the severity of the potential hazards (via safety studies) due to the proposed changes. The revised risk levels shall be in line with the governing risk criteria adopted by DOE.

- Development of an Emergency Response Plan is essential to manage emergencies within the proposed RAPID boundary. This is in line with the approval conditions obtained during the approval of the RAPID DEIA in 2012 (Approval Conditions 61 and 62).

  This plan shall address the following key elements:

  - Alerting - Notifying the offsite population that are affected or exposed to risk greater than 1E-06 fatality per year. An effective alarm and warning system for all levels of emergency shall be established and regularly tested.
  - Evacuation - Evacuation of the potentially exposed public
  - Sheltering - Provision of shelter for the evacuated public population

  The role, duties and responsibility of the person(s) initiating the off-site warning system should be defined. The plan should identify the means by which the facility operator will warn (and keep informed) people likely to be affected by the emergency. This should cover the activation of the warning system to alert people to take protective action. The key step is to determine when there is a threat to the community.

  The evacuation of people outside the facility and the control of public roads, pedestrians and vehicles is the responsibility of the Police.

Procedures should be established for liaison with the Police and Fire Services and for the provision of information that will assist in making decisions regarding public protection issues.

The plan should identify the facility's strategy for protecting people during an emergency. It should address the provision of advice to people on-site and off-site as to the appropriate action to be taken when there is a threat to their health and safety. This function is responsible for ensuring that this information is communicated and acted upon during an emergency, prior to the arrival of the emergency services.

Protective actions may include stand-by alerts, partial evacuations, full evacuation, or the use of shelters and havens. The actions taken will depend on the nature, scale and the likely duration of the emergency. Appropriate methods of protection may be determined by reference to the levels of emergency and the control zones for various emergencies.

- The proposed facility is deemed to be a Major Hazard Installation, in compliance to the CIMAH Regulations 1996, a safety report and emergency response plan shall be prepared and submitted to the Department of Occupational Safety and Health's Major Hazard Division 3 months prior to commissioning.

5.0 REFERENCES

[1] Offshore Hydrocarbon Release Data,HSE OSD, 2011, from HSE on-line database, https://www.hse.gov.uk/hcr3/.

[2] Cox, Lee &Ang, *Classification of Hazardous Location,* 1990.

[3] Operations & Maintenance Best Practices, A Guide to Achieving Operational Efficiency, US Department of Energy, August 2010.

SUB-APPENDIX 3A: EVENTS IDENTIFIED FOR EURO 5 MOGAS UNITS AND OLEFINS STORAGE TANKAGES

Table 3A-1: Events Identified

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
1	IS01_NAPH_SSHDSFSD_L	Release of Naphtha due to leak/catastrophic failure of Second Stage HDS Feed Surge Drum (1410-V-025). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
2	IS02_NAPH_SSHDSR_V	Release of Naphtha due to leak/catastrophic failure of Second Stage HDS Reactor (1410-R-004). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
3	IS03_NAPH_SSHDSSDBP_L	Release of Naphtha due to leak/catastrophic failure of Second Stage HDS Separator Drum Bottom Part (1410-V-026). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
4	IS04_H2_SSHDSSDUP_V	Release of Hydrogen due to leak/catastrophic failure of Second Stage HDS Separator Drum Upper Part (1410-V-026). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
5	IS05_H2_SSHDSAAKOD_V	Release of Hydrogen due to leak/catastrophic failure of Second Stage HDS Amine Absorber K.O. Drum (1410-V-027). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
6	IS06_MDEA_SSHDSLASD_L	Release of MDEA due to leak/catastrophic failure of Second Stage HDS Lean Amine Surge Drum (1410-V-030). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
7	IS07_MDEA_SSHDSAABP_L	Release of MDEA due to leak/catastrophic failure of Second Stage HDS Amine Absorber Bottom Part (1410-C-005). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
8	IS08_H2_SSHDSAAUP_V	Release of Hydrogen due to leak/catastrophic failure of Second Stage HDS Amine Absorber Upper Part (1410-C-005). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
9	IS09_H2_SSHDSRGCKOD_V	Release of Hydrogen due to leak/catastrophic failure of Second Stage HDS Recycle Gas Compressors K.O. Drum (1410-V-028). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and	Jet Fire, Flash Fire and Explosion

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
		Explosion.	
10	IS10_NAPH_SSHDSS_V	Release of Naphtha due to leak/catastrophic failure of Second Stage HDS Stabilizer (1410-C-006). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
11	IS11_H2_SSHDSSRD_V	Release of Hydrogen due to leak/catastrophic failure of Second Stage HDS Stabilizer Reflux Drum (1410-V-029). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
12	IS12_NAPH_LCNFSD_L	Release of Naphtha due to leak/catastrophic failure of LCN Feed Surge Drum (1440-V-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
13	IS13_MEOH_FR_L	Release of Methanol due to leak/catastrophic failure of First Reactor (1440-R-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
14	IS14_MEOH_SR_L	Release of Methanol due to leak/catastrophic failure of Second Reactor (1440-R-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
15	IS15_TAME_TFBP_L	Release of TAME due to leak/catastrophic failure of TAME Fractionator Bottom Part (1440-C-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
16	IS16_MEOH_TFUP_V	Release of Methanol due to leak/catastrophic failure of TAME Fractionator Upper Part (1440-C-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
17	IS17_MEOH_TFRDBP_L	Release of Methanol due to leak/catastrophic failure of TAME Fractionator Reflux Drum Bottom Part (1440-V-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
18	IS18_NAPH_TFRDUP_V	Release of Naphtha due to leak/catastrophic failure of TAME Fractionator Reflux Drum Upper Part (1440-V-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
19	IS19_MEOH_TR_L	Release of Methanol due to leak/catastrophic failure of Third Reactor (1440-R-003). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
20	IS20_NAPH_RWCBP_L	Release of Naphtha due to leak/catastrophic failure of Raffinate Washing Column Bottom Part (1440-C-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
21	IS21_MEOH_RWCUP_V	Release of Methanol due to leak/catastrophic failure of Raffinate Washing Column Upper Part (1440-C-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
22	IS22_MEOH_MCFD_L	Release of Methanol due to leak/catastrophic failure of Methanol Column Feed Drum (1440-V-004). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
23	IS23_MEOH_RC_L	Release of Methanol due to leak/catastrophic failure of Raffinate Coalescer (1440-V-003). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
24	IS24_MEOH_MC_V	Release of Methanol due to leak/catastrophic failure of Methanol Column (1440-C-003). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
25	IS25_MEOH_MCRD_L	Release of Methanol due to leak/catastrophic failure of Methanol Column Reflux Drum (1440-V-005). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
26	IS26_MEOH_MGP_L	Release of Methanol due to leak/catastrophic failure of Methanol Guard Pot (1440-V-007 A/B). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
27	IS27_MEOH_MMUSD_L	Release of Methanol due to leak/catastrophic failure of Methanol Make-Up Surge Drum (1440-V-006). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
28	IS28_MEOH_MDD_V	Release of Methanol due to leak/catastrophic failure of Methanol Drains Drum (1440-V-008). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
29	IS29_HC_HCDD_L	Release of Hydrocarbon due to leak/catastrophic failure of HC Drains Drum (1440-V-009). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
30	IS30_NAPH_SGB_L	Release of Naphtha due to leak/catastrophic failure of Sulphur Guard Bed (1450-V-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
31	IS31_NAPH_FSD_L	Release of Naphtha due to leak/catastrophic failure of Feed Surge Drum (1450-V-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
32	IS32_NAPH_FD_L	Release of Naphtha due to leak/catastrophic failure of Feed Dryers (1450-V-003 A/B). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
33	IS33_H2_H2PR_V	Release of Hydrogen due to leak/catastrophic failure of H2 Purification Reactor (1450-R-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
34	IS34_H2_HD_V	Release of Hydrogen due to leak/catastrophic failure of Hydrogen Dryers (1450-V-004 A/B). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
35	IS35_ISOM_CGB_L	Release of Isomer due to leak/catastrophic failure of Chloride Guard Bed (1450-V-006). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
36	IS36_H2_FIR_V	Release of Hydrogen due to leak/catastrophic failure of First Isomerization Reactor (1450-R-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
37	IS37_NAPH_SIRBP_L	Release of Naphtha due to leak/catastrophic failure of Second Isomerization Reactor Bottom Part (1450-R-003). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
38	IS38_H2_SIRUP_V	Release of Hydrogen due to leak/catastrophic failure of Second Isomerization Reactor Upper Part (1450-R-003). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
39	IS39_LPG_S_V	Release of LPG due to leak/catastrophic failure of Stabilizer (1450-C-001). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
40	IS40_ISOM_SRDBP_L	Release of Isomer due to leak/catastrophic failure of Stabilizer Reflux Drum Bottom Part (1450-V-007). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
41	IS41_LPG_SRDUP_V	Release of LPG due to leak/catastrophic failure of Stabilizer Reflux Drum Upper Part (1450-V-007). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
42	IS42_ISOM_DRD_L	Release of Isomer due to leak/catastrophic failure of Dryers Regeneration Degasser (1450-V-008). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
43	IS43_H2_CS_V	Release of Hydrogen due to leak/catastrophic failure of Caustic Scrubber (1450-C-002). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
44	IS44_TAME_TST_L	Release of TAME due to leak/catastrophic failure of TAME Storage Tanks (5150-V-004 A/B). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
45	IS45_ISOM_IST_L	Release of Isomer due to leak/catastrophic failure of Isomerate Storage Tanks (5150-V-005 A/B). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
46	IS46_NAPH_MST_L	Release of Naphtha due to leak/catastrophic failure of MCN Storage Tank (5150-T-011C). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
47	IS47_TAME_PIPESTPU_L	Release of TAME due to leak/catastrophic failure of pipeline from TAME storage tanks to process unit. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
48	IS48_TAME_PIPEPUST_L	Release of TAME due to leak/catastrophic failure of pipeline from process unit to TAME storage tanks. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
49	IS49_ISOM_PIPEPUST_L	Release of Isomer due to leak/catastrophic failure of pipeline from process unit to Isomerate storage tanks. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
50	IS50_NAPH_PIPESTPU_L	Release of Naphtha due to leak/catastrophic failure of pipeline from MCN storage tanks to process unit. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
51	IS51_NAPH_PIPEPUST_L	Release of Naphtha due to leak/catastrophic failure of pipeline from process unit to MCN storage tanks. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
52	IS52_NAPH_PIPEPUMHST_L	Release of Naphtha due to leak/catastrophic failure of pipeline from process unit (CHNT2) to MCN + HCN storage tank. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
53	IS53_ETHY_EST_L	Release of Ethylene due to leak/catastrophic failure of Ethylene Storage Tank (5220-T-101). For minor, small, medium and large release, an immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire, Flash Fire and Explosion. For catastrophic release, an immediate outcome will result in BLEVE while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Pool Fire, Flash Fire, Explosion, BLEVE
54	IS54_ETHY_BOGC_V	Release of Ethylene due to leak/catastrophic failure of BOG Compressor (5220-A-105). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
55	IS55_ETHY_HPEBOGLR_V	Release of Ethylene due to leak/catastrophic failure of HP Ethylene BOG Liquid Receiver (5220-V-102). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
56	IS56_ETHY_LPEBOGLR_L	Release of Ethylene due to leak/catastrophic failure of LP Ethylene BOG Liquid Receiver (5220-V-103). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
57	IS57_PROPY_PSV_L	Release of Propylene due to leak/catastrophic failure of Propylene Storage Vessels (5220-V-104 A/B/C/D). For minor, small, medium and large release, an immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire, Flash Fire and Explosion. For catastrophic release, an immediate outcome will result in BLEVE while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Pool Fire, Flash Fire, Explosion, BLEVE
58	IS58_BUTD_BSV_L	Release of Butadiene due to leak/catastrophic failure of Butadiene Storage Vessels (5220-V-101 A/B/C/D). For minor, small, medium and large release, an immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire, Flash Fire and Explosion. For catastrophic release, an immediate outcome will result in BLEVE while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Pool Fire, Flash Fire, Explosion, BLEVE
59	IS59_ETHY_CFKOD_L	Release of Ethylene due to leak/catastrophic failure of Cold Flare Knock Out Drum (5220-V-109). An immediate and delayed outcome will result in Pool Fire.	Pool Fire
60	IS60_ETHY_PIPEU2100U5220_L	Release of Ethylene due to leak/catastrophic failure of pipeline U-2100 to/from U-5220. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
61	IS61_ETHY_PIPEU5220PDT2_L	Release of Ethylene due to leak/catastrophic failure of pipeline U-5220 to/from PDT2 BL. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
62	IS62_ETHY_PIPEU5220BLU_V	Release of Ethylene due to leak/catastrophic failure of pipeline U-5220 BL to users. An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion

No.	Isolatable Sub-section ID	Description	Potential Outcome (s)
63	IS63_PROPY_PIPEU5210U5220_V	Release of Propylene due to leak/catastrophic failure of pipeline U-5210 BL to/from U-5220 BL. An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
64	IS64_PROPY_PIPEU5220J_V	Release of Propylene due to leak/catastrophic failure of pipeline U-5220 BL to/from jetty. An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
65	IS65_PROPY_PIPEMURP_V	Release of Propylene due to leak/catastrophic failure of pipeline make-up to refrigerant package (within U-5220, downstream of 5220-E-102). An immediate outcome will result in Jet Fire while delayed outcome will result in Flash Fire and Explosion.	Jet Fire, Flash Fire and Explosion
66	IS66_BUTD_PIPEU5210U5220_L	Release of Butadiene due to leak/catastrophic failure of pipeline U-5210 BL to/from U-5220 BL. An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
67	IS67_BUTD_PIPEU5220JLI_L	Release of Butadiene due to leak/catastrophic failure of pipeline U-5220 BL to/from jetty (loading/import). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire
68	IS68_BUTD_PIPEU5220JCLI_L	Release of Butadiene due to leak/catastrophic failure of pipeline U-5220 BL to/from jetty (circulation/loading/import). An immediate outcome will result in Jet Fire while delayed outcome will result in Pool Fire.	Jet Fire and Pool Fire

SUB-APPENDIX 3B: CONSEQUENCE MODELLING RESULT FOR EURO 5 MOGAS UNITS AND OLEFINS STORAGE TANKAGES

Pool Fire Events Due to Minor Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
3	IS03_NAPH_SSHDSSDBP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
6	IS06_MDEA_SSHDSLASD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
7	IS07_MDEA_SSHDSAABP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_PF_0_1	1.00	11.01	13.02	14.32
	IS12_NAPH_LCNFSD_L_PF_0_0.5	0.50	18.94	21.96	17.64
	IS12_NAPH_LCNFSD_L_PF_0_0.03	0.03	32.35	29.80	20.40
13	IS13_MEOH_FR_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS13_MEOH_FR_L_PF_0_0.5	0.50	20.94	23.42	24.36
	IS13_MEOH_FR_L_PF_0_0.03	0.03	30.02	30.62	30.63
14	IS14_MEOH_SR_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS14_MEOH_SR_L_PF_0_0.5	0.50	19.79	22.15	23.03
	IS14_MEOH_SR_L_PF_0_0.03	0.03	28.53	29.14	29.13
15	IS15_TAME_TFBP_L_PF_0_1	1.00	12.50	14.96	0.00
	IS15_TAME_TFBP_L_PF_0_0.5	0.50	18.63	19.79	0.00
	IS15_TAME_TFBP_L_PF_0_0.03	0.03	27.13	23.98	0.00
17	IS17_MEOH_TFRDBP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS17_MEOH_TFRDBP_L_PF_0_0.5	0.50	12.27	13.81	14.34
	IS17_MEOH_TFRDBP_L_PF_0_0.03	0.03	19.62	20.06	20.00
19	IS19_MEOH_TR_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS19_MEOH_TR_L_PF_0_0.5	0.50	20.86	23.33	24.27
	IS19_MEOH_TR_L_PF_0_0.03	0.03	29.92	30.52	30.53
20	IS20_NAPH_RWCBP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
22	IS22_MEOH_MCFD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS22_MEOH_MCFD_L_PF_0_0.5	0.50	15.09	Not reachable	Not reachable
	IS22_MEOH_MCFD_L_PF_0_0.03	0.03	21.33	Not reachable	Not reachable
23	IS23_MEOH_RC_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS23_MEOH_RC_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS23_MEOH_RC_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
25	IS25_MEOH_MCRD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS25_MEOH_MCRD_L_PF_0_0.5	0.50	12.61	14.07	14.60
	IS25_MEOH_MCRD_L_PF_0_0.03	0.03	19.64	20.13	20.08
26	IS26_MEOH_MGP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
27	IS27_MEOH_MMUSD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS27_MEOH_MMUSD_L_PF_0_0.5	0.50	12.18	13.75	14.28
	IS27_MEOH_MMUSD_L_PF_0_0.03	0.03	19.47	19.92	19.87
29	IS29_HC_HCDD_L_PF_0_1	1.00	7.06	7.61	8.01
	IS29_HC_HCDD_L_PF_0_0.5	0.50	14.70	18.94	20.67
	IS29_HC_HCDD_L_PF_0_0.03	0.03	26.59	28.98	30.01

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
30	IS30_NAPH_SGB_L_PF_0_1	1.00	14.18	16.82	17.90
	IS30_NAPH_SGB_L_PF_0_0.5	0.50	21.30	23.23	18.74
	IS30_NAPH_SGB_L_PF_0_0.03	0.03	31.67	28.81	19.58
31	IS31_NAPH_FSD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
32	IS32_NAPH_FD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
35	IS35_ISOM_CGB_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
37	IS37_NAPH_SIRBP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
40	IS40_ISOM_SRDBP_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
42	IS42_ISOM_DRD_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS42_ISOM_DRD_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS42_ISOM_DRD_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
44	IS44_TAME_TST_L_PF_0_1	1.00	10.25	10.85	11.73
	IS44_TAME_TST_L_PF_0_0.5	0.50	18.03	23.08	24.99
	IS44_TAME_TST_L_PF_0_0.03	0.03	32.81	34.79	34.88
45	IS45_ISOM_IST_L_PF_0_1	1.00	10.25	10.85	11.73
	IS45_ISOM_IST_L_PF_0_0.5	0.50	18.03	23.08	24.99

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS45_ISOM_IST_L_PF_0_0.03	0.03	32.81	34.79	34.88
46	IS46_NAPH_MST_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
47	IS47_TAME_PIPESTPU_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
48	IS48_TAME_PIPEPUST_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
49	IS49_ISOM_PIPEPUST_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
50	IS50_NAPH_PIPESTPU_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
51	IS51_NAPH_PIPEPUST_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
52	IS52_NAPH_PIPEPUMHST_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
53	IS53_ETHY_EST_L_PF_0_1	1.00	2.64	3.02	3.22
	IS53_ETHY_EST_L_PF_0_0.5	0.50	2.64	3.57	4.07
	IS53_ETHY_EST_L_PF_0_0.03	0.03	4.08	5.01	5.33
56	IS56_ETHY_LPEBOGLR_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS56_ETHY_LPEBOGLR_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
58	IS58_BUTD_BSV_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
59	IS59_ETHY_CFKOD_L_PF_0_1	1.00	3.09	3.33	3.53
	IS59_ETHY_CFKOD_L_PF_0_0.5	0.50	3.66	4.26	4.95
	IS59_ETHY_CFKOD_L_PF_0_0.03	0.03	5.69	5.83	6.27
60	IS60_ETHY_PIPEU2100U5220_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
61	IS61_ETHY_PIPEU5220PDT2_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
66	IS66_BUTD_PIPEU5210U5220_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
67	IS67_BUTD_PIPEU5220JLI_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
68	IS68_BUTD_PIPEU5220JCLI_L_PF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_0_0.03	0.03	Not reachable	Not reachable	Not reachable

Pool Fire Events Due to Small Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
3	IS03_NAPH_SSHDSSDBP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
6	IS06_MDEA_SSHDSLASD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
7	IS07_MDEA_SSHDSAABP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS12_NAPH_LCNFSD_L_PF_S_0.5	0.50	25.59	28.22	30.75
	IS12_NAPH_LCNFSD_L_PF_S_0.03	0.03	50.19	58.73	60.55
13	IS13_MEOH_FR_L_PF_S_1	1.00	41.55	41.53	41.14
	IS13_MEOH_FR_L_PF_S_0.5	0.50	53.05	57.83	58.89
	IS13_MEOH_FR_L_PF_S_0.03	0.03	76.78	77.35	76.39
14	IS14_MEOH_SR_L_PF_S_1	1.00	39.35	39.25	38.87
	IS14_MEOH_SR_L_PF_S_0.5	0.50	50.25	54.81	55.86
	IS14_MEOH_SR_L_PF_S_0.03	0.03	73.01	73.51	72.61
15	IS15_TAME_TFBP_L_PF_S_1	1.00	23.45	23.90	24.27
	IS15_TAME_TFBP_L_PF_S_0.5	0.50	28.88	35.48	39.74
	IS15_TAME_TFBP_L_PF_S_0.03	0.03	48.31	53.16	52.32

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
17	IS17_MEOH_TFRDBP_L_PF_S_1	1.00	24.89	24.10	23.61
	IS17_MEOH_TFRDBP_L_PF_S_0.5	0.50	33.43	36.82	37.70
	IS17_MEOH_TFRDBP_L_PF_S_0.03	0.03	52.36	52.33	51.65
19	IS19_MEOH_TR_L_PF_S_1	1.00	41.41	41.38	40.98
	IS19_MEOH_TR_L_PF_S_0.5	0.50	52.87	57.62	58.68
	IS19_MEOH_TR_L_PF_S_0.03	0.03	76.54	77.10	76.14
20	IS20_NAPH_RWCBP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
22	IS22_MEOH_MCFD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS22_MEOH_MCFD_L_PF_S_0.5	0.50	33.62	37.03	37.55
	IS22_MEOH_MCFD_L_PF_S_0.03	0.03	47.87	47.66	46.24
23	IS23_MEOH_RC_L_PF_S_1	1.00	37.29	Not reachable	Not reachable
	IS23_MEOH_RC_L_PF_S_0.5	0.50	45.94	43.78	36.98
	IS23_MEOH_RC_L_PF_S_0.03	0.03	65.03	54.66	42.98
25	IS25_MEOH_MCRD_L_PF_S_1	1.00	22.52	Not reachable	Not reachable
	IS25_MEOH_MCRD_L_PF_S_0.5	0.50	28.84	32.31	33.46
	IS25_MEOH_MCRD_L_PF_S_0.03	0.03	44.09	44.87	44.84
26	IS26_MEOH_MGP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_S_0.5	0.50	31.25	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_S_0.03	0.03	38.46	Not reachable	Not reachable
27	IS27_MEOH_MMUSD_L_PF_S_1	1.00	24.72	23.95	23.47
	IS27_MEOH_MMUSD_L_PF_S_0.5	0.50	33.17	36.55	37.41
	IS27_MEOH_MMUSD_L_PF_S_0.03	0.03	51.93	51.90	51.22
29	IS29_HC_HCDD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS29_HC_HCDD_L_PF_S_0.5	0.50	17.37	20.03	21.53

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS29_HC_HCDD_L_PF_S_0.03	0.03	39.08	46.93	49.85
30	IS30_NAPH_SGB_L_PF_S_1	1.00	24.36	25.75	26.43
	IS30_NAPH_SGB_L_PF_S_0.5	0.50	30.94	37.82	41.87
	IS30_NAPH_SGB_L_PF_S_0.03	0.03	48.75	54.15	54.55
31	IS31_NAPH_FSD_L_PF_S_1	1.00	22.55	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_S_0.5	0.50	28.49	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_S_0.03	0.03	47.27	Not reachable	Not reachable
32	IS32_NAPH_FD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
35	IS35_ISOM_CGB_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
37	IS37_NAPH_SIRBP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
40	IS40_ISOM_SRDBP_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
42	IS42_ISOM_DRD_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS42_ISOM_DRD_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS42_ISOM_DRD_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
44	IS44_TAME_TST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS44_TAME_TST_L_PF_S_0.5	0.50	23.32	25.19	26.54
	IS44_TAME_TST_L_PF_S_0.03	0.03	48.10	57.41	60.74
45	IS45_ISOM_IST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS45_ISOM_IST_L_PF_S_0.5	0.50	23.32	25.19	26.54
	IS45_ISOM_IST_L_PF_S_0.03	0.03	48.10	57.41	60.74
46	IS46_NAPH_MST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
47	IS47_TAME_PIPESTPU_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
48	IS48_TAME_PIPEPUST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
49	IS49_ISOM_PIPEPUST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
50	IS50_NAPH_PIPESTPU_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
51	IS51_NAPH_PIPEPUST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
52	IS52_NAPH_PIPEPUMHST_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
53	IS53_ETHY_EST_L_PF_S_1	1.00	4.00	4.25	4.51
	IS53_ETHY_EST_L_PF_S_0.5	0.50	7.97	8.66	9.01
	IS53_ETHY_EST_L_PF_S_0.03	0.03	12.95	12.30	12.28

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
56	IS56_ETHY_LPEBOGLR_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
58	IS58_BUTD_BSV_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
59	IS59_ETHY_CFKOD_L_PF_S_1	1.00	4.97	5.44	5.72
	IS59_ETHY_CFKOD_L_PF_S_0.5	0.50	9.49	10.54	10.87
	IS59_ETHY_CFKOD_L_PF_S_0.03	0.03	15.16	14.96	14.90
60	IS60_ETHY_PIPEU2100U5220_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
61	IS61_ETHY_PIPEU5220PDT2_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
66	IS66_BUTD_PIPEU5210U5220_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
67	IS67_BUTD_PIPEU5220JLI_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
68	IS68_BUTD_PIPEU5220JCLI_L_PF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_S_0.5	0.50	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS68_BUTD_PIPEU5220JCLI_L_PF_S_0.03	0.03	Not reachable	Not reachable	Not reachable

Pool Fire Events Due to Medium Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
3	IS03_NAPH_SSHDSSDBP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_M_0.5	0.50	75.10	64.72	0.00
	IS03_NAPH_SSHDSSDBP_L_PF_M_0.03	0.03	113.75	96.56	0.00
6	IS06_MDEA_SSHDSLASD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
7	IS07_MDEA_SSHDSAABP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS12_NAPH_LCNFSD_L_PF_M_0.5	0.50	61.90	60.12	59.27
	IS12_NAPH_LCNFSD_L_PF_M_0.03	0.03	106.64	123.65	132.47
13	IS13_MEOH_FR_L_PF_M_1	1.00	102.91	103.03	101.91
	IS13_MEOH_FR_L_PF_M_0.5	0.50	136.76	146.44	149.12
	IS13_MEOH_FR_L_PF_M_0.03	0.03	196.07	198.65	197.20
14	IS14_MEOH_SR_L_PF_M_1	1.00	100.35	100.11	98.85
	IS14_MEOH_SR_L_PF_M_0.5	0.50	133.89	143.08	145.52
	IS14_MEOH_SR_L_PF_M_0.03	0.03	192.69	194.73	193.02

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
15	IS15_TAME_TFBP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS15_TAME_TFBP_L_PF_M_0.5	0.50	58.53	57.52	56.96
	IS15_TAME_TFBP_L_PF_M_0.03	0.03	93.71	106.31	111.12
17	IS17_MEOH_TFRDBP_L_PF_M_1	1.00	54.03	53.02	52.34
	IS17_MEOH_TFRDBP_L_PF_M_0.5	0.50	75.54	82.13	84.42
	IS17_MEOH_TFRDBP_L_PF_M_0.03	0.03	115.31	116.75	116.47
19	IS19_MEOH_TR_L_PF_M_1	1.00	102.74	102.83	101.70
	IS19_MEOH_TR_L_PF_M_0.5	0.50	136.58	146.22	148.88
	IS19_MEOH_TR_L_PF_M_0.03	0.03	195.87	198.39	196.92
20	IS20_NAPH_RWCBP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_M_0.5	0.50	75.21	70.22	68.97
	IS20_NAPH_RWCBP_L_PF_M_0.03	0.03	118.11	120.98	123.60
22	IS22_MEOH_MCFD_L_PF_M_1	1.00	40.89	44.20	44.82
	IS22_MEOH_MCFD_L_PF_M_0.5	0.50	48.64	56.23	58.52
	IS22_MEOH_MCFD_L_PF_M_0.03	0.03	66.26	70.96	72.11
23	IS23_MEOH_RC_L_PF_M_1	1.00	65.84	70.41	71.10
	IS23_MEOH_RC_L_PF_M_0.5	0.50	82.93	93.53	96.71
	IS23_MEOH_RC_L_PF_M_0.03	0.03	115.66	121.00	122.10
25	IS25_MEOH_MCRD_L_PF_M_1	1.00	30.34	30.59	30.59
	IS25_MEOH_MCRD_L_PF_M_0.5	0.50	37.94	42.65	44.39
	IS25_MEOH_MCRD_L_PF_M_0.03	0.03	55.32	57.41	58.08
26	IS26_MEOH_MGP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_M_0.5	0.50	55.44	66.51	69.66
	IS26_MEOH_MGP_L_PF_M_0.03	0.03	67.39	75.99	78.27
27	IS27_MEOH_MMUSD_L_PF_M_1	1.00	33.21	33.11	33.01
	IS27_MEOH_MMUSD_L_PF_M_0.5	0.50	44.38	49.73	51.77

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS27_MEOH_MMUSD_L_PF_M_0.03	0.03	67.60	69.64	70.27
29	IS29_HC_HCDD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS29_HC_HCDD_L_PF_M_0.5	0.50	45.40	44.35	44.42
	IS29_HC_HCDD_L_PF_M_0.03	0.03	85.82	101.71	110.13
30	IS30_NAPH_SGB_L_PF_M_1	1.00	Not reachable	Not reachable	42.55
	IS30_NAPH_SGB_L_PF_M_0.5	0.50	43.23	50.43	53.44
	IS30_NAPH_SGB_L_PF_M_0.03	0.03	63.82	74.25	77.16
31	IS31_NAPH_FSD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_M_0.5	0.50	55.48	56.05	56.38
	IS31_NAPH_FSD_L_PF_M_0.03	0.03	90.29	104.67	111.37
32	IS32_NAPH_FD_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
35	IS35_ISOM_CGB_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
37	IS37_NAPH_SIRBP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
40	IS40_ISOM_SRDBP_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
42	IS42_ISOM_DRD_L_PF_M_1	1.00	Not reachable	54.09	Not reachable
	IS42_ISOM_DRD_L_PF_M_0.5	0.50	54.10	65.28	Not reachable
	IS42_ISOM_DRD_L_PF_M_0.03	0.03	79.08	83.96	Not reachable
44	IS44_TAME_TST_L_PF_M_1	1.00	37.15	42.90	44.08

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS44_TAME_TST_L_PF_M_0.5	0.50	43.91	55.54	59.43
	IS44_TAME_TST_L_PF_M_0.03	0.03	61.41	69.91	71.36
45	IS45_ISOM_IST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS45_ISOM_IST_L_PF_M_0.5	0.50	44.69	43.81	43.83
	IS45_ISOM_IST_L_PF_M_0.03	0.03	80.56	96.47	105.05
46	IS46_NAPH_MST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_M_0.5	0.50	90.66	76.67	72.73
	IS46_NAPH_MST_L_PF_M_0.03	0.03	142.40	131.12	127.95
47	IS47_TAME_PIPESTPU_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_M_0.5	0.50	51.21	54.13	55.24
	IS47_TAME_PIPESTPU_L_PF_M_0.03	0.03	80.13	93.60	99.34
48	IS48_TAME_PIPEPUST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_M_0.5	0.50	70.15	68.25	67.40
	IS48_TAME_PIPEPUST_L_PF_M_0.03	0.03	113.01	124.36	130.13
49	IS49_ISOM_PIPEPUST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_M_0.5	0.50	79.40	74.89	72.90
	IS49_ISOM_PIPEPUST_L_PF_M_0.03	0.03	128.62	137.90	143.03
50	IS50_NAPH_PIPESTPU_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_M_0.5	0.50	71.36	67.11	66.33
	IS50_NAPH_PIPESTPU_L_PF_M_0.03	0.03	110.10	111.15	112.57
51	IS51_NAPH_PIPEPUST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_M_0.5	0.50	77.28	73.42	71.66
	IS51_NAPH_PIPEPUST_L_PF_M_0.03	0.03	125.08	134.94	140.25
52	IS52_NAPH_PIPEPUMHST_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_M_0.5	0.50	78.07	71.24	69.46
	IS52_NAPH_PIPEPUMHST_L_PF_M_0.03	0.03	122.16	121.47	122.57

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
53	IS53_ETHY_EST_L_PF_M_1	1.00	13.88	17.31	18.71
	IS53_ETHY_EST_L_PF_M_0.5	0.50	27.07	29.70	29.67
	IS53_ETHY_EST_L_PF_M_0.03	0.03	44.86	45.39	44.03
56	IS56_ETHY_LPEBOGLR_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
58	IS58_BUTD_BSV_L_PF_M_1	1.00	62.31	47.01	31.49
	IS58_BUTD_BSV_L_PF_M_0.5	0.50	99.25	63.89	38.65
	IS58_BUTD_BSV_L_PF_M_0.03	0.03	152.65	86.14	44.75
59	IS59_ETHY_CFKOD_L_PF_M_1	1.00	17.19	21.53	23.36
	IS59_ETHY_CFKOD_L_PF_M_0.5	0.50	32.50	35.41	35.48
	IS59_ETHY_CFKOD_L_PF_M_0.03	0.03	53.43	54.05	52.62
60	IS60_ETHY_PIPEU2100U5220_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
61	IS61_ETHY_PIPEU5220PDT2_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
66	IS66_BUTD_PIPEU5210U5220_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
67	IS67_BUTD_PIPEU5220JLI_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS67_BUTD_PIPEU5220JLI_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable
68	IS68_BUTD_PIPEU5220JCLI_L_PF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_M_0.03	0.03	Not reachable	Not reachable	Not reachable

Pool Fire Events Due to Large Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_PF_L_1	1.00	Not reachable	Not reachable	76.97
	IS01_NAPH_SSHDSFSD_L_PF_L_0.5	0.50	73.03	84.27	92.02
	IS01_NAPH_SSHDSFSD_L_PF_L_0.03	0.03	97.36	109.85	106.19
3	IS03_NAPH_SSHDSSDBP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_L_0.5	0.50	111.39	114.19	115.43
	IS03_NAPH_SSHDSSDBP_L_PF_L_0.03	0.03	165.99	188.02	201.95
6	IS06_MDEA_SSHDSLASD_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
7	IS07_MDEA_SSHDSAABP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS12_NAPH_LCNFSD_L_PF_L_0.5	0.50	75.09	75.52	75.75
	IS12_NAPH_LCNFSD_L_PF_L_0.03	0.03	125.38	148.57	161.97
13	IS13_MEOH_FR_L_PF_L_1	1.00	125.30	127.60	127.54
	IS13_MEOH_FR_L_PF_L_0.5	0.50	163.80	177.18	182.04
	IS13_MEOH_FR_L_PF_L_0.03	0.03	230.47	237.14	238.03

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
14	IS14_MEOH_SR_L_PF_L_1	1.00	122.63	124.61	124.43
	IS14_MEOH_SR_L_PF_L_0.5	0.50	161.04	174.05	178.73
	IS14_MEOH_SR_L_PF_L_0.03	0.03	227.55	233.83	234.52
15	IS15_TAME_TFBP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS15_TAME_TFBP_L_PF_L_0.5	0.50	91.01	90.94	90.32
	IS15_TAME_TFBP_L_PF_L_0.03	0.03	142.74	163.79	174.72
17	IS17_MEOH_TFRDBP_L_PF_L_1	1.00	60.85	60.67	60.45
	IS17_MEOH_TFRDBP_L_PF_L_0.5	0.50	84.23	92.41	95.70
	IS17_MEOH_TFRDBP_L_PF_L_0.03	0.03	126.95	130.22	131.06
19	IS19_MEOH_TR_L_PF_L_1	1.00	125.13	127.39	127.33
	IS19_MEOH_TR_L_PF_L_0.5	0.50	163.63	176.97	181.81
	IS19_MEOH_TR_L_PF_L_0.03	0.03	230.28	236.92	237.79
20	IS20_NAPH_RWCBP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_L_0.5	0.50	103.28	106.61	107.45
	IS20_NAPH_RWCBP_L_PF_L_0.03	0.03	157.93	182.23	196.53
22	IS22_MEOH_MCFD_L_PF_L_1	1.00	48.96	53.43	53.95
	IS22_MEOH_MCFD_L_PF_L_0.5	0.50	57.18	66.23	68.60
	IS22_MEOH_MCFD_L_PF_L_0.03	0.03	75.56	81.82	83.11
23	IS23_MEOH_RC_L_PF_L_1	1.00	79.12	85.97	86.92
	IS23_MEOH_RC_L_PF_L_0.5	0.50	97.75	111.62	115.60
	IS23_MEOH_RC_L_PF_L_0.03	0.03	132.94	142.10	144.12
25	IS25_MEOH_MCRD_L_PF_L_1	1.00	35.41	36.24	36.27
	IS25_MEOH_MCRD_L_PF_L_0.5	0.50	43.25	48.66	50.51
	IS25_MEOH_MCRD_L_PF_L_0.03	0.03	61.01	63.81	64.62
26	IS26_MEOH_MGP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_L_0.5	0.50	71.14	84.44	87.84

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS26_MEOH_MGP_L_PF_L_0.03	0.03	84.04	95.08	97.66
27	IS27_MEOH_MMUSD_L_PF_L_1	1.00	36.93	37.25	37.29
	IS27_MEOH_MMUSD_L_PF_L_0.5	0.50	48.54	54.54	56.86
	IS27_MEOH_MMUSD_L_PF_L_0.03	0.03	72.46	75.20	76.16
29	IS29_HC_HCDD_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS29_HC_HCDD_L_PF_L_0.5	0.50	87.98	85.74	85.23
	IS29_HC_HCDD_L_PF_L_0.03	0.03	153.62	176.60	190.30
30	IS30_NAPH_SGB_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS30_NAPH_SGB_L_PF_L_0.5	0.50	53.31	61.08	63.72
	IS30_NAPH_SGB_L_PF_L_0.03	0.03	74.88	87.44	91.37
31	IS31_NAPH_FSD_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_L_0.5	0.50	68.75	72.06	72.96
	IS31_NAPH_FSD_L_PF_L_0.03	0.03	108.35	129.72	140.80
32	IS32_NAPH_FD_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_L_0.5	0.50	89.94	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_L_0.03	0.03	114.78	Not reachable	Not reachable
35	IS35_ISOM_CGB_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS35_ISOM_CGB_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
37	IS37_NAPH_SIRBP_L_PF_L_1	1.00	83.91	92.40	95.91
	IS37_NAPH_SIRBP_L_PF_L_0.5	0.50	90.70	103.96	101.69
	IS37_NAPH_SIRBP_L_PF_L_0.03	0.03	108.13	114.52	106.21
40	IS40_ISOM_SRDBP_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS40_ISOM_SRDBP_L_PF_L_0.5	0.50	74.42	82.70	84.95
	IS40_ISOM_SRDBP_L_PF_L_0.03	0.03	103.28	123.17	131.76
42	IS42_ISOM_DRD_L_PF_L_1	1.00	47.93	55.50	56.57

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS42_ISOM_DRD_L_PF_L_0.5	0.50	53.33	65.68	69.21
	IS42_ISOM_DRD_L_PF_L_0.03	0.03	72.79	86.53	89.40
44	IS44_TAME_TST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS44_TAME_TST_L_PF_L_0.5	0.50	54.66	54.68	55.08
	IS44_TAME_TST_L_PF_L_0.03	0.03	95.39	114.97	126.23
45	IS45_ISOM_IST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS45_ISOM_IST_L_PF_L_0.5	0.50	51.26	51.40	51.88
	IS45_ISOM_IST_L_PF_L_0.03	0.03	89.49	108.26	118.94
46	IS46_NAPH_MST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_L_0.5	0.50	197.10	182.36	177.25
	IS46_NAPH_MST_L_PF_L_0.03	0.03	297.60	310.75	326.53
47	IS47_TAME_PIPESTPU_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_L_0.5	0.50	64.43	69.63	70.93
	IS47_TAME_PIPESTPU_L_PF_L_0.03	0.03	97.02	117.14	126.55
48	IS48_TAME_PIPEPUST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_L_0.5	0.50	91.41	94.52	95.21
	IS48_TAME_PIPEPUST_L_PF_L_0.03	0.03	143.15	167.68	181.43
49	IS49_ISOM_PIPEPUST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_L_0.5	0.50	108.03	109.50	109.57
	IS49_ISOM_PIPEPUST_L_PF_L_0.03	0.03	169.93	195.74	211.18
50	IS50_NAPH_PIPESTPU_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_L_0.5	0.50	98.13	102.48	103.69
	IS50_NAPH_PIPESTPU_L_PF_L_0.03	0.03	147.72	171.24	184.61
51	IS51_NAPH_PIPEPUST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_L_0.5	0.50	103.85	105.77	106.06
	IS51_NAPH_PIPEPUST_L_PF_L_0.03	0.03	163.29	188.88	203.95

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
52	IS52_NAPH_PIPEPUMHST_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_L_0.5	0.50	109.52	112.30	113.11
	IS52_NAPH_PIPEPUMHST_L_PF_L_0.03	0.03	166.97	191.19	205.95
53	IS53_ETHY_EST_L_PF_L_1	1.00	34.80	41.60	43.67
	IS53_ETHY_EST_L_PF_L_0.5	0.50	64.01	66.44	65.41
	IS53_ETHY_EST_L_PF_L_0.03	0.03	106.01	103.75	99.29
56	IS56_ETHY_LPEBOGLR_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS56_ETHY_LPEBOGLR_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
58	IS58_BUTD_BSV_L_PF_L_1	1.00	181.53	184.66	185.36
	IS58_BUTD_BSV_L_PF_L_0.5	0.50	294.04	275.02	264.55
	IS58_BUTD_BSV_L_PF_L_0.03	0.03	465.79	417.31	393.58
59	IS59_ETHY_CFKOD_L_PF_L_1	1.00	27.84	35.06	38.05
	IS59_ETHY_CFKOD_L_PF_L_0.5	0.50	51.32	55.88	56.67
	IS59_ETHY_CFKOD_L_PF_L_0.03	0.03	84.55	86.51	85.32
60	IS60_ETHY_PIPEU2100U5220_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS60_ETHY_PIPEU2100U5220_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
61	IS61_ETHY_PIPEU5220PDT2_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
66	IS66_BUTD_PIPEU5210U5220_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS66_BUTD_PIPEU5210U5220_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS66_BUTD_PIPEU5210U5220_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
67	IS67_BUTD_PIPEU5220JLI_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS67_BUTD_PIPEU5220JLI_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable
68	IS68_BUTD_PIPEU5220JCLI_L_PF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS68_BUTD_PIPEU5220JCLI_L_PF_L_0.03	0.03	Not reachable	Not reachable	Not reachable

Pool Fire Events Due to Catastrophic Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS01_NAPH_SSHDSFSD_L_PF_C_0.5	0.50	111.82	118.06	121.22
	IS01_NAPH_SSHDSFSD_L_PF_C_0.03	0.03	146.00	168.17	179.27
3	IS03_NAPH_SSHDSSDBP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS03_NAPH_SSHDSSDBP_L_PF_C_0.5	0.50	147.00	154.93	156.93
	IS03_NAPH_SSHDSSDBP_L_PF_C_0.03	0.03	208.60	242.89	261.50
6	IS06_MDEA_SSHDSLASD_L_PF_C_1	1.00	98.79	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_C_0.5	0.50	102.00	Not reachable	Not reachable
	IS06_MDEA_SSHDSLASD_L_PF_C_0.03	0.03	106.83	Not reachable	Not reachable
7	IS07_MDEA_SSHDSAABP_L_PF_C_1	1.00	107.58	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_C_0.5	0.50	116.34	Not reachable	Not reachable
	IS07_MDEA_SSHDSAABP_L_PF_C_0.03	0.03	127.56	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS12_NAPH_LCNFSD_L_PF_C_0.5	0.50	86.93	88.43	89.09
	IS12_NAPH_LCNFSD_L_PF_C_0.03	0.03	139.53	165.37	180.61

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
13	IS13_MEOH_FR_L_PF_C_1	1.00	151.77	155.45	156.10
	IS13_MEOH_FR_L_PF_C_0.5	0.50	192.64	208.12	214.21
	IS13_MEOH_FR_L_PF_C_0.03	0.03	263.03	271.99	274.16
14	IS14_MEOH_SR_L_PF_C_1	1.00	148.21	151.74	152.30
	IS14_MEOH_SR_L_PF_C_0.5	0.50	189.11	204.44	210.45
	IS14_MEOH_SR_L_PF_C_0.03	0.03	259.56	268.36	270.45
15	IS15_TAME_TFBP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS15_TAME_TFBP_L_PF_C_0.5	0.50	122.399	125.495	126.428
	IS15_TAME_TFBP_L_PF_C_0.03	0.03	183.632	213.572	230.998
17	IS17_MEOH_TFRDBP_L_PF_C_1	1.00	67.41	67.70	67.72
	IS17_MEOH_TFRDBP_L_PF_C_0.5	0.50	91.49	100.42	104.16
	IS17_MEOH_TFRDBP_L_PF_C_0.03	0.03	135.33	139.43	140.77
19	IS19_MEOH_TR_L_PF_C_1	1.00	151.51	155.20	155.77
	IS19_MEOH_TR_L_PF_C_0.5	0.50	192.38	207.87	213.89
	IS19_MEOH_TR_L_PF_C_0.03	0.03	262.77	271.75	273.85
20	IS20_NAPH_RWCBP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS20_NAPH_RWCBP_L_PF_C_0.5	0.50	130.77	137.97	139.40
	IS20_NAPH_RWCBP_L_PF_C_0.03	0.03	190.64	223.94	241.65
22	IS22_MEOH_MCFD_L_PF_C_1	1.00	62.53	67.70	68.28
	IS22_MEOH_MCFD_L_PF_C_0.5	0.50	71.05	80.99	83.48
	IS22_MEOH_MCFD_L_PF_C_0.03	0.03	89.92	97.11	98.52
23	IS23_MEOH_RC_L_PF_C_1	1.00	99.27	107.02	108.04
	IS23_MEOH_RC_L_PF_C_0.5	0.50	118.70	133.97	138.19
	IS23_MEOH_RC_L_PF_C_0.03	0.03	155.15	165.99	168.23
25	IS25_MEOH_MCRD_L_PF_C_1	1.00	43.72	45.49	45.63
	IS25_MEOH_MCRD_L_PF_C_0.5	0.50	51.74	58.15	60.16

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS25_MEOH_MCRD_L_PF_C_0.03	0.03	69.80	73.59	74.54
26	IS26_MEOH_MGP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_PF_C_0.5	0.50	98.40	112.20	115.90
	IS26_MEOH_MGP_L_PF_C_0.03	0.03	111.95	123.60	126.45
27	IS27_MEOH_MMUSD_L_PF_C_1	1.00	42.39	43.04	43.14
	IS27_MEOH_MMUSD_L_PF_C_0.5	0.50	54.20	60.60	63.03
	IS27_MEOH_MMUSD_L_PF_C_0.03	0.03	78.45	81.58	82.66
29	IS29_HC_HCDD_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS29_HC_HCDD_L_PF_C_0.5	0.50	113.96	111.96	111.44
	IS29_HC_HCDD_L_PF_C_0.03	0.03	192.34	220.11	237.54
30	IS30_NAPH_SGB_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS30_NAPH_SGB_L_PF_C_0.5	0.50	71.36	79.52	81.99
	IS30_NAPH_SGB_L_PF_C_0.03	0.03	93.78	108.21	113.10
31	IS31_NAPH_FSD_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS31_NAPH_FSD_L_PF_C_0.5	0.50	83.76	88.26	89.35
	IS31_NAPH_FSD_L_PF_C_0.03	0.03	125.78	150.31	162.85
32	IS32_NAPH_FD_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS32_NAPH_FD_L_PF_C_0.5	0.50	132.24	143.32	147.10
	IS32_NAPH_FD_L_PF_C_0.03	0.03	159.73	183.51	193.82
35	IS35_ISOM_CGB_L_PF_C_1	1.00	112.08	119.71	124.09
	IS35_ISOM_CGB_L_PF_C_0.5	0.50	118.43	130.96	138.27
	IS35_ISOM_CGB_L_PF_C_0.03	0.03	136.60	149.44	154.55
37	IS37_NAPH_SIRBP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS37_NAPH_SIRBP_L_PF_C_0.5	0.50	123.05	132.27	137.26
	IS37_NAPH_SIRBP_L_PF_C_0.03	0.03	147.59	165.65	174.50
40	IS40_ISOM_SRDBP_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS40_ISOM_SRDBP_L_PF_C_0.5	0.50	102.37	112.12	114.37
	IS40_ISOM_SRDBP_L_PF_C_0.03	0.03	134.17	159.26	169.65
42	IS42_ISOM_DRD_L_PF_C_1	1.00	Not reachable	Not reachable	75.27
	IS42_ISOM_DRD_L_PF_C_0.5	0.50	70.63	82.94	86.08
	IS42_ISOM_DRD_L_PF_C_0.03	0.03	90.98	106.66	110.13
44	IS44_TAME_TST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS44_TAME_TST_L_PF_C_0.5	0.50	61.72	62.40	63.17
	IS44_TAME_TST_L_PF_C_0.03	0.03	103.59	124.56	136.83
45	IS45_ISOM_IST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS45_ISOM_IST_L_PF_C_0.5	0.50	58.06	58.79	59.62
	IS45_ISOM_IST_L_PF_C_0.03	0.03	97.27	117.25	128.77
46	IS46_NAPH_MST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS46_NAPH_MST_L_PF_C_0.5	0.50	507.81	474.98	459.88
	IS46_NAPH_MST_L_PF_C_0.03	0.03	698.89	722.92	753.91
47	IS47_TAME_PIPESTPU_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS47_TAME_PIPESTPU_L_PF_C_0.5	0.50	82.11	88.58	90.06
	IS47_TAME_PIPESTPU_L_PF_C_0.03	0.03	116.80	140.25	150.94
48	IS48_TAME_PIPEPUST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS48_TAME_PIPEPUST_L_PF_C_0.5	0.50	112.48	118.12	119.77
	IS48_TAME_PIPEPUST_L_PF_C_0.03	0.03	168.09	198.65	215.05
49	IS49_ISOM_PIPEPUST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS49_ISOM_PIPEPUST_L_PF_C_0.5	0.50	132.47	137.49	138.42
	IS49_ISOM_PIPEPUST_L_PF_C_0.03	0.03	199.77	233.78	253.24
50	IS50_NAPH_PIPESTPU_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS50_NAPH_PIPESTPU_L_PF_C_0.5	0.50	126.63	134.62	136.23
	IS50_NAPH_PIPESTPU_L_PF_C_0.03	0.03	181.17	213.30	229.79

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
51	IS51_NAPH_PIPEPUST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS51_NAPH_PIPEPUST_L_PF_C_0.5	0.50	127.32	132.51	133.55
	IS51_NAPH_PIPEPUST_L_PF_C_0.03	0.03	191.73	224.93	243.65
52	IS52_NAPH_PIPEPUMHST_L_PF_C_1	1.00	Not reachable	Not reachable	Not reachable
	IS52_NAPH_PIPEPUMHST_L_PF_C_0.5	0.50	139.53	146.81	148.22
	IS52_NAPH_PIPEPUMHST_L_PF_C_0.03	0.03	202.88	237.39	256.13
56	IS56_ETHY_LPEBOGLR_L_PF_C_1	1.00	93.87	107.98	111.35
	IS56_ETHY_LPEBOGLR_L_PF_C_0.5	0.50	110.14	121.30	123.13
	IS56_ETHY_LPEBOGLR_L_PF_C_0.03	0.03	132.48	138.73	139.55
59	IS59_ETHY_CFKOD_L_PF_C_1	1.00	36.38	45.82	49.88
	IS59_ETHY_CFKOD_L_PF_C_0.5	0.50	66.02	72.47	74.22
	IS59_ETHY_CFKOD_L_PF_C_0.03	0.03	108.67	112.76	112.47
60	IS60_ETHY_PIPEU2100U5220_L_PF_C_1	1.00	174.36	168.96	0.00
	IS60_ETHY_PIPEU2100U5220_L_PF_C_0.5	0.50	239.63	209.03	0.00
	IS60_ETHY_PIPEU2100U5220_L_PF_C_0.03	0.03	338.07	271.48	0.00
61	IS61_ETHY_PIPEU5220PDT2_L_PF_C_1	1.00	163.76	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_C_0.5	0.50	219.19	Not reachable	Not reachable
	IS61_ETHY_PIPEU5220PDT2_L_PF_C_0.03	0.03	302.11	Not reachable	Not reachable
66	IS66_BUTD_PIPEU5210U5220_L_PF_C_1	1.00	148.25	165.69	173.47
	IS66_BUTD_PIPEU5210U5220_L_PF_C_0.5	0.50	208.51	214.93	218.46
	IS66_BUTD_PIPEU5210U5220_L_PF_C_0.03	0.03	298.10	290.67	290.53
67	IS67_BUTD_PIPEU5220JLI_L_PF_C_1	1.00	238.82	253.69	264.37
	IS67_BUTD_PIPEU5220JLI_L_PF_C_0.5	0.50	357.20	351.56	354.89
	IS67_BUTD_PIPEU5220JLI_L_PF_C_0.03	0.03	538.20	505.94	502.79
68	IS68_BUTD_PIPEU5220JCLI_L_PF_C_1	1.00	163.70	180.92	189.32
	IS68_BUTD_PIPEU5220JCLI_L_PF_C_0.5	0.50	233.73	238.16	241.81

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS68_BUTD_PIPEU5220JCLI_L_PF_C_0.03	0.03	338.61	326.87	326.36

Jet Fire Events Due to Minor Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_JF_0_1	1.00	10.28	8.56	7.80
	IS01_NAPH_SSHDSFSD_L_JF_0_0.5	0.50	12.26	10.60	9.90
	IS01_NAPH_SSHDSFSD_L_JF_0_0.03	0.03	15.38	13.89	13.29
2	IS02_NAPH_SSHDSR_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_JF_0_0.03	0.03	4.41	4.26	4.02
3	IS03_NAPH_SSHDSSDBP_L_JF_0_1	1.00	15.03	12.58	11.48
	IS03_NAPH_SSHDSSDBP_L_JF_0_0.5	0.50	17.80	15.48	14.41
	IS03_NAPH_SSHDSSDBP_L_JF_0_0.03	0.03	22.27	20.24	19.27
4	IS04_H2_SSHDSSDUP_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
5	IS05_H2_SSHDSAAKOD_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
6	IS06_MDEA_SSHDSLASD_L_JF_0_1	1.00	13.66	11.15	10.03
	IS06_MDEA_SSHDSLASD_L_JF_0_0.5	0.50	15.72	13.22	12.13
	IS06_MDEA_SSHDSLASD_L_JF_0_0.03	0.03	18.82	16.44	15.44
7	IS07_MDEA_SSHDSAABP_L_JF_0_1	1.00	14.84	12.13	10.93
	IS07_MDEA_SSHDSAABP_L_JF_0_0.5	0.50	17.06	14.35	13.18
	IS07_MDEA_SSHDSAABP_L_JF_0_0.03	0.03	20.41	17.83	16.75
8	IS08_H2_SSHDSAAUP_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
9	IS09_H2_SSHDSRGCKOD_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS09_H2_SSHDSRGCKOD_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
10	IS10_NAPH_SSHDSS_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
11	IS11_H2_SSHDSSRD_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
12	IS12_NAPH_LCNFSD_L_JF_0_1	1.00	11.47	9.52	8.63
	IS12_NAPH_LCNFSD_L_JF_0_0.5	0.50	13.71	11.79	10.85
	IS12_NAPH_LCNFSD_L_JF_0_0.03	0.03	17.18	15.39	14.42
13	IS13_MEOH_FR_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS13_MEOH_FR_L_JF_0_0.5	0.50	20.77	17.02	15.34
	IS13_MEOH_FR_L_JF_0_0.03	0.03	24.11	20.28	18.59
14	IS14_MEOH_SR_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS14_MEOH_SR_L_JF_0_0.5	0.50	19.73	16.18	14.58
	IS14_MEOH_SR_L_JF_0_0.03	0.03	22.94	19.29	17.67
15	IS15_TAME_TFBP_L_JF_0_1	1.00	10.02	8.34	7.59
	IS15_TAME_TFBP_L_JF_0_0.5	0.50	11.96	10.37	9.65
	IS15_TAME_TFBP_L_JF_0_0.03	0.03	15.00	13.59	12.95
16	IS16_MEOH_TFUP_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_JF_0_0.5	0.50	Not reachable	12.14	10.79
	IS16_MEOH_TFUP_V_JF_0_0.03	0.03	16.85	14.36	13.25
17	IS17_MEOH_TFRDBP_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS17_MEOH_TFRDBP_L_JF_0_0.5	0.50	Not reachable	Not reachable	9.61
	IS17_MEOH_TFRDBP_L_JF_0_0.03	0.03	14.13	12.20	11.33

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
18	IS18_NAPH_TFRDUP_V_JF_0_1	1.00	10.21	8.45	7.63
	IS18_NAPH_TFRDUP_V_JF_0_0.5	0.50	12.27	10.48	9.60
	IS18_NAPH_TFRDUP_V_JF_0_0.03	0.03	15.39	13.66	12.72
19	IS19_MEOH_TR_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS19_MEOH_TR_L_JF_0_0.5	0.50	20.70	16.97	15.29
	IS19_MEOH_TR_L_JF_0_0.03	0.03	24.03	20.21	18.53
20	IS20_NAPH_RWCBP_L_JF_0_1	1.00	14.10	11.79	10.74
	IS20_NAPH_RWCBP_L_JF_0_0.5	0.50	16.73	14.53	13.49
	IS20_NAPH_RWCBP_L_JF_0_0.03	0.03	20.93	19.00	18.02
21	IS21_MEOH_RWCUP_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_JF_0_0.5	0.50	20.74	16.70	15.17
	IS21_MEOH_RWCUP_V_JF_0_0.03	0.03	24.17	20.31	18.56
22	IS22_MEOH_MCFD_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS22_MEOH_MCFD_L_JF_0_0.5	0.50	Not reachable	15.72	14.34
	IS22_MEOH_MCFD_L_JF_0_0.03	0.03	22.93	19.25	17.57
23	IS23_MEOH_RC_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS23_MEOH_RC_L_JF_0_0.5	0.50	21.22	17.23	15.62
	IS23_MEOH_RC_L_JF_0_0.03	0.03	24.84	20.88	19.09
24	IS24_MEOH_MC_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
25	IS25_MEOH_MCRD_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS25_MEOH_MCRD_L_JF_0_0.5	0.50	Not reachable	11.33	10.08
	IS25_MEOH_MCRD_L_JF_0_0.03	0.03	15.60	13.29	12.26
26	IS26_MEOH_MGP_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_JF_0_0.5	0.50	23.36	19.15	17.30

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS26_MEOH_MGP_L_JF_0_0.03	0.03	27.29	22.98	21.05
27	IS27_MEOH_MMUSD_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS27_MEOH_MMUSD_L_JF_0_0.5	0.50	Not reachable	Not reachable	9.90
	IS27_MEOH_MMUSD_L_JF_0_0.03	0.03	14.63	12.64	11.74
28	IS28_MEOH_MDD_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
30	IS30_NAPH_SGB_L_JF_0_1	1.00	12.55	10.49	9.57
	IS30_NAPH_SGB_L_JF_0_0.5	0.50	14.88	12.92	12.05
	IS30_NAPH_SGB_L_JF_0_0.03	0.03	18.63	16.90	16.13
31	IS31_NAPH_FSD_L_JF_0_1	1.00	12.52	10.43	9.47
	IS31_NAPH_FSD_L_JF_0_0.5	0.50	14.91	12.89	11.91
	IS31_NAPH_FSD_L_JF_0_0.03	0.03	18.67	16.85	15.86
32	IS32_NAPH_FD_L_JF_0_1	1.00	17.40	14.59	13.36
	IS32_NAPH_FD_L_JF_0_0.5	0.50	20.55	17.89	16.72
	IS32_NAPH_FD_L_JF_0_0.03	0.03	25.72	23.37	22.38
33	IS33_H2_H2PR_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
34	IS34_H2_HD_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_JF_0_0.03	0.03	4.19	4.41	4.56
35	IS35_ISOM_CGB_L_JF_0_1	1.00	12.64	10.55	9.64
	IS35_ISOM_CGB_L_JF_0_0.5	0.50	14.98	12.97	12.11
	IS35_ISOM_CGB_L_JF_0_0.03	0.03	18.77	16.94	16.21
36	IS36_H2_FIR_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS36_H2_FIR_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
37	IS37_NAPH_SIRBP_L_JF_0_1	1.00	14.96	12.51	11.45
	IS37_NAPH_SIRBP_L_JF_0_0.5	0.50	17.68	15.33	14.33
	IS37_NAPH_SIRBP_L_JF_0_0.03	0.03	22.14	20.01	19.16
38	IS38_H2_SIRUP_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
39	IS39_LPG_S_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
40	IS40_ISOM_SRDBP_L_JF_0_1	1.00	15.00	12.55	11.45
	IS40_ISOM_SRDBP_L_JF_0_0.5	0.50	17.76	15.45	14.38
	IS40_ISOM_SRDBP_L_JF_0_0.03	0.03	22.22	20.19	19.22
41	IS41_LPG_SRDUP_V_JF_0_1	1.00	12.61	10.41	9.45
	IS41_LPG_SRDUP_V_JF_0_0.5	0.50	14.76	12.61	11.69
	IS41_LPG_SRDUP_V_JF_0_0.03	0.03	18.19	16.16	15.34
42	IS42_ISOM_DRD_L_JF_0_1	1.00	13.75	11.48	10.46
	IS42_ISOM_DRD_L_JF_0_0.5	0.50	16.32	14.16	13.13
	IS42_ISOM_DRD_L_JF_0_0.03	0.03	20.42	18.51	17.53
43	IS43_H2_CS_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_JF_0_0.03	0.03	Not reachable	Not reachable	Not reachable
44	IS44_TAME_TST_L_JF_0_1	1.00	10.46	8.66	7.82
	IS44_TAME_TST_L_JF_0_0.5	0.50	12.55	10.73	9.84
	IS44_TAME_TST_L_JF_0_0.03	0.03	15.74	13.99	13.05

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
45	IS45_ISOM_IST_L_JF_0_1	1.00	10.46	8.66	7.82
	IS45_ISOM_IST_L_JF_0_0.5	0.50	12.55	10.73	9.84
	IS45_ISOM_IST_L_JF_0_0.03	0.03	15.74	13.99	13.05
46	IS46_NAPH_MST_L_JF_0_1	1.00	14.52	12.15	11.08
	IS46_NAPH_MST_L_JF_0_0.5	0.50	17.21	14.96	13.91
	IS46_NAPH_MST_L_JF_0_0.03	0.03	21.53	19.56	18.58
47	IS47_TAME_PIPESTPU_L_JF_0_1	1.00	13.23	11.04	10.05
	IS47_TAME_PIPESTPU_L_JF_0_0.5	0.50	15.73	13.63	12.62
	IS47_TAME_PIPESTPU_L_JF_0_0.03	0.03	19.69	17.82	16.84
48	IS48_TAME_PIPEPUST_L_JF_0_1	1.00	13.23	11.04	10.05
	IS48_TAME_PIPEPUST_L_JF_0_0.5	0.50	15.73	13.63	12.62
	IS48_TAME_PIPEPUST_L_JF_0_0.03	0.03	19.69	17.82	16.84
49	IS49_ISOM_PIPEPUST_L_JF_0_1	1.00	13.23	11.04	10.05
	IS49_ISOM_PIPEPUST_L_JF_0_0.5	0.50	15.73	13.63	12.62
	IS49_ISOM_PIPEPUST_L_JF_0_0.03	0.03	19.69	17.82	16.84
50	IS50_NAPH_PIPESTPU_L_JF_0_1	1.00	14.44	12.08	11.01
	IS50_NAPH_PIPESTPU_L_JF_0_0.5	0.50	17.12	14.88	13.83
	IS50_NAPH_PIPESTPU_L_JF_0_0.03	0.03	21.41	19.45	18.47
51	IS51_NAPH_PIPEPUST_L_JF_0_1	1.00	13.23	11.04	10.05
	IS51_NAPH_PIPEPUST_L_JF_0_0.5	0.50	15.73	13.63	12.62
	IS51_NAPH_PIPEPUST_L_JF_0_0.03	0.03	19.69	17.82	16.84
52	IS52_NAPH_PIPEPUMHST_L_JF_0_1	1.00	14.31	11.96	10.91
	IS52_NAPH_PIPEPUMHST_L_JF_0_0.5	0.50	16.97	14.74	13.70
	IS52_NAPH_PIPEPUMHST_L_JF_0_0.03	0.03	21.23	19.28	18.30
53	IS53_ETHY_EST_L_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS53_ETHY_EST_L_JF_0_0.03	0.03	3.24	2.81	2.59
54	IS54_ETHY_BOGC_V_JF_0_1	1.00	19.89	16.34	14.76
	IS54_ETHY_BOGC_V_JF_0_0.5	0.50	22.90	19.36	17.82
	IS54_ETHY_BOGC_V_JF_0_0.03	0.03	27.44	24.11	22.69
55	IS55_ETHY_HPEBOGLR_V_JF_0_1	1.00	19.89	16.34	14.76
	IS55_ETHY_HPEBOGLR_V_JF_0_0.5	0.50	22.90	19.36	17.82
	IS55_ETHY_HPEBOGLR_V_JF_0_0.03	0.03	27.44	24.11	22.69
56	IS56_ETHY_LPEBOGLR_L_JF_0_1	1.00	16.83	13.80	12.46
	IS56_ETHY_LPEBOGLR_L_JF_0_0.5	0.50	19.53	16.50	15.14
	IS56_ETHY_LPEBOGLR_L_JF_0_0.03	0.03	23.43	20.61	19.32
57	IS57_PROPY_PSV_L_JF_0_1	1.00	4.26	3.35	2.94
	IS57_PROPY_PSV_L_JF_0_0.5	0.50	5.42	4.57	4.19
	IS57_PROPY_PSV_L_JF_0_0.03	0.03	6.85	5.97	5.60
58	IS58_BUTD_BSV_L_JF_0_1	1.00	13.62	11.25	10.20
	IS58_BUTD_BSV_L_JF_0_0.5	0.50	16.09	13.74	12.62
	IS58_BUTD_BSV_L_JF_0_0.03	0.03	19.79	17.61	16.47
60	IS60_ETHY_PIPEU2100U5220_L_JF_0_1	1.00	17.60	14.44	13.03
	IS60_ETHY_PIPEU2100U5220_L_JF_0_0.5	0.50	20.36	17.21	15.81
	IS60_ETHY_PIPEU2100U5220_L_JF_0_0.03	0.03	24.41	21.48	20.17
61	IS61_ETHY_PIPEU5220PDT2_L_JF_0_1	1.00	17.96	14.74	13.31
	IS61_ETHY_PIPEU5220PDT2_L_JF_0_0.5	0.50	20.76	17.55	16.13
	IS61_ETHY_PIPEU5220PDT2_L_JF_0_0.03	0.03	24.88	21.89	20.57
62	IS62_ETHY_PIPEU5220BLU_V_JF_0_1	1.00	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_JF_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_JF_0_0.03	0.03	5.81	5.51	5.46
63	IS63_PROPY_PIPEU5210U5220_V_JF_0_1	1.00	14.45	11.87	10.74

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_JF_0_0.5	0.50	16.74	14.17	13.07
	IS63_PROPY_PIPEU5210U5220_V_JF_0_0.03	0.03	20.36	17.89	16.87
64	IS64_PROPY_PIPEU5220J_V_JF_0_1	1.00	14.29	11.74	10.62
	IS64_PROPY_PIPEU5220J_V_JF_0_0.5	0.50	16.56	14.03	12.94
	IS64_PROPY_PIPEU5220J_V_JF_0_0.03	0.03	20.14	17.71	16.72
65	IS65_PROPY_PIPEMURP_V_JF_0_1	1.00	4.26	3.35	2.94
	IS65_PROPY_PIPEMURP_V_JF_0_0.5	0.50	5.42	4.57	4.19
	IS65_PROPY_PIPEMURP_V_JF_0_0.03	0.03	6.85	5.97	5.60
66	IS66_BUTD_PIPEU5210U5220_L_JF_0_1	1.00	16.59	13.76	12.50
	IS66_BUTD_PIPEU5210U5220_L_JF_0_0.5	0.50	19.42	16.68	15.44
	IS66_BUTD_PIPEU5210U5220_L_JF_0_0.03	0.03	23.84	21.37	20.22
67	IS67_BUTD_PIPEU5220JLI_L_JF_0_1	1.00	16.68	13.83	12.56
	IS67_BUTD_PIPEU5220JLI_L_JF_0_0.5	0.50	19.51	16.77	15.52
	IS67_BUTD_PIPEU5220JLI_L_JF_0_0.03	0.03	23.96	21.48	20.32
68	IS68_BUTD_PIPEU5220JCLI_L_JF_0_1	1.00	16.68	13.83	12.56
	IS68_BUTD_PIPEU5220JCLI_L_JF_0_0.5	0.50	19.51	16.77	15.52
	IS68_BUTD_PIPEU5220JCLI_L_JF_0_0.03	0.03	23.96	21.48	20.32

Jet Fire Events Due to Small Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_JF_S_1	1.00	28.42	23.93	21.97
	IS01_NAPH_SSHDSFSD_L_JF_S_0.5	0.50	33.56	29.28	27.45
	IS01_NAPH_SSHDSFSD_L_JF_S_0.03	0.03	42.13	38.32	36.77
2	IS02_NAPH_SSHDSR_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_JF_S_0.5	0.50	12.84	13.26	13.65
	IS02_NAPH_SSHDSR_V_JF_S_0.03	0.03	16.47	16.57	16.64
3	IS03_NAPH_SSHDSSDBP_L_JF_S_1	1.00	40.21	33.97	31.16
	IS03_NAPH_SSHDSSDBP_L_JF_S_0.5	0.50	47.68	41.83	39.11
	IS03_NAPH_SSHDSSDBP_L_JF_S_0.03	0.03	60.06	55.02	52.57
4	IS04_H2_SSHDSSDUP_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_JF_S_0.5	0.50	9.89	7.78	8.81
	IS04_H2_SSHDSSDUP_V_JF_S_0.03	0.03	12.50	10.49	11.05
5	IS05_H2_SSHDSAAKOD_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_JF_S_0.5	0.50	9.89	7.78	8.81
	IS05_H2_SSHDSAAKOD_V_JF_S_0.03	0.03	12.50	10.49	11.05
6	IS06_MDEA_SSHDSLASD_L_JF_S_1	1.00	37.07	30.58	27.69
	IS06_MDEA_SSHDSLASD_L_JF_S_0.5	0.50	42.54	36.05	33.23
	IS06_MDEA_SSHDSLASD_L_JF_S_0.03	0.03	51.02	44.87	42.30
7	IS07_MDEA_SSHDSAABP_L_JF_S_1	1.00	40.13	33.12	29.99
	IS07_MDEA_SSHDSAABP_L_JF_S_0.5	0.50	46.05	39.04	35.99
	IS07_MDEA_SSHDSAABP_L_JF_S_0.03	0.03	55.25	48.60	45.83
8	IS08_H2_SSHDSAAUP_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_JF_S_0.5	0.50	6.41	7.56	8.60
	IS08_H2_SSHDSAAUP_V_JF_S_0.03	0.03	9.70	10.31	10.85
9	IS09_H2_SSHDSRGCKOD_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS09_H2_SSHDSRGCKOD_V_JF_S_0.5	0.50	6.35	7.52	8.56
	IS09_H2_SSHDSRGCKOD_V_JF_S_0.03	0.03	9.67	10.27	10.82
10	IS10_NAPH_SSHDSS_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_JF_S_0.5	0.50	6.18	6.42	6.42
	IS10_NAPH_SSHDSS_V_JF_S_0.03	0.03	8.80	8.96	9.10
11	IS11_H2_SSHDSSRD_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_JF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_JF_S_0.03	0.03	4.70	4.98	5.23
12	IS12_NAPH_LCNFSD_L_JF_S_1	1.00	30.77	25.85	23.60
	IS12_NAPH_LCNFSD_L_JF_S_0.5	0.50	36.69	31.85	29.45
	IS12_NAPH_LCNFSD_L_JF_S_0.03	0.03	46.18	41.72	39.24
13	IS13_MEOH_FR_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS13_MEOH_FR_L_JF_S_0.5	0.50	55.32	45.54	41.20
	IS13_MEOH_FR_L_JF_S_0.03	0.03	63.96	54.20	49.88
14	IS14_MEOH_SR_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS14_MEOH_SR_L_JF_S_0.5	0.50	52.62	43.32	39.18
	IS14_MEOH_SR_L_JF_S_0.03	0.03	60.89	51.59	47.46
15	IS15_TAME_TFBP_L_JF_S_1	1.00	27.53	23.20	21.26
	IS15_TAME_TFBP_L_JF_S_0.5	0.50	32.55	28.47	26.63
	IS15_TAME_TFBP_L_JF_S_0.03	0.03	40.85	37.31	35.69
16	IS16_MEOH_TFUP_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_JF_S_0.5	0.50	35.12	30.02	27.79
	IS16_MEOH_TFUP_V_JF_S_0.03	0.03	42.59	36.61	33.93
17	IS17_MEOH_TFRDBP_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS17_MEOH_TFRDBP_L_JF_S_0.5	0.50	Not reachable	24.30	23.03
	IS17_MEOH_TFRDBP_L_JF_S_0.03	0.03	34.53	30.06	28.07

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
18	IS18_NAPH_TFRDUP_V_JF_S_1	1.00	25.78	22.72	21.03
	IS18_NAPH_TFRDUP_V_JF_S_0.5	0.50	30.83	27.94	26.13
	IS18_NAPH_TFRDUP_V_JF_S_0.03	0.03	38.75	36.45	34.62
19	IS19_MEOH_TR_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS19_MEOH_TR_L_JF_S_0.5	0.50	55.14	45.40	41.06
	IS19_MEOH_TR_L_JF_S_0.03	0.03	63.76	54.02	49.71
20	IS20_NAPH_RWCBP_L_JF_S_1	1.00	37.73	31.84	29.17
	IS20_NAPH_RWCBP_L_JF_S_0.5	0.50	44.79	39.24	36.59
	IS20_NAPH_RWCBP_L_JF_S_0.03	0.03	56.40	51.59	49.11
21	IS21_MEOH_RWCUP_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_JF_S_0.5	0.50	54.12	44.66	40.51
	IS21_MEOH_RWCUP_V_JF_S_0.03	0.03	63.64	53.89	49.42
22	IS22_MEOH_MCFD_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS22_MEOH_MCFD_L_JF_S_0.5	0.50	51.00	42.18	38.33
	IS22_MEOH_MCFD_L_JF_S_0.03	0.03	60.37	51.07	46.78
23	IS23_MEOH_RC_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS23_MEOH_RC_L_JF_S_0.5	0.50	55.80	45.99	41.71
	IS23_MEOH_RC_L_JF_S_0.03	0.03	65.42	55.43	50.86
24	IS24_MEOH_MC_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_JF_S_0.5	0.50	7.14	5.50	4.78
	IS24_MEOH_MC_V_JF_S_0.03	0.03	8.29	6.87	6.25
25	IS25_MEOH_MCRD_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS25_MEOH_MCRD_L_JF_S_0.5	0.50	33.13	28.03	25.89
	IS25_MEOH_MCRD_L_JF_S_0.03	0.03	39.67	34.10	31.62
26	IS26_MEOH_MGP_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS26_MEOH_MGP_L_JF_S_0.5	0.50	61.93	50.99	46.17

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS26_MEOH_MGP_L_JF_S_0.03	0.03	71.97	61.06	56.15
27	IS27_MEOH_MMUSD_L_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS27_MEOH_MMUSD_L_JF_S_0.5	0.50	Not reachable	25.20	23.86
	IS27_MEOH_MMUSD_L_JF_S_0.03	0.03	35.76	31.13	29.08
28	IS28_MEOH_MDD_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_S_0.03	0.03	Not reachable	Not reachable	Not reachable
30	IS30_NAPH_SGB_L_JF_S_1	1.00	33.95	28.65	26.29
	IS30_NAPH_SGB_L_JF_S_0.5	0.50	40.18	35.19	32.95
	IS30_NAPH_SGB_L_JF_S_0.03	0.03	50.51	46.19	44.24
31	IS31_NAPH_FSD_L_JF_S_1	1.00	33.53	28.23	25.80
	IS31_NAPH_FSD_L_JF_S_0.5	0.50	39.89	34.80	32.30
	IS31_NAPH_FSD_L_JF_S_0.03	0.03	50.23	45.70	43.20
32	IS32_NAPH_FD_L_JF_S_1	1.00	46.61	39.42	36.24
	IS32_NAPH_FD_L_JF_S_0.5	0.50	55.21	48.43	45.47
	IS32_NAPH_FD_L_JF_S_0.03	0.03	69.60	63.68	61.18
33	IS33_H2_H2PR_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_JF_S_0.5	0.50	10.51	11.62	12.74
	IS33_H2_H2PR_V_JF_S_0.03	0.03	14.28	15.01	15.65
34	IS34_H2_HD_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_JF_S_0.5	0.50	11.80	12.96	14.53
	IS34_H2_HD_V_JF_S_0.03	0.03	16.05	16.81	17.47
35	IS35_ISOM_CGB_L_JF_S_1	1.00	34.56	29.11	26.74
	IS35_ISOM_CGB_L_JF_S_0.5	0.50	40.82	35.59	33.39
	IS35_ISOM_CGB_L_JF_S_0.03	0.03	51.30	46.60	44.75
36	IS36_H2_FIR_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS36_H2_FIR_V_JF_S_0.5	0.50	10.17	11.27	12.36
	IS36_H2_FIR_V_JF_S_0.03	0.03	13.83	14.54	15.18
37	IS37_NAPH_SIRBP_L_JF_S_1	1.00	40.53	34.19	31.42
	IS37_NAPH_SIRBP_L_JF_S_0.5	0.50	47.91	41.84	39.28
	IS37_NAPH_SIRBP_L_JF_S_0.03	0.03	60.30	54.86	52.71
38	IS38_H2_SIRUP_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_JF_S_0.5	0.50	9.78	10.87	11.96
	IS38_H2_SIRUP_V_JF_S_0.03	0.03	13.32	14.02	14.66
39	IS39_LPG_S_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_JF_S_0.5	0.50	10.44	10.65	10.86
	IS39_LPG_S_V_JF_S_0.03	0.03	13.54	13.56	13.56
40	IS40_ISOM_SRDBP_L_JF_S_1	1.00	40.12	33.90	31.09
	IS40_ISOM_SRDBP_L_JF_S_0.5	0.50	47.58	41.74	39.02
	IS40_ISOM_SRDBP_L_JF_S_0.03	0.03	59.93	54.90	52.45
41	IS41_LPG_SRDUP_V_JF_S_1	1.00	34.61	28.87	26.35
	IS41_LPG_SRDUP_V_JF_S_0.5	0.50	40.32	34.69	32.30
	IS41_LPG_SRDUP_V_JF_S_0.03	0.03	49.75	44.49	42.39
42	IS42_ISOM_DRD_L_JF_S_1	1.00	36.78	31.03	28.40
	IS42_ISOM_DRD_L_JF_S_0.5	0.50	43.68	38.24	35.62
	IS42_ISOM_DRD_L_JF_S_0.03	0.03	55.00	50.26	47.78
43	IS43_H2_CS_V_JF_S_1	1.00	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_JF_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_JF_S_0.03	0.03	6.41	6.97	7.39
44	IS44_TAME_TST_L_JF_S_1	1.00	25.89	22.93	21.52
	IS44_TAME_TST_L_JF_S_0.5	0.50	30.95	28.21	26.76
	IS44_TAME_TST_L_JF_S_0.03	0.03	38.90	36.82	35.50

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
45	IS45_ISOM_IST_L_JF_S_1	1.00	25.89	22.93	21.52
	IS45_ISOM_IST_L_JF_S_0.5	0.50	30.95	28.21	26.76
	IS45_ISOM_IST_L_JF_S_0.03	0.03	38.90	36.82	35.50
46	IS46_NAPH_MST_L_JF_S_1	1.00	38.84	32.80	30.06
	IS46_NAPH_MST_L_JF_S_0.5	0.50	46.09	40.40	37.73
	IS46_NAPH_MST_L_JF_S_0.03	0.03	58.05	53.14	50.67
47	IS47_TAME_PIPESTPU_L_JF_S_1	1.00	35.42	29.86	27.31
	IS47_TAME_PIPESTPU_L_JF_S_0.5	0.50	42.10	36.80	34.23
	IS47_TAME_PIPESTPU_L_JF_S_0.03	0.03	53.01	48.36	45.87
48	IS48_TAME_PIPEPUST_L_JF_S_1	1.00	35.42	29.86	27.31
	IS48_TAME_PIPEPUST_L_JF_S_0.5	0.50	42.10	36.80	34.23
	IS48_TAME_PIPEPUST_L_JF_S_0.03	0.03	53.01	48.36	45.87
49	IS49_ISOM_PIPEPUST_L_JF_S_1	1.00	35.42	29.86	27.31
	IS49_ISOM_PIPEPUST_L_JF_S_0.5	0.50	42.10	36.80	34.23
	IS49_ISOM_PIPEPUST_L_JF_S_0.03	0.03	53.01	48.36	45.87
50	IS50_NAPH_PIPESTPU_L_JF_S_1	1.00	38.62	32.61	29.88
	IS50_NAPH_PIPESTPU_L_JF_S_0.5	0.50	45.83	40.18	37.50
	IS50_NAPH_PIPESTPU_L_JF_S_0.03	0.03	57.72	52.83	50.36
51	IS51_NAPH_PIPEPUST_L_JF_S_1	1.00	35.42	29.86	27.31
	IS51_NAPH_PIPEPUST_L_JF_S_0.5	0.50	42.10	36.80	34.23
	IS51_NAPH_PIPEPUST_L_JF_S_0.03	0.03	53.01	48.36	45.87
52	IS52_NAPH_PIPEPUMHST_L_JF_S_1	1.00	38.28	32.32	29.61
	IS52_NAPH_PIPEPUMHST_L_JF_S_0.5	0.50	45.43	39.81	37.15
	IS52_NAPH_PIPEPUMHST_L_JF_S_0.03	0.03	57.21	52.35	49.88
53	IS53_ETHY_EST_L_JF_S_1	1.00	Not reachable	Not reachable	5.35
	IS53_ETHY_EST_L_JF_S_0.5	0.50	8.90	7.20	6.34

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS53_ETHY_EST_L_JF_S_0.03	0.03	10.48	8.89	8.07
54	IS54_ETHY_BOGC_V_JF_S_1	1.00	53.02	43.86	39.78
	IS54_ETHY_BOGC_V_JF_S_0.5	0.50	61.05	52.00	48.04
	IS54_ETHY_BOGC_V_JF_S_0.03	0.03	73.57	65.13	61.54
55	IS55_ETHY_HPEBOGLR_V_JF_S_1	1.00	53.02	43.86	39.78
	IS55_ETHY_HPEBOGLR_V_JF_S_0.5	0.50	61.05	52.00	48.04
	IS55_ETHY_HPEBOGLR_V_JF_S_0.03	0.03	73.57	65.13	61.54
56	IS56_ETHY_LPEBOGLR_L_JF_S_1	1.00	44.83	37.04	33.59
	IS56_ETHY_LPEBOGLR_L_JF_S_0.5	0.50	51.91	44.22	40.75
	IS56_ETHY_LPEBOGLR_L_JF_S_0.03	0.03	62.59	55.51	52.25
57	IS57_PROPY_PSV_L_JF_S_1	1.00	13.98	11.47	10.36
	IS57_PROPY_PSV_L_JF_S_0.5	0.50	16.20	13.68	12.60
	IS57_PROPY_PSV_L_JF_S_0.03	0.03	19.71	17.26	16.25
58	IS58_BUTD_BSV_L_JF_S_1	1.00	36.31	30.29	27.59
	IS58_BUTD_BSV_L_JF_S_0.5	0.50	42.81	36.88	34.03
	IS58_BUTD_BSV_L_JF_S_0.03	0.03	52.94	47.50	44.61
60	IS60_ETHY_PIPEU2100U5220_L_JF_S_1	1.00	46.89	38.75	35.14
	IS60_ETHY_PIPEU2100U5220_L_JF_S_0.5	0.50	54.17	46.15	42.58
	IS60_ETHY_PIPEU2100U5220_L_JF_S_0.03	0.03	65.30	57.90	54.59
61	IS61_ETHY_PIPEU5220PDT2_L_JF_S_1	1.00	47.85	39.57	35.88
	IS61_ETHY_PIPEU5220PDT2_L_JF_S_0.5	0.50	55.25	47.07	43.44
	IS61_ETHY_PIPEU5220PDT2_L_JF_S_0.03	0.03	66.59	59.04	55.69
62	IS62_ETHY_PIPEU5220BLU_V_JF_S_1	1.00	12.43	12.92	13.38
	IS62_ETHY_PIPEU5220BLU_V_JF_S_0.5	0.50	16.28	16.56	16.82
	IS62_ETHY_PIPEU5220BLU_V_JF_S_0.03	0.03	20.29	20.28	20.25
63	IS63_PROPY_PIPEU5210U5220_V_JF_S_1	1.00	39.60	32.84	29.84

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_JF_S_0.5	0.50	45.74	38.98	36.08
	IS63_PROPY_PIPEU5210U5220_V_JF_S_0.03	0.03	55.75	49.25	46.61
64	IS64_PROPY_PIPEU5220J_V_JF_S_1	1.00	39.09	32.43	29.48
	IS64_PROPY_PIPEU5220J_V_JF_S_0.5	0.50	45.17	38.53	35.69
	IS64_PROPY_PIPEU5220J_V_JF_S_0.03	0.03	55.07	48.72	46.14
65	IS65_PROPY_PIPEMURP_V_JF_S_1	1.00	13.98	11.47	10.36
	IS65_PROPY_PIPEMURP_V_JF_S_0.5	0.50	16.20	13.68	12.60
	IS65_PROPY_PIPEMURP_V_JF_S_0.03	0.03	19.71	17.26	16.25
66	IS66_BUTD_PIPEU5210U5220_L_JF_S_1	1.00	44.20	36.97	33.73
	IS66_BUTD_PIPEU5210U5220_L_JF_S_0.5	0.50	51.77	44.85	41.68
	IS66_BUTD_PIPEU5210U5220_L_JF_S_0.03	0.03	63.98	57.83	54.90
67	IS67_BUTD_PIPEU5220JLI_L_JF_S_1	1.00	44.43	37.16	33.91
	IS67_BUTD_PIPEU5220JLI_L_JF_S_0.5	0.50	52.03	45.08	41.90
	IS67_BUTD_PIPEU5220JLI_L_JF_S_0.03	0.03	64.31	58.12	55.20
68	IS68_BUTD_PIPEU5220JCLI_L_JF_S_1	1.00	44.43	37.16	33.91
	IS68_BUTD_PIPEU5220JCLI_L_JF_S_0.5	0.50	52.03	45.08	41.90
	IS68_BUTD_PIPEU5220JCLI_L_JF_S_0.03	0.03	64.31	58.12	55.20

Jet Fire Events Due to Medium Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_JF_M_1	1.00	82.94	70.34	64.47
	IS01_NAPH_SSHDSFSD_L_JF_M_0.5	0.50	98.56	86.64	80.99
	IS01_NAPH_SSHDSFSD_L_JF_M_0.03	0.03	124.84	114.35	109.18
2	IS02_NAPH_SSHDSR_V_JF_M_1	1.00	33.62	35.58	12.95
	IS02_NAPH_SSHDSR_V_JF_M_0.5	0.50	43.32	44.89	14.62
	IS02_NAPH_SSHDSR_V_JF_M_0.03	0.03	56.84	57.23	30.77
3	IS03_NAPH_SSHDSSDBP_L_JF_M_1	1.00	115.71	98.52	90.70
	IS03_NAPH_SSHDSSDBP_L_JF_M_0.5	0.50	138.29	122.31	114.83
	IS03_NAPH_SSHDSSDBP_L_JF_M_0.03	0.03	176.01	162.44	155.73
4	IS04_H2_SSHDSSDUP_V_JF_M_1	1.00	16.53	20.95	24.30
	IS04_H2_SSHDSSDUP_V_JF_M_0.5	0.50	24.10	26.97	29.01
	IS04_H2_SSHDSSDUP_V_JF_M_0.03	0.03	33.87	34.54	34.81
5	IS05_H2_SSHDSAAKOD_V_JF_M_1	1.00	16.53	20.95	24.30
	IS05_H2_SSHDSAAKOD_V_JF_M_0.5	0.50	24.10	26.97	29.01
	IS05_H2_SSHDSAAKOD_V_JF_M_0.03	0.03	33.87	34.54	34.81
6	IS06_MDEA_SSHDSLASD_L_JF_M_1	1.00	107.57	89.18	81.02
	IS06_MDEA_SSHDSLASD_L_JF_M_0.5	0.50	123.82	105.62	97.75
	IS06_MDEA_SSHDSLASD_L_JF_M_0.03	0.03	149.67	132.57	125.46
7	IS07_MDEA_SSHDSAABP_L_JF_M_1	1.00	116.35	96.49	87.67
	IS07_MDEA_SSHDSAABP_L_JF_M_0.5	0.50	133.94	114.28	105.79
	IS07_MDEA_SSHDSAABP_L_JF_M_0.03	0.03	161.99	143.50	135.82
8	IS08_H2_SSHDSAAUP_V_JF_M_1	1.00	16.19	20.64	24.00
	IS08_H2_SSHDSAAUP_V_JF_M_0.5	0.50	23.74	26.59	28.63
	IS08_H2_SSHDSAAUP_V_JF_M_0.03	0.03	33.36	34.04	34.33
9	IS09_H2_SSHDSRGCKOD_V_JF_M_1	1.00	16.13	20.58	23.94

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS09_H2_SSHDSRGCKOD_V_JF_M_0.5	0.50	23.67	26.52	28.56
	IS09_H2_SSHDSRGCKOD_V_JF_M_0.03	0.03	33.26	33.94	34.24
10	IS10_NAPH_SSHDSS_V_JF_M_1	1.00	18.42	20.54	22.54
	IS10_NAPH_SSHDSS_V_JF_M_0.5	0.50	24.45	25.91	27.25
	IS10_NAPH_SSHDSS_V_JF_M_0.03	0.03	32.09	32.62	33.06
11	IS11_H2_SSHDSSRD_V_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_JF_M_0.5	0.50	14.02	15.55	17.43
	IS11_H2_SSHDSSRD_V_JF_M_0.03	0.03	19.25	20.04	20.71
12	IS12_NAPH_LCNFSD_L_JF_M_1	1.00	79.70	71.26	67.42
	IS12_NAPH_LCNFSD_L_JF_M_0.5	0.50	95.55	88.42	84.83
	IS12_NAPH_LCNFSD_L_JF_M_0.03	0.03	121.46	116.98	114.18
13	IS13_MEOH_FR_L_JF_M_1	1.00	Not reachable	109.03	98.87
	IS13_MEOH_FR_L_JF_M_0.5	0.50	158.71	131.31	119.11
	IS13_MEOH_FR_L_JF_M_0.03	0.03	183.80	156.85	144.91
14	IS14_MEOH_SR_L_JF_M_1	1.00	Not reachable	103.32	93.61
	IS14_MEOH_SR_L_JF_M_0.5	0.50	151.03	124.93	113.31
	IS14_MEOH_SR_L_JF_M_0.03	0.03	174.97	149.30	137.89
15	IS15_TAME_TFBP_L_JF_M_1	1.00	79.83	67.79	62.40
	IS15_TAME_TFBP_L_JF_M_0.5	0.50	95.02	83.79	78.71
	IS15_TAME_TFBP_L_JF_M_0.03	0.03	120.45	110.84	106.43
16	IS16_MEOH_TFUP_V_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_JF_M_0.5	0.50	95.69	80.39	73.95
	IS16_MEOH_TFUP_V_JF_M_0.03	0.03	113.13	97.46	90.32
17	IS17_MEOH_TFRDBP_L_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS17_MEOH_TFRDBP_L_JF_M_0.5	0.50	70.22	61.08	57.13
	IS17_MEOH_TFRDBP_L_JF_M_0.03	0.03	85.42	74.46	69.53

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
18	IS18_NAPH_TFRDUP_V_JF_M_1	1.00	61.27	53.91	50.69
	IS18_NAPH_TFRDUP_V_JF_M_0.5	0.50	73.51	66.63	63.38
	IS18_NAPH_TFRDUP_V_JF_M_0.03	0.03	93.22	87.67	84.73
19	IS19_MEOH_TR_L_JF_M_1	1.00	Not reachable	108.64	98.52
	IS19_MEOH_TR_L_JF_M_0.5	0.50	158.19	130.88	118.72
	IS19_MEOH_TR_L_JF_M_0.03	0.03	183.21	156.35	144.44
20	IS20_NAPH_RWCBP_L_JF_M_1	1.00	108.43	92.22	84.78
	IS20_NAPH_RWCBP_L_JF_M_0.5	0.50	129.69	114.57	107.27
	IS20_NAPH_RWCBP_L_JF_M_0.03	0.03	165.08	152.15	145.33
21	IS21_MEOH_RWCUP_V_JF_M_1	1.00	Not reachable	Not reachable	93.32
	IS21_MEOH_RWCUP_V_JF_M_0.5	0.50	140.03	126.13	116.53
	IS21_MEOH_RWCUP_V_JF_M_0.03	0.03	163.81	152.29	142.56
22	IS22_MEOH_MCFD_L_JF_M_1	1.00	Not reachable	Not reachable	82.00
	IS22_MEOH_MCFD_L_JF_M_0.5	0.50	123.28	109.42	101.89
	IS22_MEOH_MCFD_L_JF_M_0.03	0.03	144.86	132.37	124.60
23	IS23_MEOH_RC_L_JF_M_1	1.00	Not reachable	Not reachable	96.42
	IS23_MEOH_RC_L_JF_M_0.5	0.50	148.73	132.20	120.02
	IS23_MEOH_RC_L_JF_M_0.03	0.03	173.80	159.45	146.80
24	IS24_MEOH_MC_V_JF_M_1	1.00	Not reachable	Not reachable	15.15
	IS24_MEOH_MC_V_JF_M_0.5	0.50	23.14	18.95	17.05
	IS24_MEOH_MC_V_JF_M_0.03	0.03	26.49	22.13	20.23
25	IS25_MEOH_MCRD_L_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS25_MEOH_MCRD_L_JF_M_0.5	0.50	90.39	75.78	69.62
	IS25_MEOH_MCRD_L_JF_M_0.03	0.03	106.50	91.72	85.04
26	IS26_MEOH_MGP_L_JF_M_1	1.00	Not reachable	119.96	108.79
	IS26_MEOH_MGP_L_JF_M_0.5	0.50	177.04	146.53	132.97

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS26_MEOH_MGP_L_JF_M_0.03	0.03	205.87	175.97	162.41
27	IS27_MEOH_MMUSD_L_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS27_MEOH_MMUSD_L_JF_M_0.5	0.50	73.42	63.69	59.50
	IS27_MEOH_MMUSD_L_JF_M_0.03	0.03	89.15	77.61	72.41
28	IS28_MEOH_MDD_V_JF_M_1	1.00	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_M_0.03	0.03	7.05	8.15	9.24
30	IS30_NAPH_SGB_L_JF_M_1	1.00	98.16	83.48	76.90
	IS30_NAPH_SGB_L_JF_M_0.5	0.50	117.03	103.34	97.17
	IS30_NAPH_SGB_L_JF_M_0.03	0.03	148.62	136.93	131.60
31	IS31_NAPH_FSD_L_JF_M_1	1.00	96.23	81.63	74.84
	IS31_NAPH_FSD_L_JF_M_0.5	0.50	115.29	101.42	94.47
	IS31_NAPH_FSD_L_JF_M_0.03	0.03	146.76	134.54	127.62
32	IS32_NAPH_FD_L_JF_M_1	1.00	134.65	114.67	103.53
	IS32_NAPH_FD_L_JF_M_0.5	0.50	160.73	142.05	130.21
	IS32_NAPH_FD_L_JF_M_0.03	0.03	204.56	188.47	175.48
33	IS33_H2_H2PR_V_JF_M_1	1.00	23.48	27.89	31.36
	IS33_H2_H2PR_V_JF_M_0.5	0.50	32.80	35.90	38.07
	IS33_H2_H2PR_V_JF_M_0.03	0.03	46.22	46.64	46.22
34	IS34_H2_HD_V_JF_M_1	1.00	26.04	30.60	34.21
	IS34_H2_HD_V_JF_M_0.5	0.50	36.20	39.51	41.70
	IS34_H2_HD_V_JF_M_0.03	0.03	51.28	51.60	50.84
35	IS35_ISOM_CGB_L_JF_M_1	1.00	100.82	85.49	76.67
	IS35_ISOM_CGB_L_JF_M_0.5	0.50	119.88	105.29	95.71
	IS35_ISOM_CGB_L_JF_M_0.03	0.03	152.01	139.00	128.13
36	IS36_H2_FIR_V_JF_M_1	1.00	22.82	27.20	30.64

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS36_H2_FIR_V_JF_M_0.5	0.50	31.87	34.98	37.14
	IS36_H2_FIR_V_JF_M_0.03	0.03	44.94	45.38	45.05
37	IS37_NAPH_SIRBP_L_JF_M_1	1.00	117.92	99.46	89.19
	IS37_NAPH_SIRBP_L_JF_M_0.5	0.50	140.39	122.45	111.29
	IS37_NAPH_SIRBP_L_JF_M_0.03	0.03	178.26	161.53	148.88
38	IS38_H2_SIRUP_V_JF_M_1	1.00	22.06	26.41	29.84
	IS38_H2_SIRUP_V_JF_M_0.5	0.50	30.81	33.94	36.10
	IS38_H2_SIRUP_V_JF_M_0.03	0.03	43.50	43.97	43.72
39	IS39_LPG_S_V_JF_M_1	1.00	28.80	30.38	31.95
	IS39_LPG_S_V_JF_M_0.5	0.50	36.80	38.02	39.18
	IS39_LPG_S_V_JF_M_0.03	0.03	47.70	48.02	48.27
40	IS40_ISOM_SRDBP_L_JF_M_1	1.00	115.45	98.29	90.49
	IS40_ISOM_SRDBP_L_JF_M_0.5	0.50	137.98	122.04	114.56
	IS40_ISOM_SRDBP_L_JF_M_0.03	0.03	175.62	162.07	155.36
41	IS41_LPG_SRDUP_V_JF_M_1	1.00	101.16	84.86	77.74
	IS41_LPG_SRDUP_V_JF_M_0.5	0.50	118.51	102.62	95.92
	IS41_LPG_SRDUP_V_JF_M_0.03	0.03	147.39	132.66	126.82
42	IS42_ISOM_DRD_L_JF_M_1	1.00	105.66	89.82	82.52
	IS42_ISOM_DRD_L_JF_M_0.5	0.50	126.42	111.60	104.37
	IS42_ISOM_DRD_L_JF_M_0.03	0.03	160.91	148.18	141.32
43	IS43_H2_CS_V_JF_M_1	1.00	7.96	13.79	18.38
	IS43_H2_CS_V_JF_M_0.5	0.50	17.66	20.05	21.94
	IS43_H2_CS_V_JF_M_0.03	0.03	24.70	25.48	26.08
44	IS44_TAME_TST_L_JF_M_1	1.00	60.62	53.52	50.48
	IS44_TAME_TST_L_JF_M_0.5	0.50	72.70	66.17	63.16
	IS44_TAME_TST_L_JF_M_0.03	0.03	92.17	87.10	84.50

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
45	IS45_ISOM_IST_L_JF_M_1	1.00	60.62	53.52	50.48
	IS45_ISOM_IST_L_JF_M_0.5	0.50	72.70	66.17	63.16
	IS45_ISOM_IST_L_JF_M_0.03	0.03	92.17	87.10	84.50
46	IS46_NAPH_MST_L_JF_M_1	1.00	111.69	95.05	87.43
	IS46_NAPH_MST_L_JF_M_0.5	0.50	133.55	118.06	110.66
	IS46_NAPH_MST_L_JF_M_0.03	0.03	169.99	156.79	150.00
47	IS47_TAME_PIPESTPU_L_JF_M_1	1.00	101.71	86.39	79.29
	IS47_TAME_PIPESTPU_L_JF_M_0.5	0.50	121.75	107.35	100.22
	IS47_TAME_PIPESTPU_L_JF_M_0.03	0.03	154.98	142.49	135.59
48	IS48_TAME_PIPEPUST_L_JF_M_1	1.00	101.71	86.39	79.29
	IS48_TAME_PIPEPUST_L_JF_M_0.5	0.50	121.75	107.35	100.22
	IS48_TAME_PIPEPUST_L_JF_M_0.03	0.03	154.98	142.49	135.59
49	IS49_ISOM_PIPEPUST_L_JF_M_1	1.00	101.71	86.39	79.29
	IS49_ISOM_PIPEPUST_L_JF_M_0.5	0.50	121.75	107.35	100.22
	IS49_ISOM_PIPEPUST_L_JF_M_0.03	0.03	154.98	142.49	135.59
50	IS50_NAPH_PIPESTPU_L_JF_M_1	1.00	111.05	94.49	86.91
	IS50_NAPH_PIPESTPU_L_JF_M_0.5	0.50	132.78	117.37	109.99
	IS50_NAPH_PIPESTPU_L_JF_M_0.03	0.03	169.02	155.87	149.08
51	IS51_NAPH_PIPEPUST_L_JF_M_1	1.00	101.71	86.39	79.29
	IS51_NAPH_PIPEPUST_L_JF_M_0.5	0.50	121.75	107.35	100.22
	IS51_NAPH_PIPEPUST_L_JF_M_0.03	0.03	154.98	142.49	135.59
52	IS52_NAPH_PIPEPUMHST_L_JF_M_1	1.00	110.04	93.62	86.09
	IS52_NAPH_PIPEPUMHST_L_JF_M_0.5	0.50	131.59	116.29	108.94
	IS52_NAPH_PIPEPUMHST_L_JF_M_0.03	0.03	167.49	154.44	147.64
53	IS53_ETHY_EST_L_JF_M_1	1.00	Not reachable	17.52	16.16
	IS53_ETHY_EST_L_JF_M_0.5	0.50	23.32	20.75	18.98

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS53_ETHY_EST_L_JF_M_0.03	0.03	28.38	25.31	23.30
54	IS54_ETHY_BOGC_V_JF_M_1	1.00	152.46	126.79	115.40
	IS54_ETHY_BOGC_V_JF_M_0.5	0.50	176.23	151.15	140.20
	IS54_ETHY_BOGC_V_JF_M_0.03	0.03	214.21	191.05	181.18
55	IS55_ETHY_HPEBOGLR_V_JF_M_1	1.00	152.46	126.79	115.40
	IS55_ETHY_HPEBOGLR_V_JF_M_0.5	0.50	176.23	151.15	140.20
	IS55_ETHY_HPEBOGLR_V_JF_M_0.03	0.03	214.21	191.05	181.18
56	IS56_ETHY_LPEBOGLR_L_JF_M_1	1.00	128.55	106.84	97.16
	IS56_ETHY_LPEBOGLR_L_JF_M_0.5	0.50	149.18	128.08	118.50
	IS56_ETHY_LPEBOGLR_L_JF_M_0.03	0.03	181.55	162.31	153.36
57	IS57_PROPY_PSV_L_JF_M_1	1.00	42.45	35.16	31.93
	IS57_PROPY_PSV_L_JF_M_0.5	0.50	48.99	41.67	38.51
	IS57_PROPY_PSV_L_JF_M_0.03	0.03	59.70	52.58	49.66
58	IS58_BUTD_BSV_L_JF_M_1	1.00	103.93	87.28	79.69
	IS58_BUTD_BSV_L_JF_M_0.5	0.50	123.08	106.91	98.99
	IS58_BUTD_BSV_L_JF_M_0.03	0.03	153.81	139.10	131.10
60	IS60_ETHY_PIPEU2100U5220_L_JF_M_1	1.00	134.54	111.85	101.76
	IS60_ETHY_PIPEU2100U5220_L_JF_M_0.5	0.50	155.90	133.85	123.97
	IS60_ETHY_PIPEU2100U5220_L_JF_M_0.03	0.03	189.62	169.48	160.40
61	IS61_ETHY_PIPEU5220PDT2_L_JF_M_1	1.00	137.36	114.21	103.91
	IS61_ETHY_PIPEU5220PDT2_L_JF_M_0.5	0.50	159.08	136.57	126.54
	IS61_ETHY_PIPEU5220PDT2_L_JF_M_0.03	0.03	193.47	172.89	163.71
62	IS62_ETHY_PIPEU5220BLU_V_JF_M_1	1.00	41.46	43.21	44.98
	IS62_ETHY_PIPEU5220BLU_V_JF_M_0.5	0.50	53.14	54.57	55.93
	IS62_ETHY_PIPEU5220BLU_V_JF_M_0.03	0.03	69.34	69.62	69.82
63	IS63_PROPY_PIPEU5210U5220_V_JF_M_1	1.00	116.08	96.69	88.15

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_JF_M_0.5	0.50	134.67	115.41	107.20
	IS63_PROPY_PIPEU5210U5220_V_JF_M_0.03	0.03	165.30	146.89	139.45
64	IS64_PROPY_PIPEU5220J_V_JF_M_1	1.00	114.39	95.34	86.96
	IS64_PROPY_PIPEU5220J_V_JF_M_0.5	0.50	132.77	113.92	105.89
	IS64_PROPY_PIPEU5220J_V_JF_M_0.03	0.03	163.05	145.13	137.90
65	IS65_PROPY_PIPEMURP_V_JF_M_1	1.00	42.45	35.16	31.93
	IS65_PROPY_PIPEMURP_V_JF_M_0.5	0.50	48.99	41.67	38.51
	IS65_PROPY_PIPEMURP_V_JF_M_0.03	0.03	59.70	52.58	49.66
66	IS66_BUTD_PIPEU5210U5220_L_JF_M_1	1.00	126.79	106.80	97.80
	IS66_BUTD_PIPEU5210U5220_L_JF_M_0.5	0.50	149.43	130.51	121.76
	IS66_BUTD_PIPEU5210U5220_L_JF_M_0.03	0.03	186.56	169.93	161.92
67	IS67_BUTD_PIPEU5220JLI_L_JF_M_1	1.00	127.46	107.37	98.33
	IS67_BUTD_PIPEU5220JLI_L_JF_M_0.5	0.50	150.21	131.20	122.42
	IS67_BUTD_PIPEU5220JLI_L_JF_M_0.03	0.03	187.52	170.81	162.80
68	IS68_BUTD_PIPEU5220JCLI_L_JF_M_1	1.00	127.46	107.37	98.33
	IS68_BUTD_PIPEU5220JCLI_L_JF_M_0.5	0.50	150.21	131.20	122.42
	IS68_BUTD_PIPEU5220JCLI_L_JF_M_0.03	0.03	187.52	170.81	162.80

Jet Fire Events Due to Large Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
1	IS01_NAPH_SSHDSFSD_L_JF_L_1	1.00	152.68	128.20	115.05
	IS01_NAPH_SSHDSFSD_L_JF_L_0.5	0.50	182.24	158.04	143.79
	IS01_NAPH_SSHDSFSD_L_JF_L_0.03	0.03	231.99	208.61	192.49
2	IS02_NAPH_SSHDSR_V_JF_L_1	1.00	59.72	62.71	65.79
	IS02_NAPH_SSHDSR_V_JF_L_0.5	0.50	78.76	81.54	83.91
	IS02_NAPH_SSHDSR_V_JF_L_0.03	0.03	107.71	107.96	107.72
3	IS03_NAPH_SSHDSSDBP_L_JF_L_1	1.00	211.64	180.95	162.57
	IS03_NAPH_SSHDSSDBP_L_JF_L_0.5	0.50	254.15	225.75	205.43
	IS03_NAPH_SSHDSSDBP_L_JF_L_0.03	0.03	325.16	301.15	277.68
4	IS04_H2_SSHDSSDUP_V_JF_L_1	1.00	32.60	37.67	42.80
	IS04_H2_SSHDSSDUP_V_JF_L_0.5	0.50	45.14	49.06	51.25
	IS04_H2_SSHDSSDUP_V_JF_L_0.03	0.03	64.68	64.76	62.99
5	IS05_H2_SSHDSAAKOD_V_JF_L_1	1.00	32.60	37.67	42.80
	IS05_H2_SSHDSAAKOD_V_JF_L_0.5	0.50	45.14	49.06	51.25
	IS05_H2_SSHDSAAKOD_V_JF_L_0.03	0.03	64.68	64.76	62.99
6	IS06_MDEA_SSHDSLASD_L_JF_L_1	1.00	197.40	164.11	149.36
	IS06_MDEA_SSHDSLASD_L_JF_L_0.5	0.50	227.80	195.03	180.88
	IS06_MDEA_SSHDSLASD_L_JF_L_0.03	0.03	276.62	245.92	233.18
7	IS07_MDEA_SSHDSAABP_L_JF_L_1	1.00	213.44	177.48	161.56
	IS07_MDEA_SSHDSAABP_L_JF_L_0.5	0.50	246.35	210.96	195.69
	IS07_MDEA_SSHDSAABP_L_JF_L_0.03	0.03	299.27	266.08	252.34
8	IS08_H2_SSHDSAAUP_V_JF_L_1	1.00	32.14	37.17	42.23
	IS08_H2_SSHDSAAUP_V_JF_L_0.5	0.50	44.51	48.38	50.57
	IS08_H2_SSHDSAAUP_V_JF_L_0.03	0.03	63.73	63.83	62.13
9	IS09_H2_SSHDSRGCKOD_V_JF_L_1	1.00	32.05	37.08	42.12

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS09_H2_SSHDSRGCKOD_V_JF_L_0.5	0.50	44.39	48.25	50.44
	IS09_H2_SSHDSRGCKOD_V_JF_L_0.03	0.03	63.55	63.65	61.97
10	IS10_NAPH_SSHDSS_V_JF_L_1	1.00	34.53	37.45	40.22
	IS10_NAPH_SSHDSS_V_JF_L_0.5	0.50	45.70	48.09	50.15
	IS10_NAPH_SSHDSS_V_JF_L_0.03	0.03	62.12	62.55	62.64
11	IS11_H2_SSHDSSRD_V_JF_L_1	1.00	18.81	23.12	26.47
	IS11_H2_SSHDSSRD_V_JF_L_0.5	0.50	26.72	29.67	31.77
	IS11_H2_SSHDSSRD_V_JF_L_0.03	0.03	37.58	38.17	38.26
12	IS12_NAPH_LCNFSD_L_JF_L_1	1.00	120.19	107.14	100.06
	IS12_NAPH_LCNFSD_L_JF_L_0.5	0.50	144.50	133.37	126.34
	IS12_NAPH_LCNFSD_L_JF_L_0.03	0.03	184.46	177.12	170.65
13	IS13_MEOH_FR_L_JF_L_1	1.00	236.75	195.78	177.89
	IS13_MEOH_FR_L_JF_L_0.5	0.50	276.40	232.11	212.37
	IS13_MEOH_FR_L_JF_L_0.03	0.03	320.65	278.01	259.14
14	IS14_MEOH_SR_L_JF_L_1	1.00	224.58	184.51	167.83
	IS14_MEOH_SR_L_JF_L_0.5	0.50	261.60	219.53	200.83
	IS14_MEOH_SR_L_JF_L_0.03	0.03	303.56	263.04	245.13
15	IS15_TAME_TFBP_L_JF_L_1	1.00	146.46	124.90	113.81
	IS15_TAME_TFBP_L_JF_L_0.5	0.50	175.18	155.16	143.83
	IS15_TAME_TFBP_L_JF_L_0.03	0.03	223.29	206.28	194.68
16	IS16_MEOH_TFUP_V_JF_L_1	1.00	Not reachable	Not reachable	100.78
	IS16_MEOH_TFUP_V_JF_L_0.5	0.50	164.46	137.91	126.29
	IS16_MEOH_TFUP_V_JF_L_0.03	0.03	193.69	167.18	154.52
17	IS17_MEOH_TFRDBP_L_JF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS17_MEOH_TFRDBP_L_JF_L_0.5	0.50	115.91	99.62	92.37
	IS17_MEOH_TFRDBP_L_JF_L_0.03	0.03	139.22	121.06	112.52

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
18	IS18_NAPH_TFRDUP_V_JF_L_1	1.00	96.90	84.84	78.96
	IS18_NAPH_TFRDUP_V_JF_L_0.5	0.50	116.60	105.23	99.14
	IS18_NAPH_TFRDUP_V_JF_L_0.03	0.03	148.57	139.09	133.12
19	IS19_MEOH_TR_L_JF_L_1	1.00	235.96	195.01	177.19
	IS19_MEOH_TR_L_JF_L_0.5	0.50	275.44	231.25	211.58
	IS19_MEOH_TR_L_JF_L_0.03	0.03	319.54	276.99	258.18
20	IS20_NAPH_RWCBP_L_JF_L_1	1.00	198.18	169.27	154.03
	IS20_NAPH_RWCBP_L_JF_L_0.5	0.50	238.17	211.32	195.27
	IS20_NAPH_RWCBP_L_JF_L_0.03	0.03	304.80	281.96	264.83
21	IS21_MEOH_RWCUP_V_JF_L_1	1.00	0.00	153.63	140.37
	IS21_MEOH_RWCUP_V_JF_L_0.5	0.50	211.35	188.40	172.86
	IS21_MEOH_RWCUP_V_JF_L_0.03	0.03	247.35	227.70	211.83
22	IS22_MEOH_MCFD_L_JF_L_1	1.00	Not reachable	Not reachable	121.58
	IS22_MEOH_MCFD_L_JF_L_0.5	0.50	187.12	164.50	151.13
	IS22_MEOH_MCFD_L_JF_L_0.03	0.03	219.56	199.12	185.11
23	IS23_MEOH_RC_L_JF_L_1	1.00	0.00	163.48	150.34
	IS23_MEOH_RC_L_JF_L_0.5	0.50	224.35	200.87	184.20
	IS23_MEOH_RC_L_JF_L_0.03	0.03	262.22	242.56	225.75
24	IS24_MEOH_MC_V_JF_L_1	1.00	0.00	31.11	27.82
	IS24_MEOH_MC_V_JF_L_0.5	0.50	43.55	35.78	32.25
	IS24_MEOH_MC_V_JF_L_0.03	0.03	49.81	41.75	38.23
25	IS25_MEOH_MCRD_L_JF_L_1	1.00	Not reachable	Not reachable	95.72
	IS25_MEOH_MCRD_L_JF_L_0.5	0.50	156.43	130.98	119.91
	IS25_MEOH_MCRD_L_JF_L_0.03	0.03	183.74	158.56	146.73
26	IS26_MEOH_MGP_L_JF_L_1	1.00	249.17	215.15	196.84
	IS26_MEOH_MGP_L_JF_L_0.5	0.50	290.49	258.79	237.18

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS26_MEOH_MGP_L_JF_L_0.03	0.03	338.22	311.51	290.52
27	IS27_MEOH_MMUSD_L_JF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS27_MEOH_MMUSD_L_JF_L_0.5	0.50	122.40	104.86	97.02
	IS27_MEOH_MMUSD_L_JF_L_0.03	0.03	146.87	127.42	118.22
28	IS28_MEOH_MDD_V_JF_L_1	1.00	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_JF_L_0.5	0.50	5.18	12.26	15.51
	IS28_MEOH_MDD_V_JF_L_0.03	0.03	14.30	16.58	18.11
30	IS30_NAPH_SGB_L_JF_L_1	1.00	179.94	153.65	138.01
	IS30_NAPH_SGB_L_JF_L_0.5	0.50	215.53	191.15	173.99
	IS30_NAPH_SGB_L_JF_L_0.03	0.03	275.17	254.47	234.80
31	IS31_NAPH_FSD_L_JF_L_1	1.00	162.07	148.91	137.43
	IS31_NAPH_FSD_L_JF_L_0.5	0.50	194.95	185.93	174.38
	IS31_NAPH_FSD_L_JF_L_0.03	0.03	249.41	247.89	236.72
32	IS32_NAPH_FD_L_JF_L_1	1.00	246.78	204.56	183.56
	IS32_NAPH_FD_L_JF_L_0.5	0.50	295.91	252.40	229.57
	IS32_NAPH_FD_L_JF_L_0.03	0.03	378.33	332.92	307.06
33	IS33_H2_H2PR_V_JF_L_1	1.00	43.61	49.79	56.35
	IS33_H2_H2PR_V_JF_L_0.5	0.50	60.35	65.44	67.44
	IS33_H2_H2PR_V_JF_L_0.03	0.03	87.68	87.45	83.61
34	IS34_H2_HD_V_JF_L_1	1.00	48.10	54.76	61.80
	IS34_H2_HD_V_JF_L_0.5	0.50	66.55	72.14	74.00
	IS34_H2_HD_V_JF_L_0.03	0.03	97.10	96.75	91.96
35	IS35_ISOM_CGB_L_JF_L_1	1.00	185.65	152.87	136.98
	IS35_ISOM_CGB_L_JF_L_0.5	0.50	221.70	187.32	170.08
	IS35_ISOM_CGB_L_JF_L_0.03	0.03	282.39	245.57	226.08
36	IS36_H2_FIR_V_JF_L_1	1.00	42.47	48.53	54.96

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS36_H2_FIR_V_JF_L_0.5	0.50	58.78	63.74	65.78
	IS36_H2_FIR_V_JF_L_0.03	0.03	85.29	85.10	81.49
37	IS37_NAPH_SIRBP_L_JF_L_1	1.00	216.86	177.49	159.06
	IS37_NAPH_SIRBP_L_JF_L_0.5	0.50	259.30	217.36	197.40
	IS37_NAPH_SIRBP_L_JF_L_0.03	0.03	330.68	284.65	262.14
38	IS38_H2_SIRUP_V_JF_L_1	1.00	41.19	47.11	53.39
	IS38_H2_SIRUP_V_JF_L_0.5	0.50	57.01	61.82	63.89
	IS38_H2_SIRUP_V_JF_L_0.03	0.03	82.61	82.44	79.09
39	IS39_LPG_S_V_JF_L_1	1.00	52.30	54.90	57.57
	IS39_LPG_S_V_JF_L_0.5	0.50	68.39	70.67	72.73
	IS39_LPG_S_V_JF_L_0.03	0.03	91.99	92.31	92.36
40	IS40_ISOM_SRDBP_L_JF_L_1	1.00	211.16	180.53	162.26
	IS40_ISOM_SRDBP_L_JF_L_0.5	0.50	253.57	225.23	205.07
	IS40_ISOM_SRDBP_L_JF_L_0.03	0.03	324.43	300.47	277.24
41	IS41_LPG_SRDUP_V_JF_L_1	1.00	186.39	156.84	141.65
	IS41_LPG_SRDUP_V_JF_L_0.5	0.50	219.16	190.47	174.71
	IS41_LPG_SRDUP_V_JF_L_0.03	0.03	273.77	247.23	230.66
42	IS42_ISOM_DRD_L_JF_L_1	1.00	193.07	164.82	150.66
	IS42_ISOM_DRD_L_JF_L_0.5	0.50	232.10	205.79	191.18
	IS42_ISOM_DRD_L_JF_L_0.03	0.03	297.06	274.56	259.54
43	IS43_H2_CS_V_JF_L_1	1.00	24.20	28.64	32.13
	IS43_H2_CS_V_JF_L_0.5	0.50	33.74	36.90	39.08
	IS43_H2_CS_V_JF_L_0.03	0.03	47.62	48.01	47.50
44	IS44_TAME_TST_L_JF_L_1	1.00	93.74	82.47	77.07
	IS44_TAME_TST_L_JF_L_0.5	0.50	112.72	102.31	96.81
	IS44_TAME_TST_L_JF_L_0.03	0.03	143.57	135.26	130.05

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
45	IS45_ISOM_IST_L_JF_L_1	1.00	93.74	82.47	77.07
	IS45_ISOM_IST_L_JF_L_0.5	0.50	112.72	102.31	96.81
	IS45_ISOM_IST_L_JF_L_0.03	0.03	143.57	135.26	130.05
46	IS46_NAPH_MST_L_JF_L_1	1.00	204.20	174.51	157.93
	IS46_NAPH_MST_L_JF_L_0.5	0.50	245.33	217.80	199.96
	IS46_NAPH_MST_L_JF_L_0.03	0.03	313.93	290.60	270.84
47	IS47_TAME_PIPESTPU_L_JF_L_1	1.00	177.16	158.46	145.70
	IS47_TAME_PIPESTPU_L_JF_L_0.5	0.50	213.00	197.88	185.08
	IS47_TAME_PIPESTPU_L_JF_L_0.03	0.03	272.55	263.95	251.56
48	IS48_TAME_PIPEPUST_L_JF_L_1	1.00	177.16	158.46	145.70
	IS48_TAME_PIPEPUST_L_JF_L_0.5	0.50	213.00	197.88	185.08
	IS48_TAME_PIPEPUST_L_JF_L_0.03	0.03	272.55	263.95	251.56
49	IS49_ISOM_PIPEPUST_L_JF_L_1	1.00	177.16	158.46	145.70
	IS49_ISOM_PIPEPUST_L_JF_L_0.5	0.50	213.00	197.88	185.08
	IS49_ISOM_PIPEPUST_L_JF_L_0.03	0.03	272.55	263.95	251.56
50	IS50_NAPH_PIPESTPU_L_JF_L_1	1.00	203.01	173.47	157.17
	IS50_NAPH_PIPESTPU_L_JF_L_0.5	0.50	243.91	216.52	199.04
	IS50_NAPH_PIPESTPU_L_JF_L_0.03	0.03	312.12	288.89	269.67
51	IS51_NAPH_PIPEPUST_L_JF_L_1	1.00	177.16	158.46	145.70
	IS51_NAPH_PIPEPUST_L_JF_L_0.5	0.50	213.00	197.88	185.08
	IS51_NAPH_PIPEPUST_L_JF_L_0.03	0.03	272.55	263.95	251.56
52	IS52_NAPH_PIPEPUMHST_L_JF_L_1	1.00	201.15	171.85	155.96
	IS52_NAPH_PIPEPUMHST_L_JF_L_0.5	0.50	241.69	214.52	197.60
	IS52_NAPH_PIPEPUMHST_L_JF_L_0.03	0.03	309.30	286.23	267.82
53	IS53_ETHY_EST_L_JF_L_1	1.00	Not reachable	31.09	28.86
	IS53_ETHY_EST_L_JF_L_0.5	0.50	40.43	36.69	33.88

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS53_ETHY_EST_L_JF_L_0.03	0.03	49.21	44.93	41.81
54	IS54_ETHY_BOGC_V_JF_L_1	1.00	278.57	232.39	211.90
	IS54_ETHY_BOGC_V_JF_L_0.5	0.50	322.92	278.03	258.41
	IS54_ETHY_BOGC_V_JF_L_0.03	0.03	394.29	352.97	335.36
55	IS55_ETHY_HPEBOGLR_V_JF_L_1	1.00	278.57	232.39	211.90
	IS55_ETHY_HPEBOGLR_V_JF_L_0.5	0.50	322.92	278.03	258.41
	IS55_ETHY_HPEBOGLR_V_JF_L_0.03	0.03	394.29	352.97	335.36
56	IS56_ETHY_LPEBOGLR_L_JF_L_1	1.00	234.48	195.53	178.13
	IS56_ETHY_LPEBOGLR_L_JF_L_0.5	0.50	272.78	235.17	218.03
	IS56_ETHY_LPEBOGLR_L_JF_L_0.03	0.03	333.61	299.48	283.49
57	IS57_PROPY_PSV_L_JF_L_1	1.00	79.18	65.75	59.81
	IS57_PROPY_PSV_L_JF_L_0.5	0.50	91.59	78.13	72.35
	IS57_PROPY_PSV_L_JF_L_0.03	0.03	112.01	98.96	93.61
58	IS58_BUTD_BSV_L_JF_L_1	1.00	189.46	159.69	145.99
	IS58_BUTD_BSV_L_JF_L_0.5	0.50	225.16	196.41	182.19
	IS58_BUTD_BSV_L_JF_L_0.03	0.03	282.96	256.89	242.53
60	IS60_ETHY_PIPEU2100U5220_L_JF_L_1	1.00	245.53	204.82	186.65
	IS60_ETHY_PIPEU2100U5220_L_JF_L_0.5	0.50	285.25	245.91	228.24
	IS60_ETHY_PIPEU2100U5220_L_JF_L_0.03	0.03	348.66	312.87	296.68
61	IS61_ETHY_PIPEU5220PDT2_L_JF_L_1	1.00	250.73	209.17	190.64
	IS61_ETHY_PIPEU5220PDT2_L_JF_L_0.5	0.50	291.16	250.97	233.02
	IS61_ETHY_PIPEU5220PDT2_L_JF_L_0.03	0.03	355.81	319.20	302.84
62	IS62_ETHY_PIPEU5220BLU_V_JF_L_1	1.00	74.21	76.98	79.95
	IS62_ETHY_PIPEU5220BLU_V_JF_L_0.5	0.50	97.04	99.73	102.09
	IS62_ETHY_PIPEU5220BLU_V_JF_L_0.03	0.03	131.66	131.89	131.69
63	IS63_PROPY_PIPEU5210U5220_V_JF_L_1	1.00	214.18	178.85	163.32

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_JF_L_0.5	0.50	249.23	214.26	199.39
	IS63_PROPY_PIPEU5210U5220_V_JF_L_0.03	0.03	307.10	273.75	260.30
64	IS64_PROPY_PIPEU5220J_V_JF_L_1	1.00	210.87	176.21	161.00
	IS64_PROPY_PIPEU5220J_V_JF_L_0.5	0.50	245.52	211.34	196.82
	IS64_PROPY_PIPEU5220J_V_JF_L_0.03	0.03	302.72	270.31	257.28
65	IS65_PROPY_PIPEMURP_V_JF_L_1	1.00	79.18	65.75	59.81
	IS65_PROPY_PIPEMURP_V_JF_L_0.5	0.50	91.59	78.13	72.35
	IS65_PROPY_PIPEMURP_V_JF_L_0.03	0.03	112.01	98.96	93.61
66	IS66_BUTD_PIPEU5210U5220_L_JF_L_1	1.00	231.48	195.75	179.60
	IS66_BUTD_PIPEU5210U5220_L_JF_L_0.5	0.50	273.92	240.26	224.61
	IS66_BUTD_PIPEU5210U5220_L_JF_L_0.03	0.03	343.75	314.29	299.98
67	IS67_BUTD_PIPEU5220JLI_L_JF_L_1	1.00	232.71	196.80	180.58
	IS67_BUTD_PIPEU5220JLI_L_JF_L_0.5	0.50	275.36	241.52	225.83
	IS67_BUTD_PIPEU5220JLI_L_JF_L_0.03	0.03	345.54	315.94	301.61
68	IS68_BUTD_PIPEU5220JCLI_L_JF_L_1	1.00	232.71	196.80	180.58
	IS68_BUTD_PIPEU5220JCLI_L_JF_L_0.5	0.50	275.36	241.52	225.83
	IS68_BUTD_PIPEU5220JCLI_L_JF_L_0.03	0.03	345.54	315.94	301.61

Jet Fire Events Due to Catastrophic Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_JF_C_1	1.00	128.51	133.32	136.86
	IS02_NAPH_SSHDSR_V_JF_C_0.5	0.50	171.10	177.29	181.13
	IS02_NAPH_SSHDSR_V_JF_C_0.03	0.03	245.81	246.52	243.95
4	IS04_H2_SSHDSSDUP_V_JF_C_1	1.00	73.09	82.44	91.94
	IS04_H2_SSHDSSDUP_V_JF_C_0.5	0.50	100.95	109.33	110.52
	IS04_H2_SSHDSSDUP_V_JF_C_0.03	0.03	149.67	148.47	139.02
5	IS05_H2_SSHDSAAKOD_V_JF_C_1	1.00	73.09	82.44	91.94
	IS05_H2_SSHDSAAKOD_V_JF_C_0.5	0.50	100.95	109.33	110.52
	IS05_H2_SSHDSAAKOD_V_JF_C_0.03	0.03	149.67	148.47	139.02
8	IS08_H2_SSHDSAAUP_V_JF_C_1	1.00	72.06	81.30	90.63
	IS08_H2_SSHDSAAUP_V_JF_C_0.5	0.50	99.54	107.81	108.93
	IS08_H2_SSHDSAAUP_V_JF_C_0.03	0.03	147.51	146.35	136.95
9	IS09_H2_SSHDSRGCKOD_V_JF_C_1	1.00	71.86	81.08	90.38
	IS09_H2_SSHDSRGCKOD_V_JF_C_0.5	0.50	99.27	107.52	108.63
	IS09_H2_SSHDSRGCKOD_V_JF_C_0.03	0.03	147.09	145.94	136.56
10	IS10_NAPH_SSHDSS_V_JF_C_1	1.00	73.53	78.27	83.73
	IS10_NAPH_SSHDSS_V_JF_C_0.5	0.50	99.32	104.17	107.05
	IS10_NAPH_SSHDSS_V_JF_C_0.03	0.03	142.34	142.37	139.86
11	IS11_H2_SSHDSSRD_V_JF_C_1	1.00	43.69	49.88	56.45
	IS11_H2_SSHDSSRD_V_JF_C_0.5	0.50	60.46	65.56	67.56
	IS11_H2_SSHDSSRD_V_JF_C_0.03	0.03	87.85	87.62	83.76
16	IS16_MEOH_TFUP_V_JF_C_1	1.00	Not reachable	224.60	206.62
	IS16_MEOH_TFUP_V_JF_C_0.5	0.50	330.60	277.57	252.84
	IS16_MEOH_TFUP_V_JF_C_0.03	0.03	389.28	336.88	310.27
18	IS18_NAPH_TFRDUP_V_JF_C_1	1.00	167.44	147.54	137.72

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_JF_C_0.5	0.50	202.21	183.81	173.76
	IS18_NAPH_TFRDUP_V_JF_C_0.03	0.03	259.01	244.16	234.45
21	IS21_MEOH_RWCUP_V_JF_C_1	1.00	319.50	267.38	245.87
	IS21_MEOH_RWCUP_V_JF_C_0.5	0.50	373.77	326.40	298.03
	IS21_MEOH_RWCUP_V_JF_C_0.03	0.03	437.78	395.16	366.11
24	IS24_MEOH_MC_V_JF_C_1	1.00	Not reachable	70.98	63.93
	IS24_MEOH_MC_V_JF_C_0.5	0.50	99.19	81.64	73.74
	IS24_MEOH_MC_V_JF_C_0.03	0.03	113.56	95.52	87.65
28	IS28_MEOH_MDD_V_JF_C_1	1.00	8.81	13.80	29.40
	IS28_MEOH_MDD_V_JF_C_0.5	0.50	24.88	28.62	33.39
	IS28_MEOH_MDD_V_JF_C_0.03	0.03	35.16	37.60	38.08
33	IS33_H2_H2PR_V_JF_C_1	1.00	98.70	109.91	123.46
	IS33_H2_H2PR_V_JF_C_0.5	0.50	136.16	146.05	148.99
	IS33_H2_H2PR_V_JF_C_0.03	0.03	202.38	199.88	189.11
34	IS34_H2_HD_V_JF_C_1	1.00	108.40	121.11	136.27
	IS34_H2_HD_V_JF_C_0.5	0.50	150.66	160.97	164.73
	IS34_H2_HD_V_JF_C_0.03	0.03	223.98	220.82	209.66
36	IS36_H2_FIR_V_JF_C_1	1.00	95.95	107.07	120.21
	IS36_H2_FIR_V_JF_C_0.5	0.50	132.48	142.26	145.00
	IS36_H2_FIR_V_JF_C_0.03	0.03	196.91	194.56	183.91
38	IS38_H2_SIRUP_V_JF_C_1	1.00	468.79	379.06	339.34
	IS38_H2_SIRUP_V_JF_C_0.5	0.50	558.19	460.60	417.79
	IS38_H2_SIRUP_V_JF_C_0.03	0.03	707.03	596.59	548.72
39	IS39_LPG_S_V_JF_C_1	1.00	111.26	115.26	118.74
	IS39_LPG_S_V_JF_C_0.5	0.50	147.91	152.75	156.13
	IS39_LPG_S_V_JF_C_0.03	0.03	210.02	210.36	208.57

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_JF_C_1	1.00	415.68	340.44	303.92
	IS41_LPG_SRDUP_V_JF_C_0.5	0.50	490.96	411.66	372.00
	IS41_LPG_SRDUP_V_JF_C_0.03	0.03	616.07	530.74	485.92
43	IS43_H2_CS_V_JF_C_1	1.00	328.82	297.85	265.27
	IS43_H2_CS_V_JF_C_0.5	0.50	397.05	372.86	334.73
	IS43_H2_CS_V_JF_C_0.03	0.03	510.36	498.16	450.94
54	IS54_ETHY_BOGC_V_JF_C_1	1.00	62.10	64.28	60.37
	IS54_ETHY_BOGC_V_JF_C_0.5	0.50	76.96	75.86	71.18
	IS54_ETHY_BOGC_V_JF_C_0.03	0.03	93.94	93.66	88.66
55	IS55_ETHY_HPEBOGLR_V_JF_C_1	1.00	614.87	514.92	470.61
	IS55_ETHY_HPEBOGLR_V_JF_C_0.5	0.50	715.23	618.58	576.31
	IS55_ETHY_HPEBOGLR_V_JF_C_0.03	0.03	877.30	788.54	750.62
62	IS62_ETHY_PIPEU5220BLU_V_JF_C_1	1.00	362.96	325.62	300.59
	IS62_ETHY_PIPEU5220BLU_V_JF_C_0.5	0.50	432.97	402.29	376.97
	IS62_ETHY_PIPEU5220BLU_V_JF_C_0.03	0.03	546.86	528.61	504.02
63	IS63_PROPY_PIPEU5210U5220_V_JF_C_1	1.00	478.35	397.37	353.19
	IS63_PROPY_PIPEU5210U5220_V_JF_C_0.5	0.50	558.70	476.86	428.32
	IS63_PROPY_PIPEU5210U5220_V_JF_C_0.03	0.03	691.07	609.50	553.82
64	IS64_PROPY_PIPEU5220J_V_JF_C_1	1.00	470.45	391.94	348.84
	IS64_PROPY_PIPEU5220J_V_JF_C_0.5	0.50	549.88	471.23	424.07
	IS64_PROPY_PIPEU5220J_V_JF_C_0.03	0.03	680.74	603.54	549.73
65	IS65_PROPY_PIPEMURP_V_JF_C_1	1.00	179.06	149.14	135.93
	IS65_PROPY_PIPEMURP_V_JF_C_0.5	0.50	207.87	178.00	165.20
	IS65_PROPY_PIPEMURP_V_JF_C_0.03	0.03	255.43	226.55	214.75

Flash Fire Events Due to Minor Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_FF_0_LFL	LFL	2.41	2.23	2.12
	IS02_NAPH_SSHDSR_V_FF_0_1/2 LFL	1/2 LFL	4.63	3.94	3.63
4	IS04_H2_SSHDSSDUP_V_FF_0_LFL	LFL	6.20	4.39	3.84
	IS04_H2_SSHDSSDUP_V_FF_0_1/2 LFL	1/2 LFL	8.93	6.30	5.48
5	IS05_H2_SSHDSAAKOD_V_FF_0_LFL	LFL	6.20	4.39	3.84
	IS05_H2_SSHDSAAKOD_V_FF_0_1/2 LFL	1/2 LFL	8.93	6.30	5.48
8	IS08_H2_SSHDSAAUP_V_FF_0_LFL	LFL	6.11	4.33	3.80
	IS08_H2_SSHDSAAUP_V_FF_0_1/2 LFL	1/2 LFL	8.82	6.23	5.41
9	IS09_H2_SSHDSRGCKOD_V_FF_0_LFL	LFL	6.08	4.32	3.78
	IS09_H2_SSHDSRGCKOD_V_FF_0_1/2 LFL	1/2 LFL	8.77	6.20	5.39
10	IS10_NAPH_SSHDSS_V_FF_0_LFL	LFL	1.52	1.41	1.35
	IS10_NAPH_SSHDSS_V_FF_0_1/2 LFL	1/2 LFL	2.86	2.46	2.27
11	IS11_H2_SSHDSSRD_V_FF_0_LFL	LFL	3.73	2.73	2.41
	IS11_H2_SSHDSSRD_V_FF_0_1/2 LFL	1/2 LFL	5.59	4.01	3.51
16	IS16_MEOH_TFUP_V_FF_0_LFL	LFL	5.03	3.97	3.58
	IS16_MEOH_TFUP_V_FF_0_1/2 LFL	1/2 LFL	7.90	5.47	5.03
18	IS18_NAPH_TFRDUP_V_FF_0_LFL	LFL	4.67	5.19	4.87
	IS18_NAPH_TFRDUP_V_FF_0_1/2 LFL	1/2 LFL	11.10	5.36	5.93
21	IS21_MEOH_RWCUP_V_FF_0_LFL	LFL	6.13	4.96	4.49
	IS21_MEOH_RWCUP_V_FF_0_1/2 LFL	1/2 LFL	12.15	7.30	6.31
24	IS24_MEOH_MC_V_FF_0_LFL	LFL	0.34	0.33	0.33
	IS24_MEOH_MC_V_FF_0_1/2 LFL	1/2 LFL	0.68	0.66	0.65
28	IS28_MEOH_MDD_V_FF_0_LFL	LFL	0.21	0.21	0.21
	IS28_MEOH_MDD_V_FF_0_1/2 LFL	1/2 LFL	0.44	0.41	0.40
33	IS33_H2_H2PR_V_FF_0_LFL	LFL	7.42	5.28	4.63

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS33_H2_H2PR_V_FF_0_1/2 LFL	1/2 LFL	10.25	7.57	6.64
34	IS34_H2_HD_V_FF_0_LFL	LFL	9.02	6.30	5.48
	IS34_H2_HD_V_FF_0_1/2 LFL	1/2 LFL	12.69	9.05	8.04
36	IS36_H2_FIR_V_FF_0_LFL	LFL	7.50	5.31	4.65
	IS36_H2_FIR_V_FF_0_1/2 LFL	1/2 LFL	10.45	7.60	6.63
38	IS38_H2_SIRUP_V_FF_0_LFL	LFL	7.38	5.20	4.55
	IS38_H2_SIRUP_V_FF_0_1/2 LFL	1/2 LFL	10.32	7.46	6.51
39	IS39_LPG_S_V_FF_0_LFL	LFL	2.34	2.17	2.07
	IS39_LPG_S_V_FF_0_1/2 LFL	1/2 LFL	4.41	3.77	3.47
41	IS41_LPG_SRDUP_V_FF_0_LFL	LFL	7.76	6.50	5.92
	IS41_LPG_SRDUP_V_FF_0_1/2 LFL	1/2 LFL	16.12	11.36	9.52
43	IS43_H2_CS_V_FF_0_LFL	LFL	4.65	3.35	2.95
	IS43_H2_CS_V_FF_0_1/2 LFL	1/2 LFL	6.84	4.87	4.25
53	IS53_ETHY_EST_L_FF_0_LFL	LFL	1.41	1.74	2.65
	IS53_ETHY_EST_L_FF_0_1/2 LFL	1/2 LFL	1.44	1.76	3.99
54	IS54_ETHY_BOGC_V_FF_0_LFL	LFL	22.72	16.17	13.60
	IS54_ETHY_BOGC_V_FF_0_1/2 LFL	1/2 LFL	61.28	40.38	33.40
55	IS55_ETHY_HPEBOGLR_V_FF_0_LFL	LFL	22.72	16.17	13.60
	IS55_ETHY_HPEBOGLR_V_FF_0_1/2 LFL	1/2 LFL	61.28	40.38	33.40
57	IS57_PROPY_PSV_L_FF_0_LFL	LFL	2.55	2.34	2.23
	IS57_PROPY_PSV_L_FF_0_1/2 LFL	1/2 LFL	4.78	4.04	3.70
58	IS58_BUTD_BSV_L_FF_0_LFL	LFL	13.41	6.48	5.69
	IS58_BUTD_BSV_L_FF_0_1/2 LFL	1/2 LFL	37.90	13.66	9.07

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
62	IS62_ETHY_PIPEU5220BLU_V_FF_0_LFL	LFL	4.21	3.78	3.55
	IS62_ETHY_PIPEU5220BLU_V_FF_0_1/2 LFL	1/2 LFL	7.84	6.38	5.77
63	IS63_PROPY_PIPEU5210U5220_V_FF_0_LFL	LFL	4.21	3.78	3.55
	IS63_PROPY_PIPEU5210U5220_V_FF_0_1/2 LFL	1/2 LFL	7.84	6.38	5.77
64	IS64_PROPY_PIPEU5220J_V_FF_0_LFL	LFL	8.35	7.16	6.59
	IS64_PROPY_PIPEU5220J_V_FF_0_1/2 LFL	1/2 LFL	17.66	13.63	11.68
65	IS65_PROPY_PIPEMURP_V_FF_0_LFL	LFL	8.43	7.15	6.56
	IS65_PROPY_PIPEMURP_V_FF_0_1/2 LFL	1/2 LFL	17.94	13.54	11.49

Flash Fire Events Due to Small Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_FF_S_LFL	LFL	7.13	6.34	5.91
	IS02_NAPH_SSHDSR_V_FF_S_1/2 LFL	1/2 LFL	14.56	11.79	10.54
4	IS04_H2_SSHDSSDUP_V_FF_S_LFL	LFL	15.44	11.13	10.30
	IS04_H2_SSHDSSDUP_V_FF_S_1/2 LFL	1/2 LFL	20.98	16.67	16.97
5	IS05_H2_SSHDSAAKOD_V_FF_S_LFL	LFL	15.44	11.13	10.30
	IS05_H2_SSHDSAAKOD_V_FF_S_1/2 LFL	1/2 LFL	20.98	16.67	16.97
8	IS08_H2_SSHDSAAUP_V_FF_S_LFL	LFL	15.24	10.94	10.13
	IS08_H2_SSHDSAAUP_V_FF_S_1/2 LFL	1/2 LFL	20.72	16.45	16.72
9	IS09_H2_SSHDSRGCKOD_V_FF_S_LFL	LFL	15.15	10.85	10.05
	IS09_H2_SSHDSRGCKOD_V_FF_S_1/2 LFL	1/2 LFL	20.59	16.33	16.56
10	IS10_NAPH_SSHDSS_V_FF_S_LFL	LFL	4.46	3.98	3.74
	IS10_NAPH_SSHDSS_V_FF_S_1/2 LFL	1/2 LFL	8.25	6.66	6.01
11	IS11_H2_SSHDSSRD_V_FF_S_LFL	LFL	9.59	6.64	5.77
	IS11_H2_SSHDSSRD_V_FF_S_1/2 LFL	1/2 LFL	13.38	9.68	8.73
16	IS16_MEOH_TFUP_V_FF_S_LFL	LFL	10.87	9.01	8.61
	IS16_MEOH_TFUP_V_FF_S_1/2 LFL	1/2 LFL	31.29	21.83	18.26
18	IS18_NAPH_TFRDUP_V_FF_S_LFL	LFL	17.74	12.11	9.59
	IS18_NAPH_TFRDUP_V_FF_S_1/2 LFL	1/2 LFL	49.24	28.49	23.56
21	IS21_MEOH_RWCUP_V_FF_S_LFL	LFL	19.08	17.97	15.74
	IS21_MEOH_RWCUP_V_FF_S_1/2 LFL	1/2 LFL	47.37	43.73	37.68
24	IS24_MEOH_MC_V_FF_S_LFL	LFL	1.00	0.97	0.96
	IS24_MEOH_MC_V_FF_S_1/2 LFL	1/2 LFL	2.03	1.91	1.85
28	IS28_MEOH_MDD_V_FF_S_LFL	LFL	0.63	0.60	0.59
	IS28_MEOH_MDD_V_FF_S_1/2 LFL	1/2 LFL	1.28	1.17	1.10
33	IS33_H2_H2PR_V_FF_S_LFL	LFL	17.29	12.69	12.35

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS33_H2_H2PR_V_FF_S_1/2 LFL	1/2 LFL	22.78	17.96	18.43
34	IS34_H2_HD_V_FF_S_LFL	LFL	22.09	16.80	16.74
	IS34_H2_HD_V_FF_S_1/2 LFL	1/2 LFL	29.55	23.42	24.99
36	IS36_H2_FIR_V_FF_S_LFL	LFL	17.77	12.86	12.77
	IS36_H2_FIR_V_FF_S_1/2 LFL	1/2 LFL	23.56	18.18	19.28
38	IS38_H2_SIRUP_V_FF_S_LFL	LFL	17.61	12.76	12.55
	IS38_H2_SIRUP_V_FF_S_1/2 LFL	1/2 LFL	23.41	18.02	19.16
39	IS39_LPG_S_V_FF_S_LFL	LFL	6.90	6.16	5.76
	IS39_LPG_S_V_FF_S_1/2 LFL	1/2 LFL	13.86	10.92	9.67
41	IS41_LPG_SRDUP_V_FF_S_LFL	LFL	29.39	26.24	24.77
	IS41_LPG_SRDUP_V_FF_S_1/2 LFL	1/2 LFL	69.55	64.81	64.79
43	IS43_H2_CS_V_FF_S_LFL	LFL	11.74	8.13	7.08
	IS43_H2_CS_V_FF_S_1/2 LFL	1/2 LFL	16.21	12.32	11.81
53	IS53_ETHY_EST_L_FF_S_LFL	LFL	27.83	17.71	10.91
	IS53_ETHY_EST_L_FF_S_1/2 LFL	1/2 LFL	40.44	24.82	17.57
54	IS54_ETHY_BOGC_V_FF_S_LFL	LFL	93.38	93.47	82.87
	IS54_ETHY_BOGC_V_FF_S_1/2 LFL	1/2 LFL	247.40	158.05	130.42
55	IS55_ETHY_HPEBOGLR_V_FF_S_LFL	LFL	93.38	93.47	82.87
	IS55_ETHY_HPEBOGLR_V_FF_S_1/2 LFL	1/2 LFL	247.40	158.05	130.42
57	IS57_PROPY_PSV_L_FF_S_LFL	LFL	7.51	6.62	6.19
	IS57_PROPY_PSV_L_FF_S_1/2 LFL	1/2 LFL	15.53	12.19	10.66
58	IS58_BUTD_BSV_L_FF_S_LFL	LFL	77.33	44.17	34.53
	IS58_BUTD_BSV_L_FF_S_1/2 LFL	1/2 LFL	132.06	67.41	53.81

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
62	IS62_ETHY_PIPEU5220BLU_V_FF_S_LFL	LFL	12.82	11.08	10.17
	IS62_ETHY_PIPEU5220BLU_V_FF_S_1/2 LFL	1/2 LFL	30.49	26.75	25.16
63	IS63_PROPY_PIPEU5210U5220_V_FF_S_LFL	LFL	12.82	11.08	10.17
	IS63_PROPY_PIPEU5210U5220_V_FF_S_1/2 LFL	1/2 LFL	30.49	26.75	25.16
64	IS64_PROPY_PIPEU5220J_V_FF_S_LFL	LFL	31.09	28.53	27.69
	IS64_PROPY_PIPEU5220J_V_FF_S_1/2 LFL	1/2 LFL	73.34	70.55	72.63
65	IS65_PROPY_PIPEMURP_V_FF_S_LFL	LFL	31.95	29.09	28.14
	IS65_PROPY_PIPEMURP_V_FF_S_1/2 LFL	1/2 LFL	75.23	72.06	74.14

Flash Fire Events Due to Medium Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_FF_M_LFL	LFL	28.63	26.65	26.10
	IS02_NAPH_SSHDSR_V_FF_M_1/2 LFL	1/2 LFL	60.41	56.37	56.70
4	IS04_H2_SSHDSSDUP_V_FF_M_LFL	LFL	36.84	30.86	31.67
	IS04_H2_SSHDSSDUP_V_FF_M_1/2 LFL	1/2 LFL	44.84	39.49	41.34
5	IS05_H2_SSHDSAAKOD_V_FF_M_LFL	LFL	38.15	31.75	32.92
	IS05_H2_SSHDSAAKOD_V_FF_M_1/2 LFL	1/2 LFL	47.07	41.01	43.59
8	IS08_H2_SSHDSAAUP_V_FF_M_LFL	LFL	38.38	30.80	30.21
	IS08_H2_SSHDSAAUP_V_FF_M_1/2 LFL	1/2 LFL	49.96	41.96	41.91
9	IS09_H2_SSHDSRGCKOD_V_FF_M_LFL	LFL	37.61	31.22	32.31
	IS09_H2_SSHDSRGCKOD_V_FF_M_1/2 LFL	1/2 LFL	46.50	40.42	42.90
10	IS10_NAPH_SSHDSS_V_FF_M_LFL	LFL	15.86	13.80	12.68
	IS10_NAPH_SSHDSS_V_FF_M_1/2 LFL	1/2 LFL	37.53	33.53	32.54
11	IS11_H2_SSHDSSRD_V_FF_M_LFL	LFL	19.68	15.47	15.36
	IS11_H2_SSHDSSRD_V_FF_M_1/2 LFL	1/2 LFL	23.88	19.47	19.89
16	IS16_MEOH_TFUP_V_FF_M_LFL	LFL	30.56	27.89	29.08
	IS16_MEOH_TFUP_V_FF_M_1/2 LFL	1/2 LFL	99.59	78.27	64.20
18	IS18_NAPH_TFRDUP_V_FF_M_LFL	LFL	64.89	57.87	50.44
	IS18_NAPH_TFRDUP_V_FF_M_1/2 LFL	1/2 LFL	152.21	88.97	74.92
21	IS21_MEOH_RWCUP_V_FF_M_LFL	LFL	49.77	51.00	56.23
	IS21_MEOH_RWCUP_V_FF_M_1/2 LFL	1/2 LFL	109.80	123.95	111.99
24	IS24_MEOH_MC_V_FF_M_LFL	LFL	3.30	3.17	3.09
	IS24_MEOH_MC_V_FF_M_1/2 LFL	1/2 LFL	6.66	6.10	5.78
28	IS28_MEOH_MDD_V_FF_M_LFL	LFL	2.06	1.92	1.84
	IS28_MEOH_MDD_V_FF_M_1/2 LFL	1/2 LFL	4.14	3.57	3.31
33	IS33_H2_H2PR_V_FF_M_LFL	LFL	38.54	34.38	34.40

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS33_H2_H2PR_V_FF_M_1/2 LFL	1/2 LFL	47.25	43.69	46.05
34	IS34_H2_HD_V_FF_M_LFL	LFL	50.21	44.41	45.04
	IS34_H2_HD_V_FF_M_1/2 LFL	1/2 LFL	61.25	56.55	59.88
36	IS36_H2_FIR_V_FF_M_LFL	LFL	40.97	35.54	34.27
	IS36_H2_FIR_V_FF_M_1/2 LFL	1/2 LFL	53.00	48.02	48.34
38	IS38_H2_SIRUP_V_FF_M_LFL	LFL	41.03	35.25	33.79
	IS38_H2_SIRUP_V_FF_M_1/2 LFL	1/2 LFL	53.18	47.68	47.77
39	IS39_LPG_S_V_FF_M_LFL	LFL	27.36	25.20	24.38
	IS39_LPG_S_V_FF_M_1/2 LFL	1/2 LFL	65.34	62.98	64.90
41	IS41_LPG_SRDUP_V_FF_M_LFL	LFL	89.50	99.44	104.45
	IS41_LPG_SRDUP_V_FF_M_1/2 LFL	1/2 LFL	120.50	139.83	139.61
43	IS43_H2_CS_V_FF_M_LFL	LFL	31.32	25.04	23.85
	IS43_H2_CS_V_FF_M_1/2 LFL	1/2 LFL	39.85	33.84	33.72
53	IS53_ETHY_EST_L_FF_M_LFL	LFL	104.28	47.54	43.46
	IS53_ETHY_EST_L_FF_M_1/2 LFL	1/2 LFL	162.80	72.12	66.04
54	IS54_ETHY_BOGC_V_FF_M_LFL	LFL	296.30	350.35	312.39
	IS54_ETHY_BOGC_V_FF_M_1/2 LFL	1/2 LFL	634.27	533.64	445.60
55	IS55_ETHY_HPEBOGLR_V_FF_M_LFL	LFL	296.30	350.35	312.39
	IS55_ETHY_HPEBOGLR_V_FF_M_1/2 LFL	1/2 LFL	634.27	533.64	445.60
57	IS57_PROPY_PSV_L_FF_M_LFL	LFL	30.48	28.29	27.70
	IS57_PROPY_PSV_L_FF_M_1/2 LFL	1/2 LFL	72.72	70.71	73.17
58	IS58_BUTD_BSV_L_FF_M_LFL	LFL	335.29	162.16	132.19
	IS58_BUTD_BSV_L_FF_M_1/2 LFL	1/2 LFL	522.72	224.18	181.33

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
62	IS62_ETHY_PIPEU5220BLU_V_FF_M_LFL	LFL	58.39	55.88	56.83
	IS62_ETHY_PIPEU5220BLU_V_FF_M_1/2 LFL	1/2 LFL	138.13	139.84	150.74
63	IS63_PROPY_PIPEU5210U5220_V_FF_M_LFL	LFL	58.39	55.88	56.83
	IS63_PROPY_PIPEU5210U5220_V_FF_M_1/2 LFL	1/2 LFL	138.13	139.84	150.74
64	IS64_PROPY_PIPEU5220J_V_FF_M_LFL	LFL	133.64	133.59	138.43
	IS64_PROPY_PIPEU5220J_V_FF_M_1/2 LFL	1/2 LFL	262.43	302.64	320.15
65	IS65_PROPY_PIPEMURP_V_FF_M_LFL	LFL	135.25	137.06	143.08
	IS65_PROPY_PIPEMURP_V_FF_M_1/2 LFL	1/2 LFL	262.48	311.01	315.83

Flash Fire Events Due to Large Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_FF_L_LFL	LFL	65.66	62.06	62.81
	IS02_NAPH_SSHDSR_V_FF_L_1/2 LFL	1/2 LFL	113.58	108.81	111.46
4	IS04_H2_SSHDSSDUP_V_FF_L_LFL	LFL	44.06	40.24	40.25
	IS04_H2_SSHDSSDUP_V_FF_L_1/2 LFL	1/2 LFL	51.47	48.23	50.28
5	IS05_H2_SSHDSAAKOD_V_FF_L_LFL	LFL	46.55	42.64	42.96
	IS05_H2_SSHDSAAKOD_V_FF_L_1/2 LFL	1/2 LFL	54.99	52.16	53.73
8	IS08_H2_SSHDSAAUP_V_FF_L_LFL	LFL	60.73	55.09	54.93
	IS08_H2_SSHDSAAUP_V_FF_L_1/2 LFL	1/2 LFL	75.67	71.01	75.11
9	IS09_H2_SSHDSRGCKOD_V_FF_L_LFL	LFL	46.02	42.12	42.43
	IS09_H2_SSHDSRGCKOD_V_FF_L_1/2 LFL	1/2 LFL	54.34	51.51	53.11
10	IS10_NAPH_SSHDSS_V_FF_L_LFL	LFL	38.37	35.69	35.50
	IS10_NAPH_SSHDSS_V_FF_L_1/2 LFL	1/2 LFL	89.63	86.97	92.02
11	IS11_H2_SSHDSSRD_V_FF_L_LFL	LFL	23.13	18.28	17.10
	IS11_H2_SSHDSSRD_V_FF_L_1/2 LFL	1/2 LFL	27.14	22.43	21.59
16	IS16_MEOH_TFUP_V_FF_L_LFL	LFL	51.09	45.16	48.01
	IS16_MEOH_TFUP_V_FF_L_1/2 LFL	1/2 LFL	152.40	135.73	109.09
18	IS18_NAPH_TFRDUP_V_FF_L_LFL	LFL	118.57	102.57	88.14
	IS18_NAPH_TFRDUP_V_FF_L_1/2 LFL	1/2 LFL	281.45	150.54	124.59
21	IS21_MEOH_RWCUP_V_FF_L_LFL	LFL	62.37	65.86	71.53
	IS21_MEOH_RWCUP_V_FF_L_1/2 LFL	1/2 LFL	130.89	151.15	164.81
24	IS24_MEOH_MC_V_FF_L_LFL	LFL	6.58	6.25	6.05
	IS24_MEOH_MC_V_FF_L_1/2 LFL	1/2 LFL	13.89	12.54	11.90
28	IS28_MEOH_MDD_V_FF_L_LFL	LFL	4.09	3.73	3.53
	IS28_MEOH_MDD_V_FF_L_1/2 LFL	1/2 LFL	8.13	6.74	6.16
33	IS33_H2_H2PR_V_FF_L_LFL	LFL	44.26	42.99	43.60

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS33_H2_H2PR_V_FF_L_1/2 LFL	1/2 LFL	52.49	52.32	55.05
34	IS34_H2_HD_V_FF_L_LFL	LFL	59.54	57.02	58.67
	IS34_H2_HD_V_FF_L_1/2 LFL	1/2 LFL	70.75	68.89	73.43
36	IS36_H2_FIR_V_FF_L_LFL	LFL	63.16	60.27	61.96
	IS36_H2_FIR_V_FF_L_1/2 LFL	1/2 LFL	78.57	76.55	83.76
38	IS38_H2_SIRUP_V_FF_L_LFL	LFL	63.51	60.23	61.69
	IS38_H2_SIRUP_V_FF_L_1/2 LFL	1/2 LFL	78.98	76.55	83.39
39	IS39_LPG_S_V_FF_L_LFL	LFL	65.38	62.49	63.96
	IS39_LPG_S_V_FF_L_1/2 LFL	1/2 LFL	151.25	152.97	164.37
41	IS41_LPG_SRDUP_V_FF_L_LFL	LFL	109.39	125.04	129.00
	IS41_LPG_SRDUP_V_FF_L_1/2 LFL	1/2 LFL	137.74	161.27	160.29
43	IS43_H2_CS_V_FF_L_LFL	LFL	41.04	36.28	36.46
	IS43_H2_CS_V_FF_L_1/2 LFL	1/2 LFL	48.74	45.01	46.58
53	IS53_ETHY_EST_L_FF_L_LFL	LFL	238.66	85.21	69.36
	IS53_ETHY_EST_L_FF_L_1/2 LFL	1/2 LFL	377.43	133.45	109.59
54	IS54_ETHY_BOGC_V_FF_L_LFL	LFL	618.58	770.96	618.40
	IS54_ETHY_BOGC_V_FF_L_1/2 LFL	1/2 LFL	921.97	1042.52	884.72
55	IS55_ETHY_HPEBOGLR_V_FF_L_LFL	LFL	618.58	770.96	618.40
	IS55_ETHY_HPEBOGLR_V_FF_L_1/2 LFL	1/2 LFL	921.97	1042.52	884.72
57	IS57_PROPY_PSV_L_FF_L_LFL	LFL	72.61	69.53	71.45
	IS57_PROPY_PSV_L_FF_L_1/2 LFL	1/2 LFL	163.90	170.39	183.05
58	IS58_BUTD_BSV_L_FF_L_LFL	LFL	745.71	311.15	245.09
	IS58_BUTD_BSV_L_FF_L_1/2 LFL	1/2 LFL	1161.60	428.00	339.70

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
62	IS62_ETHY_PIPEU5220BLU_V_FF_L_LFL	LFL	136.57	133.10	139.00
	IS62_ETHY_PIPEU5220BLU_V_FF_L_1/2 LFL	1/2 LFL	293.69	320.43	351.13
63	IS63_PROPY_PIPEU5210U5220_V_FF_L_LFL	LFL	136.57	133.10	139.00
	IS63_PROPY_PIPEU5210U5220_V_FF_L_1/2 LFL	1/2 LFL	293.69	320.43	351.13
64	IS64_PROPY_PIPEU5220J_V_FF_L_LFL	LFL	275.31	289.42	308.67
	IS64_PROPY_PIPEU5220J_V_FF_L_1/2 LFL	1/2 LFL	500.87	607.73	653.09
65	IS65_PROPY_PIPEMURP_V_FF_L_LFL	LFL	275.71	293.10	316.03
	IS65_PROPY_PIPEMURP_V_FF_L_1/2 LFL	1/2 LFL	497.96	623.83	641.99

Flash Fire Events Due to Catastrophic Releases

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_FF_C_LFL	LFL	163.84	156.87	159.94
	IS02_NAPH_SSHDSR_V_FF_C_1/2 LFL	1/2 LFL	241.74	219.70	227.93
4	IS04_H2_SSHDSSDUP_V_FF_C_LFL	LFL	46.07	45.41	45.03
	IS04_H2_SSHDSSDUP_V_FF_C_1/2 LFL	1/2 LFL	53.45	53.73	55.74
5	IS05_H2_SSHDSAAKOD_V_FF_C_LFL	LFL	49.96	48.92	49.36
	IS05_H2_SSHDSAAKOD_V_FF_C_1/2 LFL	1/2 LFL	57.85	58.44	60.40
8	IS08_H2_SSHDSAAUP_V_FF_C_LFL	LFL	75.73	75.24	78.41
	IS08_H2_SSHDSAAUP_V_FF_C_1/2 LFL	1/2 LFL	90.80	90.69	98.85
9	IS09_H2_SSHDSRGCKOD_V_FF_C_LFL	LFL	49.12	48.22	48.87
	IS09_H2_SSHDSRGCKOD_V_FF_C_1/2 LFL	1/2 LFL	57.34	57.21	59.70
10	IS10_NAPH_SSHDSS_V_FF_C_LFL	LFL	118.46	115.08	120.06
	IS10_NAPH_SSHDSS_V_FF_C_1/2 LFL	1/2 LFL	247.36	245.81	272.34
11	IS11_H2_SSHDSSRD_V_FF_C_LFL	LFL	25.20	20.24	18.53
	IS11_H2_SSHDSSRD_V_FF_C_1/2 LFL	1/2 LFL	29.02	24.28	23.13
16	IS16_MEOH_TFUP_V_FF_C_LFL	LFL	111.22	106.20	117.47
	IS16_MEOH_TFUP_V_FF_C_1/2 LFL	1/2 LFL	301.07	291.23	252.72
18	IS18_NAPH_TFRDUP_V_FF_C_LFL	LFL	46.14	54.22	53.78
	IS18_NAPH_TFRDUP_V_FF_C_1/2 LFL	1/2 LFL	52.22	64.24	64.76
21	IS21_MEOH_RWCUP_V_FF_C_LFL	LFL	83.72	87.10	90.56
	IS21_MEOH_RWCUP_V_FF_C_1/2 LFL	1/2 LFL	188.78	184.75	201.88
24	IS24_MEOH_MC_V_FF_C_LFL	LFL	17.73	16.94	16.61
	IS24_MEOH_MC_V_FF_C_1/2 LFL	1/2 LFL	43.51	40.89	41.06
28	IS28_MEOH_MDD_V_FF_C_LFL	LFL	10.32	9.05	8.46
	IS28_MEOH_MDD_V_FF_C_1/2 LFL	1/2 LFL	24.30	21.39	20.21
33	IS33_H2_H2PR_V_FF_C_LFL	LFL	44.39	46.04	47.22

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS33_H2_H2PR_V_FF_C_1/2 LFL	1/2 LFL	51.73	54.86	58.66
34	IS34_H2_HD_V_FF_C_LFL	LFL	62.98	63.46	65.13
	IS34_H2_HD_V_FF_C_1/2 LFL	1/2 LFL	72.85	75.41	80.40
36	IS36_H2_FIR_V_FF_C_LFL	LFL	74.82	76.39	80.09
	IS36_H2_FIR_V_FF_C_1/2 LFL	1/2 LFL	90.30	92.20	101.46
38	IS38_H2_SIRUP_V_FF_C_LFL	LFL	597.48	695.88	775.27
	IS38_H2_SIRUP_V_FF_C_1/2 LFL	1/2 LFL	1039.70	1517.41	1464.41
39	IS39_LPG_S_V_FF_C_LFL	LFL	197.22	190.26	199.23
	IS39_LPG_S_V_FF_C_1/2 LFL	1/2 LFL	338.48	393.44	401.48
41	IS41_LPG_SRDUP_V_FF_C_LFL	LFL	126.51	144.88	149.07
	IS41_LPG_SRDUP_V_FF_C_1/2 LFL	1/2 LFL	152.47	177.69	176.84
43	IS43_H2_CS_V_FF_C_LFL	LFL	286.70	365.34	381.30
	IS43_H2_CS_V_FF_C_1/2 LFL	1/2 LFL	521.28	674.87	565.03
53	IS53_ETHY_EST_L_FF_C_LFL	LFL	717.93	198.18	143.95
	IS53_ETHY_EST_L_FF_C_1/2 LFL	1/2 LFL	1112.81	320.50	240.29
54	IS54_ETHY_BOGC_V_FF_C_LFL	LFL	784.89	974.00	982.69
	IS54_ETHY_BOGC_V_FF_C_1/2 LFL	1/2 LFL	1081.26	1217.58	1213.51
55	IS55_ETHY_HPEBOGLR_V_FF_C_LFL	LFL	784.89	974.00	982.69
	IS55_ETHY_HPEBOGLR_V_FF_C_1/2 LFL	1/2 LFL	1081.26	1217.58	1213.51
57	IS57_PROPY_PSV_L_FF_C_LFL	LFL	211.70	211.12	221.65
	IS57_PROPY_PSV_L_FF_C_1/2 LFL	1/2 LFL	415.82	465.60	516.51
58	IS58_BUTD_BSV_L_FF_C_LFL	LFL	2154.78	757.15	516.31
	IS58_BUTD_BSV_L_FF_C_1/2 LFL	1/2 LFL	3420.88	1098.57	746.35

Ref.	Scenarios	Fatality Probability	Weather Condition 1.5F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
62	IS62_ETHY_PIPEU5220BLU_V_FF_C_LFL	LFL	316.67	342.12	372.18
	IS62_ETHY_PIPEU5220BLU_V_FF_C_1/2 LFL	1/2 LFL	451.07	523.99	547.07
63	IS63_PROPY_PIPEU5210U5220_V_FF_C_LFL	LFL	316.67	342.12	372.18
	IS63_PROPY_PIPEU5210U5220_V_FF_C_1/2 LFL	1/2 LFL	451.07	523.99	547.07
64	IS64_PROPY_PIPEU5220J_V_FF_C_LFL	LFL	667.52	730.87	789.85
	IS64_PROPY_PIPEU5220J_V_FF_C_1/2 LFL	1/2 LFL	945.32	1143.04	1210.79
65	IS65_PROPY_PIPEMURP_V_FF_C_LFL	LFL	642.45	713.57	772.32
	IS65_PROPY_PIPEMURP_V_FF_C_1/2 LFL	1/2 LFL	1192.65	1456.56	1515.88

Explosion Events Due to Minor Releases

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
4	IS04_H2_SSHDSSDUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
5	IS05_H2_SSHDSAAKOD_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
8	IS08_H2_SSHDSAAUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
9	IS09_H2_SSHDSRGCKOD_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
10	IS10_NAPH_SSHDSS_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
11	IS11_H2_SSHDSSRD_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
16	IS16_MEOH_TFUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
18	IS18_NAPH_TFRDUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_EXP_0_0.5	0.50	11.21	Not reachable	Not reachable
	IS18_NAPH_TFRDUP_V_EXP_0_0.01	0.01	13.25	Not reachable	Not reachable
21	IS21_MEOH_RWCUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_0_0.5	0.50	10.92	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_0_0.01	0.01	12.47	Not reachable	Not reachable
24	IS24_MEOH_MC_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
28	IS28_MEOH_MDD_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
33	IS33_H2_H2PR_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_0_0.5	0.50	11.12	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_0_0.01	0.01	13.01	Not reachable	Not reachable
34	IS34_H2_HD_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_0_0.5	0.50	11.29	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_0_0.01	0.01	13.45	Not reachable	Not reachable
36	IS36_H2_FIR_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_0_0.5	0.50	11.10	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_0_0.01	0.01	12.96	Not reachable	Not reachable
38	IS38_H2_SIRUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_0_0.5	0.50	11.07	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_0_0.01	0.01	12.88	Not reachable	Not reachable
39	IS39_LPG_S_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS41_LPG_SRDUP_V_EXP_0_0.5	0.50	11.27	11.11	Not reachable
	IS41_LPG_SRDUP_V_EXP_0_0.01	0.01	13.40	12.99	Not reachable
43	IS43_H2_CS_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
53	IS53_ETHY_EST_L_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
54	IS54_ETHY_BOGC_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS54_ETHY_BOGC_V_EXP_0_0.5	0.50	63.19	42.35	32.11
	IS54_ETHY_BOGC_V_EXP_0_0.01	0.01	68.55	46.29	35.66
55	IS55_ETHY_HPEBOGLR_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS55_ETHY_HPEBOGLR_V_EXP_0_0.5	0.50	63.19	42.35	32.11
	IS55_ETHY_HPEBOGLR_V_EXP_0_0.01	0.01	68.55	46.29	35.66
57	IS57_PROPY_PSV_L_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
58	IS58_BUTD_BSV_L_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_EXP_0_0.5	0.50	32.16	11.37	Not reachable
	IS58_BUTD_BSV_L_EXP_0_0.01	0.01	35.79	13.67	Not reachable
62	IS62_ETHY_PIPEU5220BLU_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
63	IS63_PROPY_PIPEU5210U5220_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS63_PROPY_PIPEU5210U5220_V_EXP_0_0.5	0.50	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_EXP_0_0.01	0.01	Not reachable	Not reachable	Not reachable
64	IS64_PROPY_PIPEU5220J_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS64_PROPY_PIPEU5220J_V_EXP_0_0.5	0.50	11.33	11.19	11.14
	IS64_PROPY_PIPEU5220J_V_EXP_0_0.01	0.01	13.58	13.19	13.05
65	IS65_PROPY_PIPEMURP_V_EXP_0_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS65_PROPY_PIPEMURP_V_EXP_0_0.5	0.50	11.35	11.20	11.14
	IS65_PROPY_PIPEMURP_V_EXP_0_0.01	0.01	13.63	13.21	13.06

Explosion Events Due to Small Releases

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_S_0.5	0.50	11.26	11.15	11.11
	IS02_NAPH_SSHDSR_V_EXP_S_0.01	0.01	13.39	13.09	12.99
4	IS04_H2_SSHDSSDUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_S_0.5	0.50	22.36	11.79	11.67
	IS04_H2_SSHDSSDUP_V_EXP_S_0.01	0.01	26.33	14.80	14.47
5	IS05_H2_SSHDSAAKOD_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_S_0.5	0.50	22.36	11.79	11.67
	IS05_H2_SSHDSAAKOD_V_EXP_S_0.01	0.01	26.33	14.80	14.47
8	IS08_H2_SSHDSAAUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_S_0.5	0.50	22.33	11.76	11.64
	IS08_H2_SSHDSAAUP_V_EXP_S_0.01	0.01	26.24	14.73	14.40
9	IS09_H2_SSHDSRGCKOD_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_S_0.5	0.50	22.32	11.76	11.64
	IS09_H2_SSHDSRGCKOD_V_EXP_S_0.01	0.01	26.22	14.71	14.39
10	IS10_NAPH_SSHDSS_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_S_0.01	0.01	Not reachable	Not reachable	Not reachable
11	IS11_H2_SSHDSSRD_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_S_0.5	0.50	11.38	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_S_0.01	0.01	13.70	Not reachable	Not reachable
16	IS16_MEOH_TFUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_S_0.5	0.50	31.90	21.67	11.59
	IS16_MEOH_TFUP_V_EXP_S_0.01	0.01	35.11	24.47	14.27
18	IS18_NAPH_TFRDUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_EXP_S_0.5	0.50	32.58	22.29	22.27
	IS18_NAPH_TFRDUP_V_EXP_S_0.01	0.01	36.92	26.15	26.08
21	IS21_MEOH_RWCUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_S_0.5	0.50	43.22	42.69	32.43
	IS21_MEOH_RWCUP_V_EXP_S_0.01	0.01	48.64	47.21	36.51
24	IS24_MEOH_MC_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_S_0.01	0.01	Not reachable	Not reachable	Not reachable
28	IS28_MEOH_MDD_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_S_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_S_0.01	0.01	Not reachable	Not reachable	Not reachable
33	IS33_H2_H2PR_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_S_0.5	0.50	23.01	12.26	12.17
	IS33_H2_H2PR_V_EXP_S_0.01	0.01	28.08	16.07	15.82
34	IS34_H2_HD_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_S_0.5	0.50	23.45	22.84	22.70
	IS34_H2_HD_V_EXP_S_0.01	0.01	29.25	27.63	27.26
36	IS36_H2_FIR_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_S_0.5	0.50	22.98	12.22	12.13
	IS36_H2_FIR_V_EXP_S_0.01	0.01	28.01	15.95	15.71
38	IS38_H2_SIRUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_S_0.5	0.50	22.91	12.17	12.08
	IS38_H2_SIRUP_V_EXP_S_0.01	0.01	27.82	15.82	15.57
39	IS39_LPG_S_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_S_0.5	0.50	11.13	11.03	0.00
	IS39_LPG_S_V_EXP_S_0.01	0.01	13.02	12.76	0.00

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS41_LPG_SRDUP_V_EXP_S_0.5	0.50	62.76	63.86	63.68
	IS41_LPG_SRDUP_V_EXP_S_0.01	0.01	67.40	70.35	69.86
43	IS43_H2_CS_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_S_0.5	0.50	11.68	11.32	11.20
	IS43_H2_CS_V_EXP_S_0.01	0.01	14.50	13.54	13.21
53	IS53_ETHY_EST_L_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_S_0.5	0.50	46.35	22.76	11.98
	IS53_ETHY_EST_L_EXP_S_0.01	0.01	57.03	27.39	15.31
54	IS54_ETHY_BOGC_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS54_ETHY_BOGC_V_EXP_S_0.5	0.50	252.03	159.43	138.96
	IS54_ETHY_BOGC_V_EXP_S_0.01	0.01	272.28	175.30	154.03
55	IS55_ETHY_HPEBOGLR_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS55_ETHY_HPEBOGLR_V_EXP_S_0.5	0.50	252.03	159.43	138.96
	IS55_ETHY_HPEBOGLR_V_EXP_S_0.01	0.01	272.28	175.30	154.03
57	IS57_PROPY_PSV_L_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_S_0.5	0.50	11.21	11.09	11.06
	IS57_PROPY_PSV_L_EXP_S_0.01	0.01	13.24	12.93	12.84
58	IS58_BUTD_BSV_L_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_EXP_S_0.5	0.50	141.88	66.00	55.18
	IS58_BUTD_BSV_L_EXP_S_0.01	0.01	161.87	76.09	63.88
62	IS62_ETHY_PIPEU5220BLU_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_S_0.5	0.50	31.91	21.72	21.65
	IS62_ETHY_PIPEU5220BLU_V_EXP_S_0.01	0.01	35.12	24.61	24.43
63	IS63_PROPY_PIPEU5210U5220_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS63_PROPY_PIPEU5210U5220_V_EXP_S_0.5	0.50	31.91	21.72	21.65

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_EXP_S_0.01	0.01	35.12	24.61	24.43
64	IS64_PROPY_PIPEU5220J_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS64_PROPY_PIPEU5220J_V_EXP_S_0.5	0.50	74.62	74.10	74.00
	IS64_PROPY_PIPEU5220J_V_EXP_S_0.01	0.01	82.39	81.01	80.73
65	IS65_PROPY_PIPEMURP_V_EXP_S_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS65_PROPY_PIPEMURP_V_EXP_S_0.5	0.50	74.73	74.16	74.04
	IS65_PROPY_PIPEMURP_V_EXP_S_0.01	0.01	82.68	81.16	80.84

Explosion Events Due to Medium Releases

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_M_0.5	0.50	64.83	54.38	54.31
	IS02_NAPH_SSHDSR_V_EXP_M_0.01	0.01	72.94	61.74	61.56
4	IS04_H2_SSHDSSDUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_M_0.5	0.50	41.07	32.82	33.02
	IS04_H2_SSHDSSDUP_V_EXP_M_0.01	0.01	42.88	37.56	38.09
5	IS05_H2_SSHDSAAKOD_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_M_0.5	0.50	42.27	33.39	34.16
	IS05_H2_SSHDSAAKOD_V_EXP_M_0.01	0.01	46.08	39.10	41.16
8	IS08_H2_SSHDSAAUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_M_0.5	0.50	46.78	45.66	45.41
	IS08_H2_SSHDSAAUP_V_EXP_M_0.01	0.01	58.17	55.17	54.52
9	IS09_H2_SSHDSRGCKOD_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_M_0.5	0.50	41.98	33.24	34.04
	IS09_H2_SSHDSRGCKOD_V_EXP_M_0.01	0.01	45.32	38.68	40.84
10	IS10_NAPH_SSHDSS_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_M_0.5	0.50	32.66	32.36	32.25
	IS10_NAPH_SSHDSS_V_EXP_M_0.01	0.01	37.13	36.33	36.05
11	IS11_H2_SSHDSSRD_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_M_0.5	0.50	20.90	11.71	11.69
	IS11_H2_SSHDSSRD_V_EXP_M_0.01	0.01	22.42	14.60	14.52
16	IS16_MEOH_TFUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_M_0.5	0.50	95.82	74.35	64.45
	IS16_MEOH_TFUP_V_EXP_M_0.01	0.01	105.61	81.68	71.93
18	IS18_NAPH_TFRDUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_EXP_M_0.5	0.50	71.18	70.63	61.48
	IS18_NAPH_TFRDUP_V_EXP_M_0.01	0.01	73.17	71.70	63.98
21	IS21_MEOH_RWCUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_M_0.5	0.50	107.37	127.59	118.16
	IS21_MEOH_RWCUP_V_EXP_M_0.01	0.01	119.78	140.35	131.89
24	IS24_MEOH_MC_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_M_0.01	0.01	Not reachable	Not reachable	Not reachable
28	IS28_MEOH_MDD_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_M_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_M_0.01	0.01	Not reachable	Not reachable	Not reachable
33	IS33_H2_H2PR_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_M_0.5	0.50	43.40	34.76	34.55
	IS33_H2_H2PR_V_EXP_M_0.01	0.01	49.11	42.77	42.21
34	IS34_H2_HD_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_M_0.5	0.50	54.39	50.95	51.63
	IS34_H2_HD_V_EXP_M_0.01	0.01	61.78	53.93	54.37
36	IS36_H2_FIR_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_M_0.5	0.50	58.50	47.20	46.79
	IS36_H2_FIR_V_EXP_M_0.01	0.01	72.81	59.30	58.22
38	IS38_H2_SIRUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_M_0.5	0.50	58.31	47.02	46.62
	IS38_H2_SIRUP_V_EXP_M_0.01	0.01	72.29	58.84	57.76
39	IS39_LPG_S_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_M_0.5	0.50	64.26	63.82	63.73
	IS39_LPG_S_V_EXP_M_0.01	0.01	71.43	70.26	70.00

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS41_LPG_SRDUP_V_EXP_M_0.5	0.50	101.51	110.61	112.59
	IS41_LPG_SRDUP_V_EXP_M_0.01	0.01	104.05	111.64	116.95
43	IS43_H2_CS_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_M_0.5	0.50	32.83	24.11	33.07
	IS43_H2_CS_V_EXP_M_0.01	0.01	37.58	31.02	38.24
53	IS53_ETHY_EST_L_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_M_0.5	0.50	182.42	79.04	67.29
	IS53_ETHY_EST_L_EXP_M_0.01	0.01	220.13	94.26	79.54
54	IS54_ETHY_BOGC_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS54_ETHY_BOGC_V_EXP_M_0.5	0.50	670.95	565.25	473.29
	IS54_ETHY_BOGC_V_EXP_M_0.01	0.01	739.84	624.55	529.30
55	IS55_ETHY_HPEBOGLR_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS55_ETHY_HPEBOGLR_V_EXP_M_0.5	0.50	670.95	565.25	473.29
	IS55_ETHY_HPEBOGLR_V_EXP_M_0.01	0.01	739.84	624.55	529.30
57	IS57_PROPY_PSV_L_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_M_0.5	0.50	74.62	74.16	74.09
	IS57_PROPY_PSV_L_EXP_M_0.01	0.01	82.39	81.16	80.96
58	IS58_BUTD_BSV_L_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_EXP_M_0.5	0.50	577.72	243.23	200.24
	IS58_BUTD_BSV_L_EXP_M_0.01	0.01	674.82	282.30	234.29
62	IS62_ETHY_PIPEU5220BLU_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_M_0.5	0.50	137.76	137.02	157.01
	IS62_ETHY_PIPEU5220BLU_V_EXP_M_0.01	0.01	150.82	148.84	168.81
63	IS63_PROPY_PIPEU5210U5220_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS63_PROPY_PIPEU5210U5220_V_EXP_M_0.5	0.50	137.76	137.02	157.01

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_EXP_M_0.01	0.01	150.82	148.84	168.81
64	IS64_PROPY_PIPEU5220J_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS64_PROPY_PIPEU5220J_V_EXP_M_0.5	0.50	277.39	315.60	335.76
	IS64_PROPY_PIPEU5220J_V_EXP_M_0.01	0.01	306.65	341.86	362.27
65	IS65_PROPY_PIPEMURP_V_EXP_M_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS65_PROPY_PIPEMURP_V_EXP_M_0.5	0.50	277.64	325.82	325.97
	IS65_PROPY_PIPEMURP_V_EXP_M_0.01	0.01	307.32	352.44	352.85

Explosion Events Due to Large Releases

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_L_0.5	0.50	120.73	109.53	119.57
	IS02_NAPH_SSHDSR_V_EXP_L_0.01	0.01	138.77	125.57	135.66
4	IS04_H2_SSHDSSDUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_L_0.5	0.50	43.53	42.60	42.58
	IS04_H2_SSHDSSDUP_V_EXP_L_0.01	0.01	49.46	46.98	46.92
5	IS05_H2_SSHDSAAKOD_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_L_0.5	0.50	51.51	43.52	43.54
	IS05_H2_SSHDSAAKOD_V_EXP_L_0.01	0.01	54.06	49.44	49.49
8	IS08_H2_SSHDSAAUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_L_0.5	0.50	66.49	63.75	66.67
	IS08_H2_SSHDSAAUP_V_EXP_L_0.01	0.01	77.40	70.06	77.88
9	IS09_H2_SSHDSRGCKOD_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_L_0.5	0.50	51.23	43.38	43.40
	IS09_H2_SSHDSRGCKOD_V_EXP_L_0.01	0.01	53.29	49.06	49.12
10	IS10_NAPH_SSHDSS_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_L_0.5	0.50	86.11	85.45	95.39
	IS10_NAPH_SSHDSS_V_EXP_L_0.01	0.01	96.40	94.62	104.45
11	IS11_H2_SSHDSSRD_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_L_0.5	0.50	21.43	11.84	11.82
	IS11_H2_SSHDSSRD_V_EXP_L_0.01	0.01	23.84	14.93	14.89
16	IS16_MEOH_TFUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_L_0.5	0.50	160.15	137.13	106.43
	IS16_MEOH_TFUP_V_EXP_L_0.01	0.01	177.22	149.12	117.23
18	IS18_NAPH_TFRDUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_EXP_L_0.5	0.50	121.91	102.24	92.20
	IS18_NAPH_TFRDUP_V_EXP_L_0.01	0.01	125.12	106.01	95.90
21	IS21_MEOH_RWCUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_L_0.5	0.50	138.93	159.72	169.93
	IS21_MEOH_RWCUP_V_EXP_L_0.01	0.01	153.96	176.07	186.64
24	IS24_MEOH_MC_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_L_0.5	0.50	11.18	11.11	11.10
	IS24_MEOH_MC_V_EXP_L_0.01	0.01	13.15	12.99	12.95
28	IS28_MEOH_MDD_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_L_0.5	0.50	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_L_0.01	0.01	Not reachable	Not reachable	Not reachable
33	IS33_H2_H2PR_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_L_0.5	0.50	45.05	44.53	44.55
	IS33_H2_H2PR_V_EXP_L_0.01	0.01	53.55	52.14	52.20
34	IS34_H2_HD_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_L_0.5	0.50	64.42	63.04	63.49
	IS34_H2_HD_V_EXP_L_0.01	0.01	71.86	68.16	69.35
36	IS36_H2_FIR_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_L_0.5	0.50	74.39	67.62	73.02
	IS36_H2_FIR_V_EXP_L_0.01	0.01	84.02	80.45	81.13
38	IS38_H2_SIRUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_L_0.5	0.50	74.55	67.43	72.56
	IS38_H2_SIRUP_V_EXP_L_0.01	0.01	83.70	79.94	80.21
39	IS39_LPG_S_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_L_0.5	0.50	159.39	158.46	168.51
	IS39_LPG_S_V_EXP_L_0.01	0.01	175.18	172.70	182.83

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS41_LPG_SRDUP_V_EXP_L_0.5	0.50	122.25	132.86	141.83
	IS41_LPG_SRDUP_V_EXP_L_0.01	0.01	126.03	137.67	144.92
43	IS43_H2_CS_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_L_0.5	0.50	42.97	40.83	40.93
	IS43_H2_CS_V_EXP_L_0.01	0.01	47.97	42.22	42.50
53	IS53_ETHY_EST_L_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_L_0.5	0.50	416.55	147.26	113.48
	IS53_ETHY_EST_L_EXP_L_0.01	0.01	494.87	176.29	136.16
54	IS54_ETHY_BOGC_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS54_ETHY_BOGC_V_EXP_L_0.5	0.50	841.17	990.75	946.99
	IS54_ETHY_BOGC_V_EXP_L_0.01	0.01	880.23	1025.43	1059.70
55	IS55_ETHY_HPEBOGLR_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS55_ETHY_HPEBOGLR_V_EXP_L_0.5	0.50	841.17	990.75	946.99
	IS55_ETHY_HPEBOGLR_V_EXP_L_0.01	0.01	880.23	1025.43	1059.70
57	IS57_PROPY_PSV_L_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_L_0.5	0.50	170.12	179.06	189.14
	IS57_PROPY_PSV_L_EXP_L_0.01	0.01	187.14	194.31	204.53
58	IS58_BUTD_BSV_L_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_EXP_L_0.5	0.50	1277.13	468.30	370.26
	IS58_BUTD_BSV_L_EXP_L_0.01	0.01	1474.18	549.55	437.99
62	IS62_ETHY_PIPEU5220BLU_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_L_0.5	0.50	254.76	292.64	321.38
	IS62_ETHY_PIPEU5220BLU_V_EXP_L_0.01	0.01	262.77	297.08	323.70
63	IS63_PROPY_PIPEU5210U5220_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS63_PROPY_PIPEU5210U5220_V_EXP_L_0.5	0.50	254.76	292.64	321.38

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_EXP_L_0.01	0.01	262.77	297.08	323.70
64	IS64_PROPY_PIPEU5220J_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS64_PROPY_PIPEU5220J_V_EXP_L_0.5	0.50	535.54	632.27	682.98
	IS64_PROPY_PIPEU5220J_V_EXP_L_0.01	0.01	595.34	686.55	738.47
65	IS65_PROPY_PIPEMURP_V_EXP_L_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS65_PROPY_PIPEMURP_V_EXP_L_0.5	0.50	525.98	652.68	673.49
	IS65_PROPY_PIPEMURP_V_EXP_L_0.01	0.01	586.51	707.67	729.83

Explosion Events Due to Catastrophic Releases

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
2	IS02_NAPH_SSHDSR_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS02_NAPH_SSHDSR_V_EXP_C_0.5	0.50	267.49	234.71	244.87
	IS02_NAPH_SSHDSR_V_EXP_C_0.01	0.01	313.73	276.27	286.72
4	IS04_H2_SSHDSSDUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS04_H2_SSHDSSDUP_V_EXP_C_0.5	0.50	51.14	50.53	43.61
	IS04_H2_SSHDSSDUP_V_EXP_C_0.01	0.01	53.05	51.43	49.69
5	IS05_H2_SSHDSAAKOD_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS05_H2_SSHDSAAKOD_V_EXP_C_0.5	0.50	53.24	52.64	52.66
	IS05_H2_SSHDSAAKOD_V_EXP_C_0.01	0.01	58.69	57.07	57.14
8	IS08_H2_SSHDSAAUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS08_H2_SSHDSAAUP_V_EXP_C_0.5	0.50	85.13	84.04	85.17
	IS08_H2_SSHDSAAUP_V_EXP_C_0.01	0.01	93.75	90.82	93.85
9	IS09_H2_SSHDSRGCKOD_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS09_H2_SSHDSRGCKOD_V_EXP_C_0.5	0.50	53.06	52.41	52.44
	IS09_H2_SSHDSRGCKOD_V_EXP_C_0.01	0.01	58.20	56.47	56.55
10	IS10_NAPH_SSHDSS_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS10_NAPH_SSHDSS_V_EXP_C_0.5	0.50	256.98	255.13	285.25
	IS10_NAPH_SSHDSS_V_EXP_C_0.01	0.01	285.55	280.59	310.91
11	IS11_H2_SSHDSSRD_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS11_H2_SSHDSSRD_V_EXP_C_0.5	0.50	21.58	21.04	20.33
	IS11_H2_SSHDSSRD_V_EXP_C_0.01	0.01	24.23	22.80	20.88
16	IS16_MEOH_TFUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS16_MEOH_TFUP_V_EXP_C_0.5	0.50	267.05	304.63	263.61
	IS16_MEOH_TFUP_V_EXP_C_0.01	0.01	295.72	329.25	286.50
18	IS18_NAPH_TFRDUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS18_NAPH_TFRDUP_V_EXP_C_0.5	0.50	52.34	60.67	60.44
	IS18_NAPH_TFRDUP_V_EXP_C_0.01	0.01	56.28	61.79	61.18
21	IS21_MEOH_RWCUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS21_MEOH_RWCUP_V_EXP_C_0.5	0.50	180.01	190.82	210.93
	IS21_MEOH_RWCUP_V_EXP_C_0.01	0.01	196.85	209.02	229.31
24	IS24_MEOH_MC_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS24_MEOH_MC_V_EXP_C_0.5	0.50	43.10	42.91	42.89
	IS24_MEOH_MC_V_EXP_C_0.01	0.01	48.31	47.80	47.75
28	IS28_MEOH_MDD_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS28_MEOH_MDD_V_EXP_C_0.5	0.50	21.91	21.75	21.70
	IS28_MEOH_MDD_V_EXP_C_0.01	0.01	25.14	24.68	24.56
33	IS33_H2_H2PR_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS33_H2_H2PR_V_EXP_C_0.5	0.50	50.78	51.75	52.49
	IS33_H2_H2PR_V_EXP_C_0.01	0.01	54.02	54.70	56.69
34	IS34_H2_HD_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS34_H2_HD_V_EXP_C_0.5	0.50	71.00	70.30	72.23
	IS34_H2_HD_V_EXP_C_0.01	0.01	74.38	73.79	75.99
36	IS36_H2_FIR_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS36_H2_FIR_V_EXP_C_0.5	0.50	86.06	86.30	92.93
	IS36_H2_FIR_V_EXP_C_0.01	0.01	96.26	96.90	99.75
38	IS38_H2_SIRUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS38_H2_SIRUP_V_EXP_C_0.5	0.50	1035.89	743.29	856.15
	IS38_H2_SIRUP_V_EXP_C_0.01	0.01	1045.79	767.07	874.45
39	IS39_LPG_S_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS39_LPG_S_V_EXP_C_0.5	0.50	224.95	265.25	292.31
	IS39_LPG_S_V_EXP_C_0.01	0.01	250.10	274.09	296.49

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
41	IS41_LPG_SRDUP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS41_LPG_SRDUP_V_EXP_C_0.5	0.50	141.35	152.98	161.13
	IS41_LPG_SRDUP_V_EXP_C_0.01	0.01	143.61	157.99	163.03
43	IS43_H2_CS_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS43_H2_CS_V_EXP_C_0.5	0.50	525.41	414.15	417.64
	IS43_H2_CS_V_EXP_C_0.01	0.01	534.52	421.14	430.48
53	IS53_ETHY_EST_L_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_EXP_C_0.5	0.50	1227.56	361.03	272.32
	IS53_ETHY_EST_L_EXP_C_0.01	0.01	1425.34	430.07	326.69
54	IS54_ETHY_BOGC_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS54_ETHY_BOGC_V_EXP_C_0.5	0.50	1012.14	1201.76	1188.64
	IS54_ETHY_BOGC_V_EXP_C_0.01	0.01	1059.92	1242.97	1236.15
55	IS55_ETHY_HPEBOGLR_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS55_ETHY_HPEBOGLR_V_EXP_C_0.5	0.50	1012.14	1201.76	1188.64
	IS55_ETHY_HPEBOGLR_V_EXP_C_0.01	0.01	1059.92	1242.97	1236.15
57	IS57_PROPY_PSV_L_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS57_PROPY_PSV_L_EXP_C_0.5	0.50	437.00	484.13	534.73
	IS57_PROPY_PSV_L_EXP_C_0.01	0.01	482.43	524.71	576.33
58	IS58_BUTD_BSV_L_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_EXP_C_0.5	0.50	3248.63	1213.36	835.40
	IS58_BUTD_BSV_L_EXP_C_0.01	0.01	3272.81	1420.88	995.89
62	IS62_ETHY_PIPEU5220BLU_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS62_ETHY_PIPEU5220BLU_V_EXP_C_0.5	0.50	354.97	382.68	421.17
	IS62_ETHY_PIPEU5220BLU_V_EXP_C_0.01	0.01	363.33	387.19	423.15
63	IS63_PROPY_PIPEU5210U5220_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS63_PROPY_PIPEU5210U5220_V_EXP_C_0.5	0.50	354.97	382.68	421.17

Ref.	Scenarios	Harm Probability %	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance (m)		
	IS63_PROPY_PIPEU5210U5220_V_EXP_C_0.01	0.01	363.33	387.19	423.15
64	IS64_PROPY_PIPEU5220J_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS64_PROPY_PIPEU5220J_V_EXP_C_0.5	0.50	813.46	887.00	951.33
	IS64_PROPY_PIPEU5220J_V_EXP_C_0.01	0.01	847.03	902.31	964.63
65	IS65_PROPY_PIPEMURP_V_EXP_C_0.99	0.99	Not reachable	Not reachable	Not reachable
	IS65_PROPY_PIPEMURP_V_EXP_C_0.5	0.50	1105.49	1245.97	1536.61
	IS65_PROPY_PIPEMURP_V_EXP_C_0.01	0.01	1249.32	1373.78	1631.86

Fireball Events Due to Catastrophic Releases (BLEVE)

Ref.	Scenarios	Fatality Probability	Radius for lethality	Fireball Radius
53	IS53_ETHY_EST_L_FB_1	1.00	Not reachable	Not reachable
	IS53_ETHY_EST_L_FB_0.5	0.50	Not reachable	Not reachable
	IS53_ETHY_EST_L_FB_0.03	0.03	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_FB_1	1.00	124.88	119.97
	IS57_PROPY_PSV_L_FB_0.5	0.50	367.33	119.97
	IS57_PROPY_PSV_L_FB_0.03	0.03	685.75	119.97
58	IS58_BUTD_BSV_L_FB_1	1.00	Not reachable	Not reachable
	IS58_BUTD_BSV_L_FB_0.5	0.50	Not reachable	Not reachable
	IS58_BUTD_BSV_L_FB_0.03	0.03	Not reachable	Not reachable

Explosion Events Due to Catastrophic Releases (BLEVE)

Ref.	Scenarios	Harm Probability %	Weather Condition 1F (m)	Weather Condition 3C (m)	Weather Condition 5D (m)
			Downwind Distance		
53	IS53_ETHY_EST_L_BLV_C_0.99	99%	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_BLV_C_0.5	50%	Not reachable	Not reachable	Not reachable
	IS53_ETHY_EST_L_BLV_C_0.01	1%	Not reachable	Not reachable	Not reachable
57	IS57_PROPY_PSV_L_BLV_C_0.99	99%	79.95	79.95	79.95
	IS57_PROPY_PSV_L_BLV_C_0.5	50%	79.99	79.99	79.99
	IS57_PROPY_PSV_L_BLV_C_0.01	1%	171.21	171.21	171.21
58	IS58_BUTD_BSV_L_BLV_C_0.99	99%	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_BLV_C_0.5	50%	Not reachable	Not reachable	Not reachable
	IS58_BUTD_BSV_L_BLV_C_0.01	1%	Not reachable	Not reachable	Not reachable

SUB-APPENDIX 3C: EVENT FREQUENCY FOR EURO 5 MOGAS UNITS AND OLEFINS STORAGE TANKAGES

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
1	IS01_NAPH_SSHDSFSD_L	Minor	Jet Fire	4.54E-06	Pool Fire	4.09E-05	-	0.00E+00	-	0.00E+00	Unignited	4.50E-03
		Small	Jet Fire	2.00E-05	Pool Fire	2.00E-05	-	0.00E+00	-	0.00E+00	Unignited	1.29E-03
		Medium	Jet Fire	7.59E-06	Pool Fire	7.59E-06	-	0.00E+00	-	0.00E+00	Unignited	4.91E-04
		Large	Jet Fire	6.19E-06	Pool Fire	4.13E-06	-	0.00E+00	-	0.00E+00	Unignited	1.19E-04
		Catastrophic	Pool Fire	3.56E-06	Pool Fire	2.37E-06	-	0.00E+00	-	0.00E+00	Unignited	6.83E-05
2	IS02_NAPH_SSHDSR_V	Minor	Jet Fire	8.73E-06	Explosion	3.14E-06	Flash Fire	7.54E-05	-	0.00E+00	Unignited	8.64E-03
		Small	Jet Fire	2.55E-06	Explosion	9.18E-07	Flash Fire	2.20E-05	-	0.00E+00	Unignited	2.52E-03
		Medium	Jet Fire	2.04E-05	Explosion	2.45E-06	Flash Fire	1.80E-05	-	0.00E+00	Unignited	5.42E-04
		Large	Jet Fire	4.62E-06	Explosion	5.54E-07	Flash Fire	4.06E-06	-	0.00E+00	Unignited	1.23E-04
		Catastrophic	Jet Fire	2.38E-05	Explosion	4.77E-06	Flash Fire	1.11E-05	-	0.00E+00	Unignited	9.27E-05
3	IS03_NAPH_SSHDSSDBP_L	Minor	Jet Fire	3.72E-06	Pool Fire	3.35E-05	-	0.00E+00	-	0.00E+00	Unignited	3.69E-03
		Small	Jet Fire	1.53E-05	Pool Fire	1.53E-05	-	0.00E+00	-	0.00E+00	Unignited	9.92E-04
		Medium	Jet Fire	1.50E-05	Pool Fire	1.00E-05	-	0.00E+00	-	0.00E+00	Unignited	2.88E-04
		Large	Jet Fire	4.25E-06	Pool Fire	2.84E-06	-	0.00E+00	-	0.00E+00	Unignited	8.15E-05
		Catastrophic	Pool Fire	2.55E-06	Pool Fire	1.70E-06	-	0.00E+00	-	0.00E+00	Unignited	4.89E-05
4	IS04_H2_SSHDSSDUP_V	Minor	Jet Fire	4.37E-07	Explosion	1.57E-07	Flash Fire	3.77E-06	-	0.00E+00	Unignited	4.32E-04
		Small	Jet Fire	2.53E-07	Explosion	9.12E-08	Flash Fire	2.19E-06	-	0.00E+00	Unignited	2.51E-04
		Medium	Jet Fire	5.36E-06	Explosion	6.43E-07	Flash Fire	4.72E-06	-	0.00E+00	Unignited	1.42E-04
		Large	Jet Fire	8.63E-07	Explosion	1.04E-07	Flash Fire	7.59E-07	-	0.00E+00	Unignited	2.29E-05
		Catastrophic	Jet Fire	4.43E-07	Explosion	5.32E-08	Flash Fire	3.90E-07	-	0.00E+00	Unignited	1.18E-05
5	IS05_H2_SSHDSAAKOD_V	Minor	Jet Fire	1.26E-06	Explosion	4.52E-07	Flash Fire	1.08E-05	-	0.00E+00	Unignited	1.24E-03
		Small	Jet Fire	5.64E-07	Explosion	2.03E-07	Flash Fire	4.87E-06	-	0.00E+00	Unignited	5.58E-04
		Medium	Jet Fire	1.21E-05	Explosion	1.45E-06	Flash Fire	1.07E-05	-	0.00E+00	Unignited	3.22E-04
		Large	Jet Fire	2.27E-06	Explosion	2.73E-07	Flash Fire	2.00E-06	-	0.00E+00	Unignited	6.04E-05
		Catastrophic	Jet Fire	1.18E-06	Explosion	1.42E-07	Flash Fire	1.04E-06	-	0.00E+00	Unignited	3.14E-05
6	IS06_MDEA_SSHDSLASD_L	Minor	Jet Fire	2.52E-06	Pool Fire	2.27E-05	-	0.00E+00	-	0.00E+00	Unignited	2.50E-03
		Small	Jet Fire	1.13E-05	Pool Fire	1.13E-05	-	0.00E+00	-	0.00E+00	Unignited	7.29E-04
		Medium	Jet Fire	7.17E-06	Pool Fire	7.17E-06	-	0.00E+00	-	0.00E+00	Unignited	4.63E-04
		Large	Jet Fire	5.61E-06	Pool Fire	3.74E-06	-	0.00E+00	-	0.00E+00	Unignited	1.08E-04
		Catastrophic	Pool Fire	2.96E-06	Pool Fire	1.97E-06	-	0.00E+00	-	0.00E+00	Unignited	5.67E-05
7	IS07_MDEA_SSHDSAABP_L	Minor	Jet Fire	1.07E-06	Pool Fire	9.63E-06	-	0.00E+00	-	0.00E+00	Unignited	1.06E-03

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Small	Jet Fire	5.21E-06	Pool Fire	5.21E-06	-	0.00E+00	-	0.00E+00	Unignited	3.37E-04
		Medium	Jet Fire	1.05E-05	Pool Fire	7.01E-06	-	0.00E+00	-	0.00E+00	Unignited	2.01E-04
		Large	Jet Fire	2.43E-06	Pool Fire	1.62E-06	-	0.00E+00	-	0.00E+00	Unignited	4.66E-05
		Catastrophic	Pool Fire	1.28E-06	Pool Fire	8.51E-07	-	0.00E+00	-	0.00E+00	Unignited	2.45E-05
8	IS08_H2_SSHDSAAUP_V	Minor	Jet Fire	1.70E-06	Explosion	6.13E-07	Flash Fire	1.47E-05	-	0.00E+00	Unignited	1.69E-03
		Small	Jet Fire	4.42E-07	Explosion	1.59E-07	Flash Fire	3.82E-06	-	0.00E+00	Unignited	4.37E-04
		Medium	Jet Fire	9.97E-06	Explosion	1.20E-06	Flash Fire	8.77E-06	-	0.00E+00	Unignited	2.65E-04
		Large	Jet Fire	2.68E-06	Explosion	3.22E-07	Flash Fire	2.36E-06	-	0.00E+00	Unignited	7.12E-05
		Catastrophic	Jet Fire	1.42E-06	Explosion	1.70E-07	Flash Fire	1.25E-06	-	0.00E+00	Unignited	3.77E-05
9	IS09_H2_SSHDSRGCKOD_V	Minor	Jet Fire	3.92E-05	Explosion	1.41E-05	Flash Fire	3.38E-04	-	0.00E+00	Unignited	3.88E-02
		Small	Jet Fire	1.15E-05	Explosion	4.13E-06	Flash Fire	9.90E-05	-	0.00E+00	Unignited	1.13E-02
		Medium	Jet Fire	3.05E-05	Explosion	3.66E-06	Flash Fire	2.68E-05	-	0.00E+00	Unignited	8.10E-04
		Large	Jet Fire	1.05E-05	Explosion	1.26E-06	Flash Fire	9.21E-06	-	0.00E+00	Unignited	2.78E-04
		Catastrophic	Jet Fire	9.48E-06	Explosion	1.14E-06	Flash Fire	8.34E-06	-	0.00E+00	Unignited	2.52E-04
10	IS10_NAPH_SSHDSS_V	Minor	Jet Fire	8.26E-06	Explosion	2.97E-06	Flash Fire	7.13E-05	-	0.00E+00	Unignited	8.17E-03
		Small	Jet Fire	2.47E-06	Explosion	8.89E-07	Flash Fire	2.13E-05	-	0.00E+00	Unignited	2.44E-03
		Medium	Jet Fire	1.86E-05	Explosion	2.23E-06	Flash Fire	1.64E-05	-	0.00E+00	Unignited	4.95E-04
		Large	Jet Fire	4.26E-06	Explosion	5.11E-07	Flash Fire	3.74E-06	-	0.00E+00	Unignited	1.13E-04
		Catastrophic	Jet Fire	2.02E-05	Explosion	4.04E-06	Flash Fire	9.42E-06	-	0.00E+00	Unignited	7.85E-05
11	IS11_H2_SSHDSSRD_V	Minor	Jet Fire	7.15E-06	Explosion	2.57E-06	Flash Fire	6.18E-05	-	0.00E+00	Unignited	7.08E-03
		Small	Jet Fire	2.29E-06	Explosion	8.26E-07	Flash Fire	1.98E-05	-	0.00E+00	Unignited	2.27E-03
		Medium	Jet Fire	4.15E-07	Explosion	1.49E-07	Flash Fire	3.59E-06	-	0.00E+00	Unignited	4.11E-04
		Large	Jet Fire	2.99E-06	Explosion	3.58E-07	Flash Fire	2.63E-06	-	0.00E+00	Unignited	7.93E-05
		Catastrophic	Jet Fire	2.73E-06	Explosion	3.27E-07	Flash Fire	2.40E-06	-	0.00E+00	Unignited	7.25E-05
12	IS12_NAPH_LCNFSD_L	Minor	Jet Fire	4.54E-06	Pool Fire	4.09E-05	-	0.00E+00	-	0.00E+00	Unignited	4.50E-03
		Small	Jet Fire	2.00E-05	Pool Fire	2.00E-05	-	0.00E+00	-	0.00E+00	Unignited	1.29E-03
		Medium	Jet Fire	7.59E-06	Pool Fire	7.59E-06	-	0.00E+00	-	0.00E+00	Unignited	4.91E-04
		Large	Jet Fire	6.19E-06	Pool Fire	4.13E-06	-	0.00E+00	-	0.00E+00	Unignited	1.19E-04
		Catastrophic	Pool Fire	3.56E-06	Pool Fire	2.37E-06	-	0.00E+00	-	0.00E+00	Unignited	6.83E-05
13	IS13_MEOH_FR_L	Minor	Jet Fire	5.12E-06	Pool Fire	4.61E-05	-	0.00E+00	-	0.00E+00	Unignited	5.07E-03
		Small	Jet Fire	1.70E-05	Pool Fire	1.70E-05	-	0.00E+00	-	0.00E+00	Unignited	1.10E-03

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Medium	Jet Fire	3.59E-05	Pool Fire	2.39E-05	-	0.00E+00	-	0.00E+00	Unignited	6.88E-04
		Large	Jet Fire	1.07E-05	Pool Fire	7.13E-06	-	0.00E+00	-	0.00E+00	Unignited	2.05E-04
		Catastrophic	Pool Fire	5.69E-06	Pool Fire	3.79E-06	-	0.00E+00	-	0.00E+00	Unignited	1.09E-04
14	IS14_MEOH_SR_L	Minor	Jet Fire	4.26E-06	Pool Fire	3.83E-05	-	0.00E+00	-	0.00E+00	Unignited	4.21E-03
		Small	Jet Fire	1.51E-05	Pool Fire	1.51E-05	-	0.00E+00	-	0.00E+00	Unignited	9.77E-04
		Medium	Jet Fire	3.16E-05	Pool Fire	2.11E-05	-	0.00E+00	-	0.00E+00	Unignited	6.05E-04
		Large	Jet Fire	9.00E-06	Pool Fire	6.00E-06	-	0.00E+00	-	0.00E+00	Unignited	1.73E-04
		Catastrophic	Pool Fire	4.78E-06	Pool Fire	3.19E-06	-	0.00E+00	-	0.00E+00	Unignited	9.16E-05
15	IS15_TAME_TFBP_L	Minor	Jet Fire	7.44E-06	Pool Fire	6.69E-05	-	0.00E+00	-	0.00E+00	Unignited	7.36E-03
		Small	Jet Fire	3.24E-05	Pool Fire	3.24E-05	-	0.00E+00	-	0.00E+00	Unignited	2.09E-03
		Medium	Jet Fire	5.09E-06	Pool Fire	5.09E-06	-	0.00E+00	-	0.00E+00	Unignited	3.29E-04
		Large	Jet Fire	3.90E-06	Pool Fire	2.60E-06	-	0.00E+00	-	0.00E+00	Unignited	7.48E-05
		Catastrophic	Pool Fire	4.37E-06	Pool Fire	2.91E-06	-	0.00E+00	-	0.00E+00	Unignited	8.38E-05
16	IS16_MEOH_TFUP_V	Minor	Jet Fire	2.34E-06	Explosion	8.41E-07	Flash Fire	2.02E-05	-	0.00E+00	Unignited	2.31E-03
		Small	Jet Fire	1.88E-05	Explosion	2.25E-06	Flash Fire	1.65E-05	-	0.00E+00	Unignited	4.98E-04
		Medium	Jet Fire	1.23E-05	Explosion	1.47E-06	Flash Fire	1.08E-05	-	0.00E+00	Unignited	3.26E-04
		Large	Jet Fire	1.85E-05	Explosion	3.69E-06	Flash Fire	8.62E-06	-	0.00E+00	Unignited	7.18E-05
		Catastrophic	Jet Fire	9.80E-06	Explosion	1.96E-06	Flash Fire	4.57E-06	-	0.00E+00	Unignited	3.81E-05
17	IS17_MEOH_TFRDBP_L	Minor	Jet Fire	2.46E-06	Pool Fire	2.21E-05	-	0.00E+00	-	0.00E+00	Unignited	2.43E-03
		Small	Jet Fire	1.25E-05	Pool Fire	1.25E-05	-	0.00E+00	-	0.00E+00	Unignited	8.09E-04
		Medium	Jet Fire	2.72E-06	Pool Fire	2.72E-06	-	0.00E+00	-	0.00E+00	Unignited	1.76E-04
		Large	Jet Fire	1.76E-06	Pool Fire	1.17E-06	-	0.00E+00	-	0.00E+00	Unignited	3.37E-05
		Catastrophic	Pool Fire	1.21E-06	Pool Fire	8.09E-07	-	0.00E+00	-	0.00E+00	Unignited	2.32E-05
18	IS18_NAPH_TFRDUP_V	Minor	Jet Fire	3.56E-06	Explosion	1.28E-06	Flash Fire	3.08E-05	-	0.00E+00	Unignited	3.52E-03
		Small	Jet Fire	3.53E-05	Explosion	4.24E-06	Flash Fire	3.11E-05	-	0.00E+00	Unignited	9.39E-04
		Medium	Jet Fire	1.04E-05	Explosion	1.25E-06	Flash Fire	9.18E-06	-	0.00E+00	Unignited	2.77E-04
		Large	Jet Fire	1.31E-05	Explosion	2.63E-06	Flash Fire	6.13E-06	-	0.00E+00	Unignited	5.11E-05
		Catastrophic	Jet Fire	1.07E-05	Explosion	2.14E-06	Flash Fire	5.00E-06	-	0.00E+00	Unignited	4.17E-05
19	IS19_MEOH_TR_L	Minor	Jet Fire	8.60E-06	Pool Fire	7.74E-05	-	0.00E+00	-	0.00E+00	Unignited	8.52E-03
		Small	Jet Fire	3.36E-05	Pool Fire	3.36E-05	-	0.00E+00	-	0.00E+00	Unignited	2.17E-03
		Medium	Jet Fire	3.60E-05	Pool Fire	2.40E-05	-	0.00E+00	-	0.00E+00	Unignited	6.90E-04

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Large	Jet Fire	9.90E-06	Pool Fire	6.60E-06	-	0.00E+00	-	0.00E+00	Unignited	1.90E-04
		Catastrophic	Pool Fire	7.27E-06	Pool Fire	4.85E-06	-	0.00E+00	-	0.00E+00	Unignited	1.39E-04
20	IS20_NAPH_RWCBP_L	Minor	Jet Fire	3.56E-06	Pool Fire	3.20E-05	-	0.00E+00	-	0.00E+00	Unignited	3.52E-03
		Small	Jet Fire	1.51E-05	Pool Fire	1.51E-05	-	0.00E+00	-	0.00E+00	Unignited	9.79E-04
		Medium	Jet Fire	4.47E-06	Pool Fire	4.47E-06	-	0.00E+00	-	0.00E+00	Unignited	2.89E-04
		Large	Jet Fire	3.50E-06	Pool Fire	2.33E-06	-	0.00E+00	-	0.00E+00	Unignited	6.71E-05
		Catastrophic	Pool Fire	2.86E-06	Pool Fire	1.90E-06	-	0.00E+00	-	0.00E+00	Unignited	5.47E-05
21	IS21_MEOH_RWCUP_V	Minor	Jet Fire	3.56E-06	Explosion	1.28E-06	Flash Fire	3.08E-05	-	0.00E+00	Unignited	3.52E-03
		Small	Jet Fire	3.53E-05	Explosion	4.24E-06	Flash Fire	3.11E-05	-	0.00E+00	Unignited	9.39E-04
		Medium	Jet Fire	1.04E-05	Explosion	1.25E-06	Flash Fire	9.18E-06	-	0.00E+00	Unignited	2.77E-04
		Large	Jet Fire	1.31E-05	Explosion	2.63E-06	Flash Fire	6.13E-06	-	0.00E+00	Unignited	5.11E-05
		Catastrophic	Jet Fire	1.07E-05	Explosion	2.14E-06	Flash Fire	5.00E-06	-	0.00E+00	Unignited	4.17E-05
22	IS22_MEOH_MCFD_L	Minor	Jet Fire	1.89E-06	Pool Fire	1.70E-05	-	0.00E+00	-	0.00E+00	Unignited	1.87E-03
		Small	Jet Fire	9.87E-06	Pool Fire	9.87E-06	-	0.00E+00	-	0.00E+00	Unignited	6.38E-04
		Medium	Jet Fire	6.18E-06	Pool Fire	6.18E-06	-	0.00E+00	-	0.00E+00	Unignited	4.00E-04
		Large	Jet Fire	4.37E-06	Pool Fire	2.91E-06	-	0.00E+00	-	0.00E+00	Unignited	8.37E-05
		Catastrophic	Pool Fire	2.29E-06	Pool Fire	1.53E-06	-	0.00E+00	-	0.00E+00	Unignited	4.39E-05
23	IS23_MEOH_RC_L	Minor	Jet Fire	1.89E-06	Pool Fire	1.70E-05	-	0.00E+00	-	0.00E+00	Unignited	1.87E-03
		Small	Jet Fire	9.87E-06	Pool Fire	9.87E-06	-	0.00E+00	-	0.00E+00	Unignited	6.38E-04
		Medium	Jet Fire	1.98E-05	Pool Fire	1.32E-05	-	0.00E+00	-	0.00E+00	Unignited	3.79E-04
		Large	Jet Fire	4.37E-06	Pool Fire	2.91E-06	-	0.00E+00	-	0.00E+00	Unignited	8.37E-05
		Catastrophic	Pool Fire	2.29E-06	Pool Fire	1.53E-06	-	0.00E+00	-	0.00E+00	Unignited	4.39E-05
24	IS24_MEOH_MC_V	Minor	Jet Fire	1.34E-05	Explosion	4.82E-06	Flash Fire	1.16E-04	-	0.00E+00	Unignited	1.33E-02
		Small	Jet Fire	3.81E-06	Explosion	1.37E-06	Flash Fire	3.29E-05	-	0.00E+00	Unignited	3.77E-03
		Medium	Jet Fire	2.47E-05	Explosion	2.96E-06	Flash Fire	2.17E-05	-	0.00E+00	Unignited	6.56E-04
		Large	Jet Fire	6.37E-06	Explosion	7.64E-07	Flash Fire	5.60E-06	-	0.00E+00	Unignited	1.69E-04
		Catastrophic	Jet Fire	6.01E-06	Explosion	7.21E-07	Flash Fire	5.28E-06	-	0.00E+00	Unignited	1.60E-04
25	IS25_MEOH_MCRD_L	Minor	Jet Fire	5.77E-06	Pool Fire	5.19E-05	-	0.00E+00	-	0.00E+00	Unignited	5.71E-03
		Small	Jet Fire	2.71E-05	Pool Fire	2.71E-05	-	0.00E+00	-	0.00E+00	Unignited	1.75E-03
		Medium	Jet Fire	6.80E-06	Pool Fire	6.80E-06	-	0.00E+00	-	0.00E+00	Unignited	4.39E-04
		Large	Jet Fire	4.77E-06	Pool Fire	3.18E-06	-	0.00E+00	-	0.00E+00	Unignited	9.13E-05

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Catastrophic	Pool Fire	3.80E-06	Pool Fire	2.54E-06	-	0.00E+00	-	0.00E+00	Unignited	7.29E-05
26	IS26_MEOH_MGP_L	Minor	Jet Fire	6.29E-06	Pool Fire	5.66E-05	-	0.00E+00	-	0.00E+00	Unignited	6.23E-03
		Small	Jet Fire	2.74E-05	Pool Fire	2.74E-05	-	0.00E+00	-	0.00E+00	Unignited	1.77E-03
		Medium	Jet Fire	4.77E-05	Pool Fire	3.18E-05	-	0.00E+00	-	0.00E+00	Unignited	9.14E-04
		Large	Jet Fire	1.20E-05	Pool Fire	7.98E-06	-	0.00E+00	-	0.00E+00	Unignited	2.29E-04
		Catastrophic	Pool Fire	6.46E-06	Pool Fire	4.31E-06	-	0.00E+00	-	0.00E+00	Unignited	1.24E-04
27	IS27_MEOH_MMUSD_L	Minor	Jet Fire	2.90E-06	Pool Fire	2.61E-05	-	0.00E+00	-	0.00E+00	Unignited	2.87E-03
		Small	Jet Fire	1.42E-05	Pool Fire	1.42E-05	-	0.00E+00	-	0.00E+00	Unignited	9.20E-04
		Medium	Jet Fire	6.39E-06	Pool Fire	6.39E-06	-	0.00E+00	-	0.00E+00	Unignited	4.13E-04
		Large	Jet Fire	4.65E-06	Pool Fire	3.10E-06	-	0.00E+00	-	0.00E+00	Unignited	8.92E-05
		Catastrophic	Pool Fire	2.59E-06	Pool Fire	1.73E-06	-	0.00E+00	-	0.00E+00	Unignited	4.97E-05
28	IS28_MEOH_MDD_V	Minor	Jet Fire	3.91E-06	Explosion	1.41E-06	Flash Fire	3.38E-05	-	0.00E+00	Unignited	3.87E-03
		Small	Jet Fire	1.24E-06	Explosion	4.46E-07	Flash Fire	1.07E-05	-	0.00E+00	Unignited	1.23E-03
		Medium	Jet Fire	4.40E-07	Explosion	1.58E-07	Flash Fire	3.80E-06	-	0.00E+00	Unignited	4.35E-04
		Large	Jet Fire	1.03E-07	Explosion	3.71E-08	Flash Fire	8.90E-07	-	0.00E+00	Unignited	1.02E-04
		Catastrophic	Jet Fire	2.11E-06	Explosion	2.53E-07	Flash Fire	1.86E-06	-	0.00E+00	Unignited	5.61E-05
29	IS29_HC_HCDD_L	Minor	Pool Fire	3.91E-06	Pool Fire	3.52E-05	-	0.00E+00	-	0.00E+00	Unignited	3.87E-03
		Small	Pool Fire	1.24E-06	Pool Fire	1.11E-05	-	0.00E+00	-	0.00E+00	Unignited	1.23E-03
		Medium	Pool Fire	6.60E-06	Pool Fire	6.60E-06	-	0.00E+00	-	0.00E+00	Unignited	4.27E-04
		Large	Pool Fire	1.54E-06	Pool Fire	1.54E-06	-	0.00E+00	-	0.00E+00	Unignited	9.99E-05
		Catastrophic	Pool Fire	2.89E-06	Pool Fire	1.93E-06	-	0.00E+00	-	0.00E+00	Unignited	5.55E-05
30	IS30_NAPH_SGB_L	Minor	Jet Fire	5.60E-06	Pool Fire	5.04E-05	-	0.00E+00	-	0.00E+00	Unignited	5.55E-03
		Small	Jet Fire	2.69E-05	Pool Fire	2.69E-05	-	0.00E+00	-	0.00E+00	Unignited	1.74E-03
		Medium	Jet Fire	6.57E-06	Pool Fire	6.57E-06	-	0.00E+00	-	0.00E+00	Unignited	4.25E-04
		Large	Jet Fire	4.01E-06	Pool Fire	2.68E-06	-	0.00E+00	-	0.00E+00	Unignited	7.69E-05
		Catastrophic	Pool Fire	4.11E-06	Pool Fire	2.74E-06	-	0.00E+00	-	0.00E+00	Unignited	7.88E-05
31	IS31_NAPH_FSD_L	Minor	Jet Fire	4.99E-06	Pool Fire	4.49E-05	-	0.00E+00	-	0.00E+00	Unignited	4.94E-03
		Small	Jet Fire	2.10E-05	Pool Fire	2.10E-05	-	0.00E+00	-	0.00E+00	Unignited	1.36E-03
		Medium	Jet Fire	8.28E-06	Pool Fire	8.28E-06	-	0.00E+00	-	0.00E+00	Unignited	5.36E-04
		Large	Jet Fire	7.07E-06	Pool Fire	4.71E-06	-	0.00E+00	-	0.00E+00	Unignited	1.35E-04
		Catastrophic	Pool Fire	4.03E-06	Pool Fire	2.69E-06	-	0.00E+00	-	0.00E+00	Unignited	7.73E-05

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
32	IS32_NAPH_FD_L	Minor	Jet Fire	4.81E-06	Pool Fire	4.33E-05	-	0.00E+00	-	0.00E+00	Unignited	4.76E-03
		Small	Jet Fire	2.20E-05	Pool Fire	2.20E-05	-	0.00E+00	-	0.00E+00	Unignited	1.42E-03
		Medium	Jet Fire	4.47E-05	Pool Fire	2.98E-05	-	0.00E+00	-	0.00E+00	Unignited	8.57E-04
		Large	Jet Fire	1.08E-05	Pool Fire	7.18E-06	-	0.00E+00	-	0.00E+00	Unignited	2.06E-04
		Catastrophic	Pool Fire	5.67E-06	Pool Fire	3.78E-06	-	0.00E+00	-	0.00E+00	Unignited	1.09E-04
33	IS33_H2_H2PR_V	Minor	Jet Fire	8.09E-06	Explosion	2.91E-06	Flash Fire	6.99E-05	-	0.00E+00	Unignited	8.01E-03
		Small	Jet Fire	2.46E-06	Explosion	8.84E-07	Flash Fire	2.12E-05	-	0.00E+00	Unignited	2.43E-03
		Medium	Jet Fire	1.81E-05	Explosion	2.17E-06	Flash Fire	1.59E-05	-	0.00E+00	Unignited	4.81E-04
		Large	Jet Fire	3.71E-06	Explosion	4.45E-07	Flash Fire	3.26E-06	-	0.00E+00	Unignited	9.85E-05
		Catastrophic	Jet Fire	2.13E-05	Explosion	4.27E-06	Flash Fire	9.96E-06	-	0.00E+00	Unignited	8.30E-05
34	IS34_H2_HD_V	Minor	Jet Fire	4.81E-06	Explosion	1.73E-06	Flash Fire	4.15E-05	-	0.00E+00	Unignited	4.76E-03
		Small	Jet Fire	1.47E-06	Explosion	5.29E-07	Flash Fire	1.27E-05	-	0.00E+00	Unignited	1.45E-03
		Medium	Jet Fire	3.26E-05	Explosion	3.91E-06	Flash Fire	2.87E-05	-	0.00E+00	Unignited	8.66E-04
		Large	Jet Fire	7.85E-06	Explosion	9.42E-07	Flash Fire	6.91E-06	-	0.00E+00	Unignited	2.09E-04
		Catastrophic	Jet Fire	2.13E-05	Explosion	4.25E-06	Flash Fire	9.92E-06	-	0.00E+00	Unignited	8.27E-05
35	IS35_ISOM_CGB_L	Minor	Jet Fire	3.75E-06	Pool Fire	3.37E-05	-	0.00E+00	-	0.00E+00	Unignited	3.71E-03
		Small	Jet Fire	1.84E-05	Pool Fire	1.84E-05	-	0.00E+00	-	0.00E+00	Unignited	1.19E-03
		Medium	Jet Fire	2.04E-05	Pool Fire	1.36E-05	-	0.00E+00	-	0.00E+00	Unignited	3.91E-04
		Large	Jet Fire	4.19E-06	Pool Fire	2.79E-06	-	0.00E+00	-	0.00E+00	Unignited	8.03E-05
		Catastrophic	Pool Fire	3.20E-06	Pool Fire	2.13E-06	-	0.00E+00	-	0.00E+00	Unignited	6.13E-05
36	IS36_H2_FIR_V	Minor	Jet Fire	6.24E-06	Explosion	2.24E-06	Flash Fire	5.39E-05	-	0.00E+00	Unignited	6.17E-03
		Small	Jet Fire	1.89E-06	Explosion	6.80E-07	Flash Fire	1.63E-05	-	0.00E+00	Unignited	1.87E-03
		Medium	Jet Fire	1.76E-05	Explosion	2.12E-06	Flash Fire	1.55E-05	-	0.00E+00	Unignited	4.69E-04
		Large	Jet Fire	3.84E-06	Explosion	4.60E-07	Flash Fire	3.38E-06	-	0.00E+00	Unignited	1.02E-04
		Catastrophic	Jet Fire	1.79E-05	Explosion	3.58E-06	Flash Fire	8.36E-06	-	0.00E+00	Unignited	6.97E-05
37	IS37_NAPH_SIRBP_L	Minor	Jet Fire	4.37E-07	Pool Fire	3.93E-06	-	0.00E+00	-	0.00E+00	Unignited	4.32E-04
		Small	Jet Fire	3.80E-06	Pool Fire	3.80E-06	-	0.00E+00	-	0.00E+00	Unignited	2.46E-04
		Medium	Jet Fire	7.35E-06	Pool Fire	4.90E-06	-	0.00E+00	-	0.00E+00	Unignited	1.41E-04
		Large	Jet Fire	1.18E-06	Pool Fire	7.89E-07	-	0.00E+00	-	0.00E+00	Unignited	2.27E-05
		Catastrophic	Pool Fire	6.08E-07	Pool Fire	4.05E-07	-	0.00E+00	-	0.00E+00	Unignited	1.17E-05
38	IS38_H2_SIRUP_V	Minor	Jet Fire	1.07E-06	Explosion	3.85E-07	Flash Fire	9.25E-06	-	0.00E+00	Unignited	1.06E-03

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Small	Jet Fire	3.48E-07	Explosion	1.25E-07	Flash Fire	3.00E-06	-	0.00E+00	Unignited	3.44E-04
		Medium	Jet Fire	7.67E-06	Explosion	9.20E-07	Flash Fire	6.75E-06	-	0.00E+00	Unignited	2.04E-04
		Large	Jet Fire	1.77E-06	Explosion	2.13E-07	Flash Fire	1.56E-06	-	0.00E+00	Unignited	4.71E-05
		Catastrophic	Jet Fire	4.79E-06	Explosion	9.58E-07	Flash Fire	2.23E-06	-	0.00E+00	Unignited	1.86E-05
39	IS39_LPG_S_V	Minor	Jet Fire	9.36E-06	Explosion	3.37E-06	Flash Fire	8.09E-05	-	0.00E+00	Unignited	9.27E-03
		Small	Jet Fire	2.64E-06	Explosion	9.52E-07	Flash Fire	2.28E-05	-	0.00E+00	Unignited	2.62E-03
		Medium	Jet Fire	2.27E-05	Explosion	2.73E-06	Flash Fire	2.00E-05	-	0.00E+00	Unignited	6.04E-04
		Large	Jet Fire	5.53E-06	Explosion	6.63E-07	Flash Fire	4.86E-06	-	0.00E+00	Unignited	1.47E-04
		Catastrophic	Jet Fire	2.63E-05	Explosion	5.27E-06	Flash Fire	1.23E-05	-	0.00E+00	Unignited	1.02E-04
40	IS40_ISOM_SRDBP_L	Minor	Jet Fire	2.90E-06	Pool Fire	2.61E-05	-	0.00E+00	-	0.00E+00	Unignited	2.87E-03
		Small	Jet Fire	1.35E-05	Pool Fire	1.35E-05	-	0.00E+00	-	0.00E+00	Unignited	8.74E-04
		Medium	Jet Fire	1.09E-05	Pool Fire	7.28E-06	-	0.00E+00	-	0.00E+00	Unignited	2.09E-04
		Large	Jet Fire	2.64E-06	Pool Fire	1.76E-06	-	0.00E+00	-	0.00E+00	Unignited	5.05E-05
		Catastrophic	Pool Fire	1.68E-06	Pool Fire	1.12E-06	-	0.00E+00	-	0.00E+00	Unignited	3.23E-05
41	IS41_LPG_SRDUP_V	Minor	Jet Fire	1.07E-06	Explosion	3.85E-07	Flash Fire	9.25E-06	-	0.00E+00	Unignited	1.06E-03
		Small	Jet Fire	1.22E-05	Explosion	1.46E-06	Flash Fire	1.07E-05	-	0.00E+00	Unignited	3.23E-04
		Medium	Jet Fire	7.67E-06	Explosion	9.20E-07	Flash Fire	6.75E-06	-	0.00E+00	Unignited	2.04E-04
		Large	Jet Fire	9.11E-06	Explosion	1.82E-06	Flash Fire	4.25E-06	-	0.00E+00	Unignited	3.54E-05
		Catastrophic	Jet Fire	4.79E-06	Explosion	9.58E-07	Flash Fire	2.23E-06	-	0.00E+00	Unignited	1.86E-05
42	IS42_ISOM_DRD_L	Minor	Jet Fire	4.64E-06	Pool Fire	4.17E-05	-	0.00E+00	-	0.00E+00	Unignited	4.59E-03
		Small	Jet Fire	2.04E-05	Pool Fire	2.04E-05	-	0.00E+00	-	0.00E+00	Unignited	1.32E-03
		Medium	Jet Fire	7.77E-06	Pool Fire	7.77E-06	-	0.00E+00	-	0.00E+00	Unignited	5.02E-04
		Large	Jet Fire	5.94E-06	Pool Fire	3.96E-06	-	0.00E+00	-	0.00E+00	Unignited	1.14E-04
		Catastrophic	Pool Fire	4.14E-06	Pool Fire	2.76E-06	-	0.00E+00	-	0.00E+00	Unignited	7.94E-05
43	IS43_H2_CS_V	Minor	Jet Fire	7.55E-06	Explosion	2.72E-06	Flash Fire	6.52E-05	-	0.00E+00	Unignited	7.47E-03
		Small	Jet Fire	2.07E-06	Explosion	7.46E-07	Flash Fire	1.79E-05	-	0.00E+00	Unignited	2.05E-03
		Medium	Jet Fire	6.39E-07	Explosion	2.30E-07	Flash Fire	5.52E-06	-	0.00E+00	Unignited	6.32E-04
		Large	Jet Fire	6.03E-06	Explosion	7.24E-07	Flash Fire	5.31E-06	-	0.00E+00	Unignited	1.60E-04
		Catastrophic	Jet Fire	2.13E-05	Explosion	4.27E-06	Flash Fire	9.95E-06	-	0.00E+00	Unignited	8.29E-05
44	IS44_TAME_TST_L	Minor	Jet Fire	1.09E-05	Pool Fire	9.78E-05	-	0.00E+00	-	0.00E+00	Unignited	1.08E-02
		Small	Jet Fire	3.98E-05	Pool Fire	3.98E-05	-	0.00E+00	-	0.00E+00	Unignited	2.57E-03

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Medium	Jet Fire	2.07E-05	Pool Fire	2.07E-05	-	0.00E+00	-	0.00E+00	Unignited	1.34E-03
		Large	Jet Fire	1.93E-05	Pool Fire	1.29E-05	-	0.00E+00	-	0.00E+00	Unignited	3.70E-04
		Catastrophic	Pool Fire	1.05E-05	Pool Fire	7.02E-06	-	0.00E+00	-	0.00E+00	Unignited	2.02E-04
45	IS45_ISOM_IST_L	Minor	Jet Fire	1.09E-05	Pool Fire	9.78E-05	-	0.00E+00	-	0.00E+00	Unignited	1.08E-02
		Small	Jet Fire	3.98E-05	Pool Fire	3.98E-05	-	0.00E+00	-	0.00E+00	Unignited	2.57E-03
		Medium	Jet Fire	2.07E-05	Pool Fire	2.07E-05	-	0.00E+00	-	0.00E+00	Unignited	1.34E-03
		Large	Jet Fire	1.93E-05	Pool Fire	1.29E-05	-	0.00E+00	-	0.00E+00	Unignited	3.70E-04
		Catastrophic	Pool Fire	1.05E-05	Pool Fire	7.02E-06	-	0.00E+00	-	0.00E+00	Unignited	2.02E-04
46	IS46_NAPH_MST_L	Minor	Jet Fire	6.44E-06	Pool Fire	5.80E-05	-	0.00E+00	-	0.00E+00	Unignited	6.38E-03
		Small	Jet Fire	2.42E-05	Pool Fire	2.42E-05	-	0.00E+00	-	0.00E+00	Unignited	1.57E-03
		Medium	Jet Fire	3.38E-05	Pool Fire	2.25E-05	-	0.00E+00	-	0.00E+00	Unignited	6.47E-04
		Large	Jet Fire	9.93E-06	Pool Fire	6.62E-06	-	0.00E+00	-	0.00E+00	Unignited	1.90E-04
		Catastrophic	Pool Fire	5.57E-06	Pool Fire	3.71E-06	-	0.00E+00	-	0.00E+00	Unignited	1.07E-04
47	IS47_TAME_PIPESTPU_L	Minor	Jet Fire	2.48E-04	Pool Fire	2.23E-03	-	0.00E+00	-	0.00E+00	Unignited	2.45E-01
		Small	Jet Fire	1.50E-03	Pool Fire	1.50E-03	-	0.00E+00	-	0.00E+00	Unignited	9.71E-02
		Medium	Jet Fire	2.65E-04	Pool Fire	2.65E-04	-	0.00E+00	-	0.00E+00	Unignited	1.71E-02
		Large	Jet Fire	0.00E+00	Pool Fire	0.00E+00	-	0.00E+00	-	0.00E+00	Unignited	0.00E+00
		Catastrophic	Pool Fire	0.00E+00	Pool Fire	0.00E+00	-	0.00E+00	-	0.00E+00	Unignited	0.00E+00
48	IS48_TAME_PIPEPUST_L	Minor	Jet Fire	9.60E-05	Pool Fire	8.64E-04	-	0.00E+00	-	0.00E+00	Unignited	9.51E-02
		Small	Jet Fire	2.14E-04	Pool Fire	2.14E-04	-	0.00E+00	-	0.00E+00	Unignited	1.38E-02
		Medium	Jet Fire	1.50E-04	Pool Fire	1.50E-04	-	0.00E+00	-	0.00E+00	Unignited	9.70E-03
		Large	Jet Fire	1.89E-04	Pool Fire	1.26E-04	-	0.00E+00	-	0.00E+00	Unignited	3.62E-03
		Catastrophic	Pool Fire	1.01E-04	Pool Fire	6.76E-05	-	0.00E+00	-	0.00E+00	Unignited	1.94E-03
49	IS49_ISOM_PIPEPUST_L	Minor	Jet Fire	9.60E-05	Pool Fire	8.64E-04	-	0.00E+00	-	0.00E+00	Unignited	9.51E-02
		Small	Jet Fire	2.14E-04	Pool Fire	2.14E-04	-	0.00E+00	-	0.00E+00	Unignited	1.38E-02
		Medium	Jet Fire	1.50E-04	Pool Fire	1.50E-04	-	0.00E+00	-	0.00E+00	Unignited	9.70E-03
		Large	Jet Fire	1.89E-04	Pool Fire	1.26E-04	-	0.00E+00	-	0.00E+00	Unignited	3.62E-03
		Catastrophic	Pool Fire	1.01E-04	Pool Fire	6.76E-05	-	0.00E+00	-	0.00E+00	Unignited	1.94E-03
50	IS50_NAPH_PIPESTPU_L	Minor	Jet Fire	9.60E-05	Pool Fire	8.64E-04	-	0.00E+00	-	0.00E+00	Unignited	9.51E-02
		Small	Jet Fire	2.14E-04	Pool Fire	2.14E-04	-	0.00E+00	-	0.00E+00	Unignited	1.38E-02
		Medium	Jet Fire	1.50E-04	Pool Fire	1.50E-04	-	0.00E+00	-	0.00E+00	Unignited	9.70E-03

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Large	Jet Fire	1.89E-04	Pool Fire	1.26E-04	-	0.00E+00	-	0.00E+00	Unignited	3.62E-03
		Catastrophic	Pool Fire	1.01E-04	Pool Fire	6.76E-05	-	0.00E+00	-	0.00E+00	Unignited	1.94E-03
51	IS51_NAPH_PIPEPUST_L	Minor	Jet Fire	8.41E-05	Pool Fire	7.57E-04	-	0.00E+00	-	0.00E+00	Unignited	8.32E-02
		Small	Jet Fire	1.87E-04	Pool Fire	1.87E-04	-	0.00E+00	-	0.00E+00	Unignited	1.21E-02
		Medium	Jet Fire	1.31E-04	Pool Fire	1.31E-04	-	0.00E+00	-	0.00E+00	Unignited	8.50E-03
		Large	Jet Fire	1.65E-04	Pool Fire	1.10E-04	-	0.00E+00	-	0.00E+00	Unignited	3.17E-03
		Catastrophic	Pool Fire	8.88E-05	Pool Fire	5.92E-05	-	0.00E+00	-	0.00E+00	Unignited	1.70E-03
52	IS52_NAPH_PIPEPUMHST_L	Minor	Jet Fire	8.41E-05	Pool Fire	7.57E-04	-	0.00E+00	-	0.00E+00	Unignited	8.32E-02
		Small	Jet Fire	1.87E-04	Pool Fire	1.87E-04	-	0.00E+00	-	0.00E+00	Unignited	1.21E-02
		Medium	Jet Fire	1.31E-04	Pool Fire	1.31E-04	-	0.00E+00	-	0.00E+00	Unignited	8.50E-03
		Large	Jet Fire	1.65E-04	Pool Fire	1.10E-04	-	0.00E+00	-	0.00E+00	Unignited	3.17E-03
		Catastrophic	Pool Fire	8.88E-05	Pool Fire	5.92E-05	-	0.00E+00	-	0.00E+00	Unignited	1.70E-03
53	IS53_ETHY_EST_L	Minor	Jet Fire	4.66E-07	Explosion	1.68E-07	Flash Fire	2.01E-06	Pool Fire	2.01E-06	Unignited	4.62E-04
		Small	Jet Fire	1.63E-07	Explosion	5.87E-08	Flash Fire	7.05E-07	Pool Fire	7.05E-07	Unignited	1.61E-04
		Medium	Jet Fire	5.04E-07	Explosion	6.05E-08	Flash Fire	2.22E-07	Pool Fire	2.22E-07	Unignited	3.26E-05
		Large	Jet Fire	9.45E-08	Explosion	1.13E-08	Flash Fire	4.16E-08	Pool Fire	4.16E-08	Unignited	6.11E-06
		Catastrophic	BLEVE	2.16E-07	Explosion	4.32E-08	Flash Fire	1.01E-07	-	0.00E+00	Unignited	4.14E-06
54	IS54_ETHY_BOGC_V	Minor	Jet Fire	3.88E-06	Explosion	1.40E-06	Flash Fire	3.35E-05	-	0.00E+00	Unignited	3.84E-03
		Small	Jet Fire	3.86E-05	Explosion	4.63E-06	Flash Fire	3.40E-05	-	0.00E+00	Unignited	1.03E-03
		Medium	Jet Fire	1.11E-05	Explosion	2.22E-06	Flash Fire	5.18E-06	-	0.00E+00	Unignited	4.32E-05
		Large	Jet Fire	4.87E-06	Explosion	9.73E-07	Flash Fire	2.27E-06	-	0.00E+00	Unignited	1.89E-05
		Catastrophic	Jet Fire	4.62E-06	Explosion	9.23E-07	Flash Fire	2.15E-06	-	0.00E+00	Unignited	1.80E-05
55	IS55_ETHY_HPEBOGLR_V	Minor	Jet Fire	1.26E-07	Explosion	4.52E-08	Flash Fire	1.08E-06	-	0.00E+00	Unignited	1.24E-04
		Small	Jet Fire	1.97E-06	Explosion	2.37E-07	Flash Fire	1.74E-06	-	0.00E+00	Unignited	5.24E-05
		Medium	Jet Fire	6.23E-06	Explosion	1.25E-06	Flash Fire	2.91E-06	-	0.00E+00	Unignited	2.42E-05
		Large	Jet Fire	1.17E-06	Explosion	2.34E-07	Flash Fire	5.46E-07	-	0.00E+00	Unignited	4.55E-06
		Catastrophic	Jet Fire	6.08E-07	Explosion	1.22E-07	Flash Fire	2.84E-07	-	0.00E+00	Unignited	2.36E-06
56	IS56_ETHY_LPEBOGLR_L	Minor	Jet Fire	1.26E-07	Pool Fire	1.13E-06	-	0.00E+00	-	0.00E+00	Unignited	1.24E-04
		Small	Jet Fire	8.45E-07	Pool Fire	8.45E-07	-	0.00E+00	-	0.00E+00	Unignited	5.47E-05
		Medium	Jet Fire	1.66E-06	Pool Fire	1.11E-06	-	0.00E+00	-	0.00E+00	Unignited	3.18E-05
		Large	Jet Fire	3.12E-07	Pool Fire	2.08E-07	-	0.00E+00	-	0.00E+00	Unignited	5.98E-06

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
		Catastrophic	Pool Fire	1.62E-07	Pool Fire	1.08E-07	-	0.00E+00	-	0.00E+00	Unignited	3.11E-06
57	IS57_PROPY_PSV_L	Minor	Jet Fire	5.02E-07	Explosion	1.81E-07	Flash Fire	2.17E-06	Pool Fire	2.17E-06	Unignited	4.97E-04
		Small	Jet Fire	2.25E-07	Explosion	8.11E-08	Flash Fire	9.74E-07	Pool Fire	9.74E-07	Unignited	2.23E-04
		Medium	Jet Fire	2.08E-06	Explosion	2.49E-07	Flash Fire	9.13E-07	Pool Fire	9.13E-07	Unignited	1.34E-04
		Large	Jet Fire	3.90E-07	Explosion	4.68E-08	Flash Fire	1.72E-07	Pool Fire	1.72E-07	Unignited	2.52E-05
		Catastrophic	BLEVE	6.48E-07	Explosion	1.30E-07	Flash Fire	3.02E-07	-	0.00E+00	Unignited	1.24E-05
58	IS58_BUTD_BSV_L	Minor	Jet Fire	5.02E-07	Explosion	1.81E-07	Flash Fire	2.17E-06	Pool Fire	2.17E-06	Unignited	4.97E-04
		Small	Jet Fire	3.38E-06	Explosion	4.06E-07	Flash Fire	1.49E-06	Pool Fire	1.49E-06	Unignited	2.19E-04
		Medium	Jet Fire	2.08E-06	Explosion	2.49E-07	Flash Fire	9.13E-07	Pool Fire	9.13E-07	Unignited	1.34E-04
		Large	Jet Fire	1.25E-06	Explosion	2.50E-07	Flash Fire	5.82E-07	Pool Fire	0.00E+00	Unignited	2.39E-05
		Catastrophic	BLEVE	6.48E-07	Explosion	1.30E-07	Flash Fire	3.02E-07	-	0.00E+00	Unignited	1.24E-05
59	IS59_ETHY_CFKOD_L	Minor	Pool Fire	1.26E-07	Pool Fire	1.13E-06	-	0.00E+00	-	0.00E+00	Unignited	1.24E-04
		Small	Pool Fire	5.64E-08	Pool Fire	5.07E-07	-	0.00E+00	-	0.00E+00	Unignited	5.58E-05
		Medium	Pool Fire	5.19E-07	Pool Fire	5.19E-07	-	0.00E+00	-	0.00E+00	Unignited	3.36E-05
		Large	Pool Fire	9.75E-08	Pool Fire	9.75E-08	-	0.00E+00	-	0.00E+00	Unignited	6.30E-06
		Catastrophic	Pool Fire	1.62E-07	Pool Fire	1.08E-07	-	0.00E+00	-	0.00E+00	Unignited	3.11E-06
60	IS60_ETHY_PIPEU2100U5220_L	Minor	Jet Fire	9.60E-06	Pool Fire	8.64E-05	-	0.00E+00	-	0.00E+00	Unignited	9.51E-03
		Small	Jet Fire	2.14E-05	Pool Fire	2.14E-05	-	0.00E+00	-	0.00E+00	Unignited	1.38E-03
		Medium	Jet Fire	4.80E-05	Pool Fire	3.20E-05	-	0.00E+00	-	0.00E+00	Unignited	9.20E-04
		Large	Jet Fire	1.89E-05	Pool Fire	1.26E-05	-	0.00E+00	-	0.00E+00	Unignited	3.62E-04
		Catastrophic	Pool Fire	1.01E-05	Pool Fire	6.76E-06	-	0.00E+00	-	0.00E+00	Unignited	1.94E-04
61	IS61_ETHY_PIPEU5220PDT2_L	Minor	Jet Fire	7.21E-06	Pool Fire	6.49E-05	-	0.00E+00	-	0.00E+00	Unignited	7.14E-03
		Small	Jet Fire	1.61E-05	Pool Fire	1.61E-05	-	0.00E+00	-	0.00E+00	Unignited	1.04E-03
		Medium	Jet Fire	3.61E-05	Pool Fire	2.40E-05	-	0.00E+00	-	0.00E+00	Unignited	6.91E-04
		Large	Jet Fire	1.42E-05	Pool Fire	9.46E-06	-	0.00E+00	-	0.00E+00	Unignited	2.72E-04
		Catastrophic	Pool Fire	7.62E-06	Pool Fire	5.08E-06	-	0.00E+00	-	0.00E+00	Unignited	1.46E-04
62	IS62_ETHY_PIPEU5220BLU_V	Minor	Jet Fire	9.60E-06	Explosion	3.46E-06	Flash Fire	8.30E-05	-	0.00E+00	Unignited	9.51E-03
		Small	Jet Fire	4.99E-05	Explosion	5.99E-06	Flash Fire	4.39E-05	-	0.00E+00	Unignited	1.33E-03
		Medium	Jet Fire	3.50E-05	Explosion	4.20E-06	Flash Fire	3.08E-05	-	0.00E+00	Unignited	9.30E-04
		Large	Jet Fire	7.09E-05	Explosion	1.42E-05	Flash Fire	3.31E-05	-	0.00E+00	Unignited	2.76E-04
		Catastrophic	Jet Fire	3.80E-05	Explosion	7.61E-06	Flash Fire	1.78E-05	-	0.00E+00	Unignited	1.48E-04

No.	Section ID	Hole Size	Immediate Ignition	Immediate Ignition Frequency (/year)	Delayed Ignition 1	Delayed Ignition 1 Frequency(/year)	Delayed Ignition 2	Delayed Ignition 2 Frequency(/year)	Delayed Ignition 3	Delayed Ignition 3 Frequency(/year)	Un-ignited Release / Toxic Dispersion	Un-ignited / Toxic Frequency(/year)
63	IS63_PROPY_PIPEU5210U5220_V	Minor	Jet Fire	9.60E-06	Explosion	3.46E-06	Flash Fire	8.30E-05	-	0.00E+00	Unignited	9.51E-03
		Small	Jet Fire	4.99E-05	Explosion	5.99E-06	Flash Fire	4.39E-05	-	0.00E+00	Unignited	1.33E-03
		Medium	Jet Fire	1.80E-04	Explosion	3.60E-05	Flash Fire	8.40E-05	-	0.00E+00	Unignited	7.00E-04
		Large	Jet Fire	7.09E-05	Explosion	1.42E-05	Flash Fire	3.31E-05	-	0.00E+00	Unignited	2.76E-04
		Catastrophic	Jet Fire	3.80E-05	Explosion	7.61E-06	Flash Fire	1.78E-05	-	0.00E+00	Unignited	1.48E-04
64	IS64_PROPY_PIPEU5220J_V	Minor	Jet Fire	1.51E-05	Explosion	5.44E-06	Flash Fire	1.31E-04	-	0.00E+00	Unignited	1.50E-02
		Small	Jet Fire	7.87E-05	Explosion	9.44E-06	Flash Fire	6.92E-05	-	0.00E+00	Unignited	2.09E-03
		Medium	Jet Fire	2.83E-04	Explosion	5.66E-05	Flash Fire	1.32E-04	-	0.00E+00	Unignited	1.10E-03
		Large	Jet Fire	1.12E-04	Explosion	2.23E-05	Flash Fire	5.21E-05	-	0.00E+00	Unignited	4.34E-04
		Catastrophic	Jet Fire	5.99E-05	Explosion	1.20E-05	Flash Fire	2.79E-05	-	0.00E+00	Unignited	2.33E-04
65	IS65_PROPY_PIPEMURP_V	Minor	Jet Fire	3.12E-06	Explosion	1.12E-06	Flash Fire	2.70E-05	-	0.00E+00	Unignited	3.09E-03
		Small	Jet Fire	1.26E-06	Explosion	4.55E-07	Flash Fire	1.09E-05	-	0.00E+00	Unignited	1.25E-03
		Medium	Jet Fire	7.80E-06	Explosion	9.36E-07	Flash Fire	6.87E-06	-	0.00E+00	Unignited	2.07E-04
		Large	Jet Fire	0.00E+00	Explosion	0.00E+00	Flash Fire	0.00E+00	-	0.00E+00	Unignited	0.00E+00
		Catastrophic	Jet Fire	0.00E+00	Explosion	0.00E+00	Flash Fire	0.00E+00	-	0.00E+00	Unignited	0.00E+00
66	IS66_BUTD_PIPEU5210U5220_L	Minor	Jet Fire	9.60E-06	Pool Fire	8.64E-05	-	0.00E+00	-	0.00E+00	Unignited	9.51E-03
		Small	Jet Fire	2.14E-05	Pool Fire	2.14E-05	-	0.00E+00	-	0.00E+00	Unignited	1.38E-03
		Medium	Jet Fire	4.80E-05	Pool Fire	3.20E-05	-	0.00E+00	-	0.00E+00	Unignited	9.20E-04
		Large	Jet Fire	1.89E-05	Pool Fire	1.26E-05	-	0.00E+00	-	0.00E+00	Unignited	3.62E-04
		Catastrophic	Pool Fire	1.01E-05	Pool Fire	6.76E-06	-	0.00E+00	-	0.00E+00	Unignited	1.94E-04
67	IS67_BUTD_PIPEU5220JLI_L	Minor	Jet Fire	1.44E-05	Pool Fire	1.29E-04	-	0.00E+00	-	0.00E+00	Unignited	1.42E-02
		Small	Jet Fire	3.20E-05	Pool Fire	3.20E-05	-	0.00E+00	-	0.00E+00	Unignited	2.07E-03
		Medium	Jet Fire	7.19E-05	Pool Fire	4.79E-05	-	0.00E+00	-	0.00E+00	Unignited	1.38E-03
		Large	Jet Fire	2.83E-05	Pool Fire	1.89E-05	-	0.00E+00	-	0.00E+00	Unignited	5.43E-04
		Catastrophic	Pool Fire	1.52E-05	Pool Fire	1.01E-05	-	0.00E+00	-	0.00E+00	Unignited	2.91E-04
68	IS68_BUTD_PIPEU5220JCLI_L	Minor	Jet Fire	1.44E-05	Pool Fire	1.29E-04	-	0.00E+00	-	0.00E+00	Unignited	1.42E-02
		Small	Jet Fire	3.20E-05	Pool Fire	3.20E-05	-	0.00E+00	-	0.00E+00	Unignited	2.07E-03
		Medium	Jet Fire	7.19E-05	Pool Fire	4.79E-05	-	0.00E+00	-	0.00E+00	Unignited	1.38E-03
		Large	Jet Fire	2.83E-05	Pool Fire	1.89E-05	-	0.00E+00	-	0.00E+00	Unignited	5.43E-04
		Catastrophic	Pool Fire	1.52E-05	Pool Fire	1.01E-05	-	0.00E+00	-	0.00E+00	Unignited	2.91E-04

SUB-APPENDIX 3D: INDIVIDUAL RISK (IR) CONTOUR

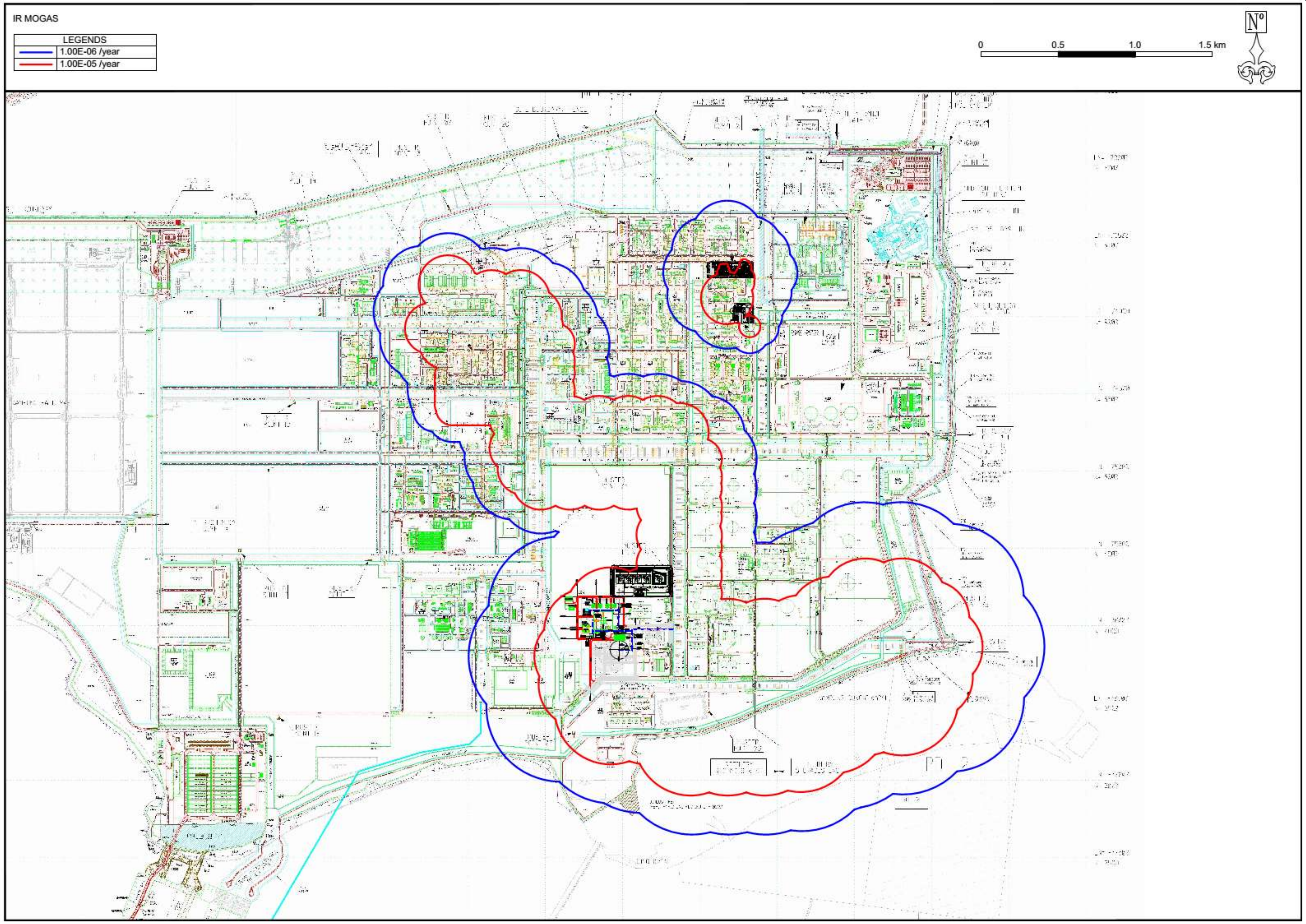

Figure D1: Individual Risk Contour for EURO 5 MOGAS Units and Storage Tanks

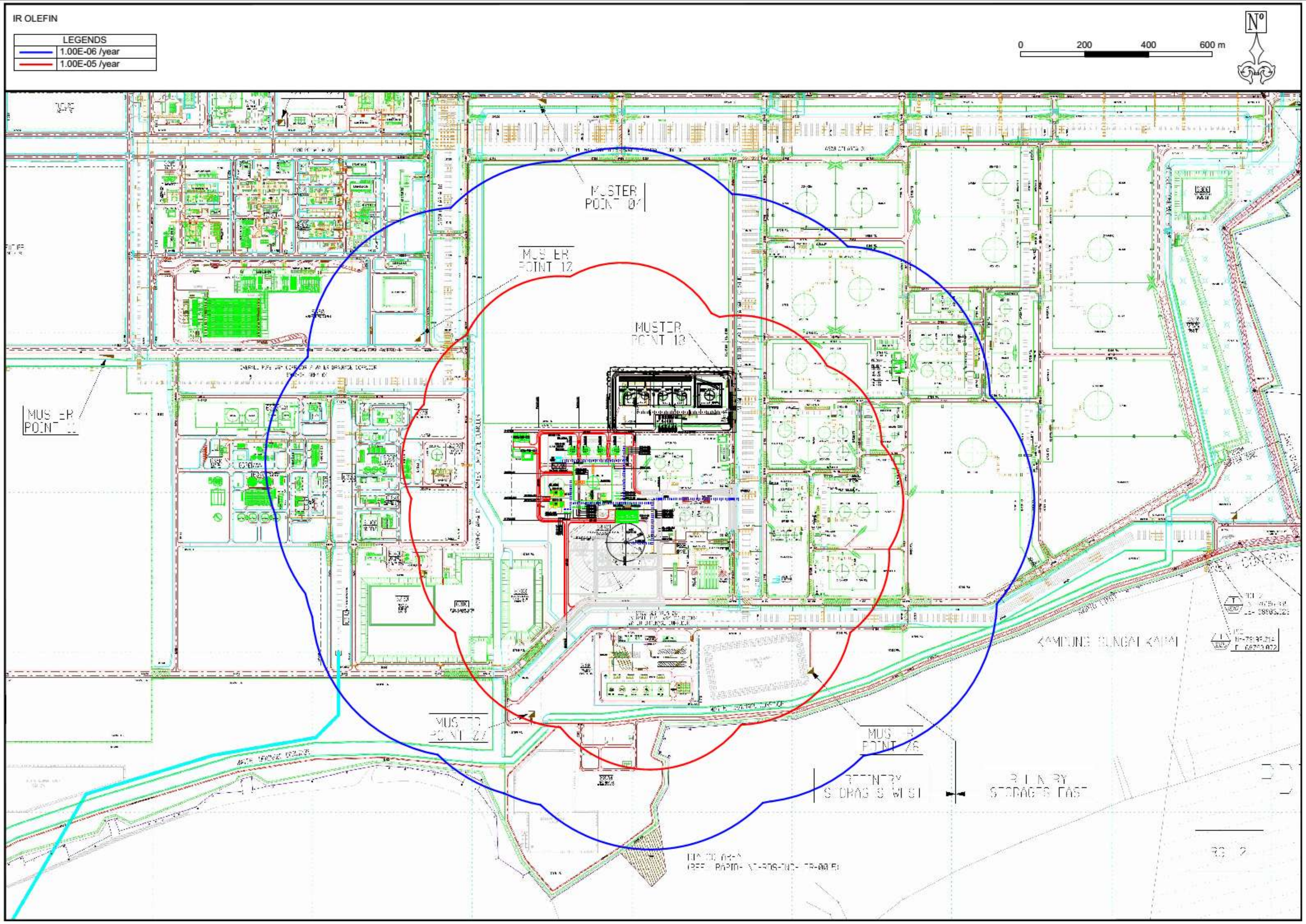

Figure D2: Individual Risk Contour for Olefins Storage Tanks

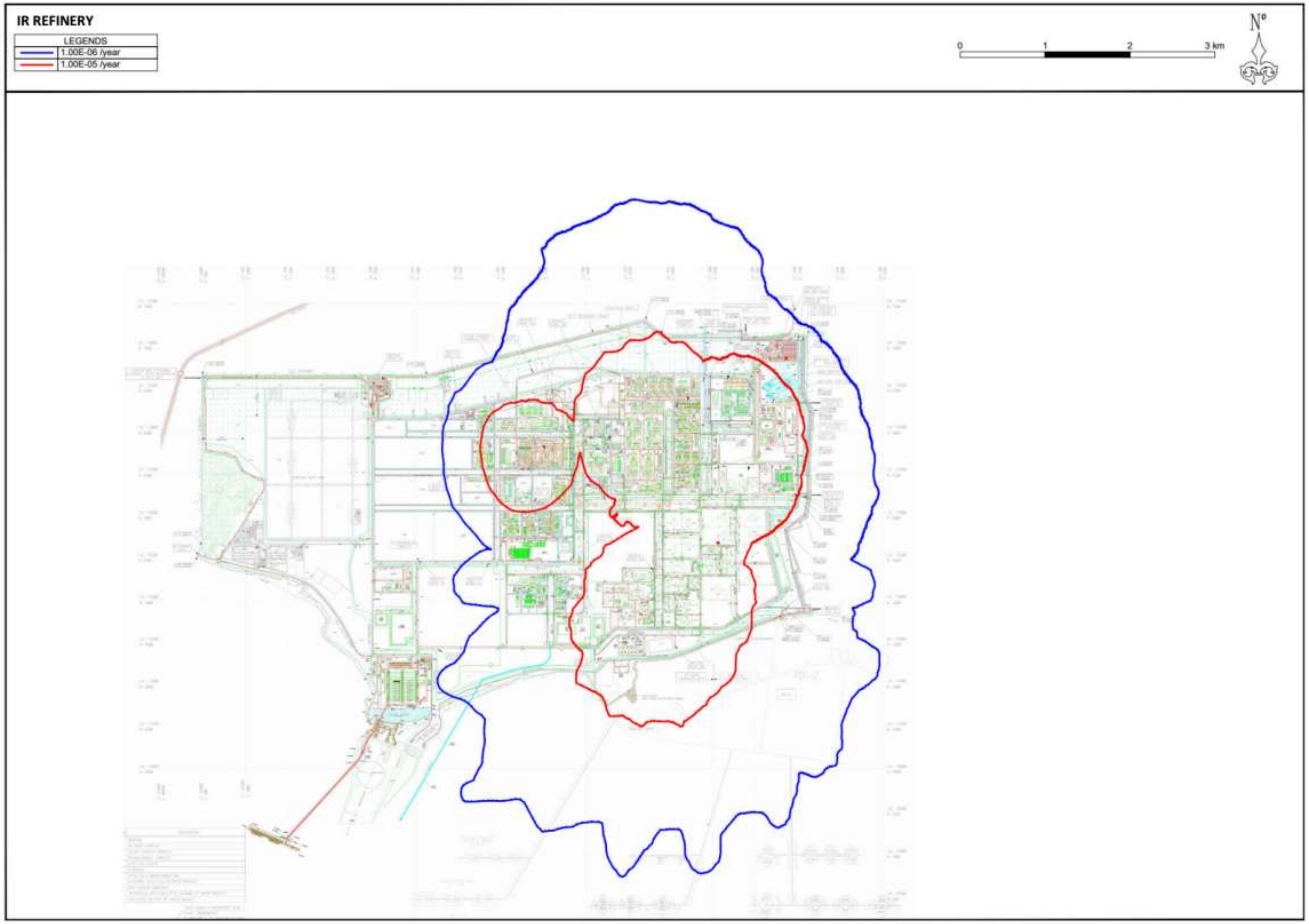

Figure D3: Cumulative Contour for Refinery Cracker Complex

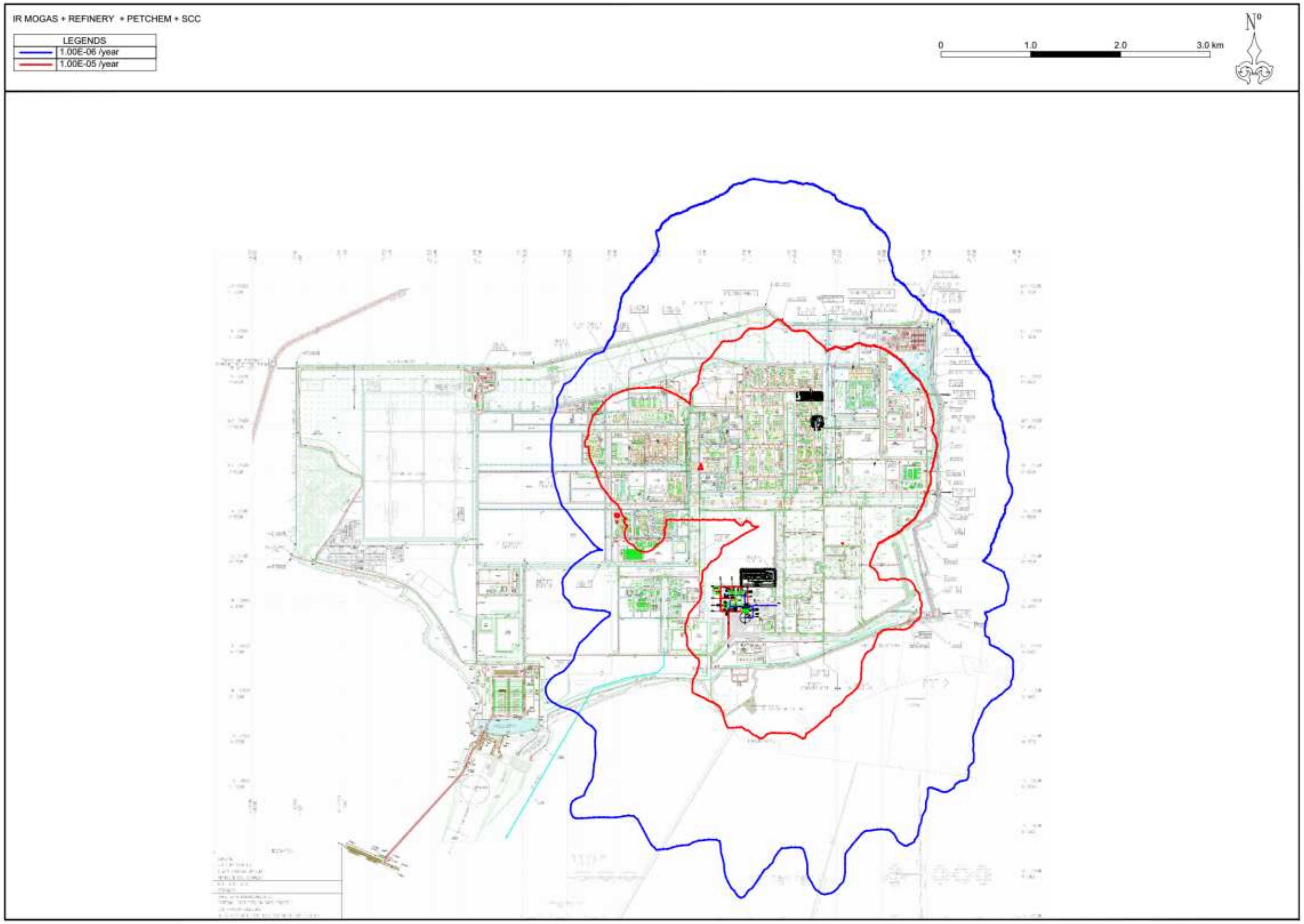

Figure D4: Cumulative Contour for EURO MOGAS Units, Olefins Storage Tankages, Refinery & Cracker Complex and Petrochemical Complex

SUB-APPENDIX 3E: WORST CASE SCENARIO (WCS) AND WORST CASE CREDIBLE SCENARIO (WCCS) FOR EURO MOGAS AND OLEFIN STORAGE TANKS.

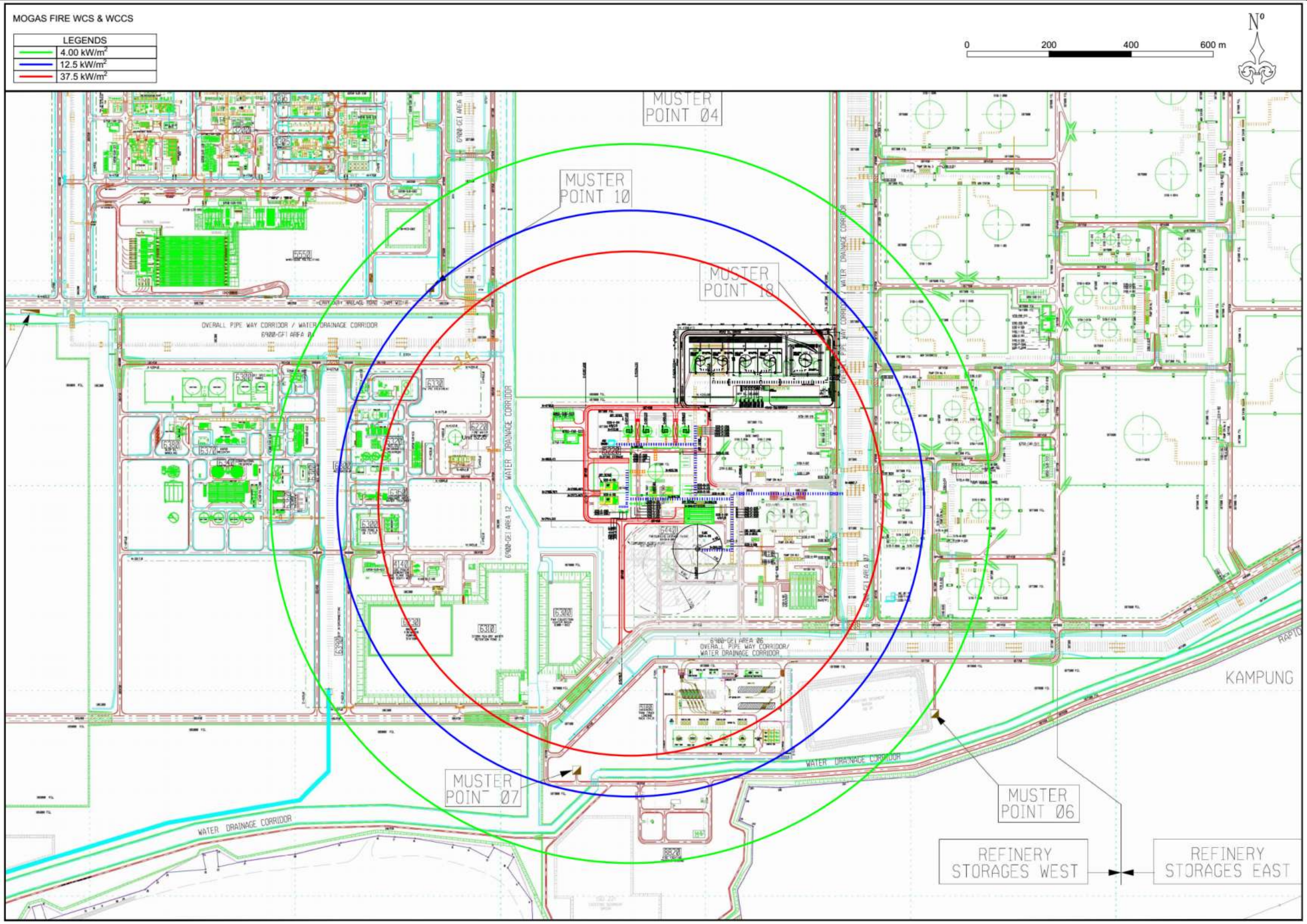

Figure E1: WCS and WCCS for Fire (Jet Fire due to Catastrophic Release at HP Ethylene BOG Liquid Receiver – Olefins Storage Tank)

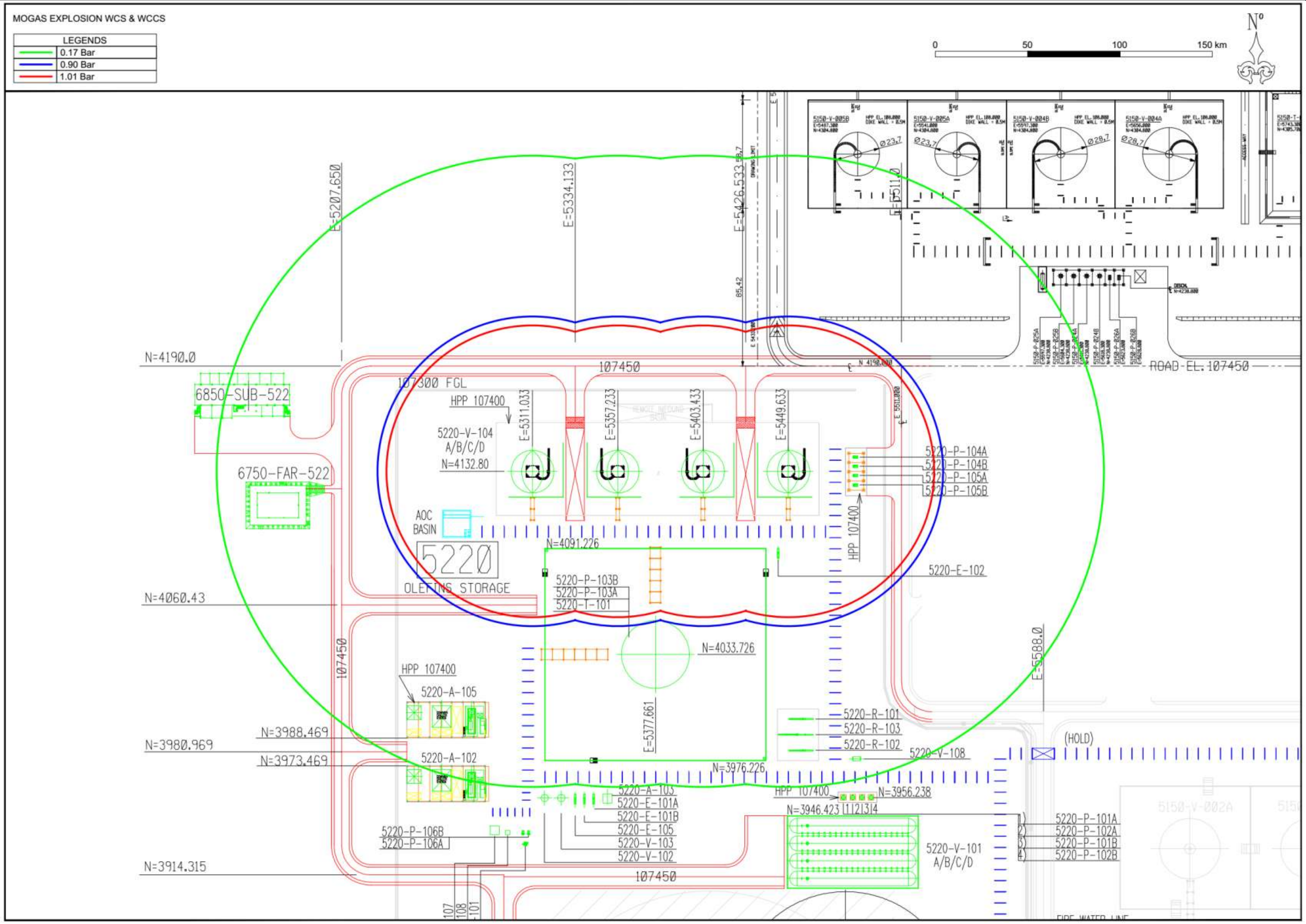

Figure E2: WCS and WCCS for Explosion (BLEVE due to Catastrophic Release at Propylene storage vessel – Olefins Storage Tank)

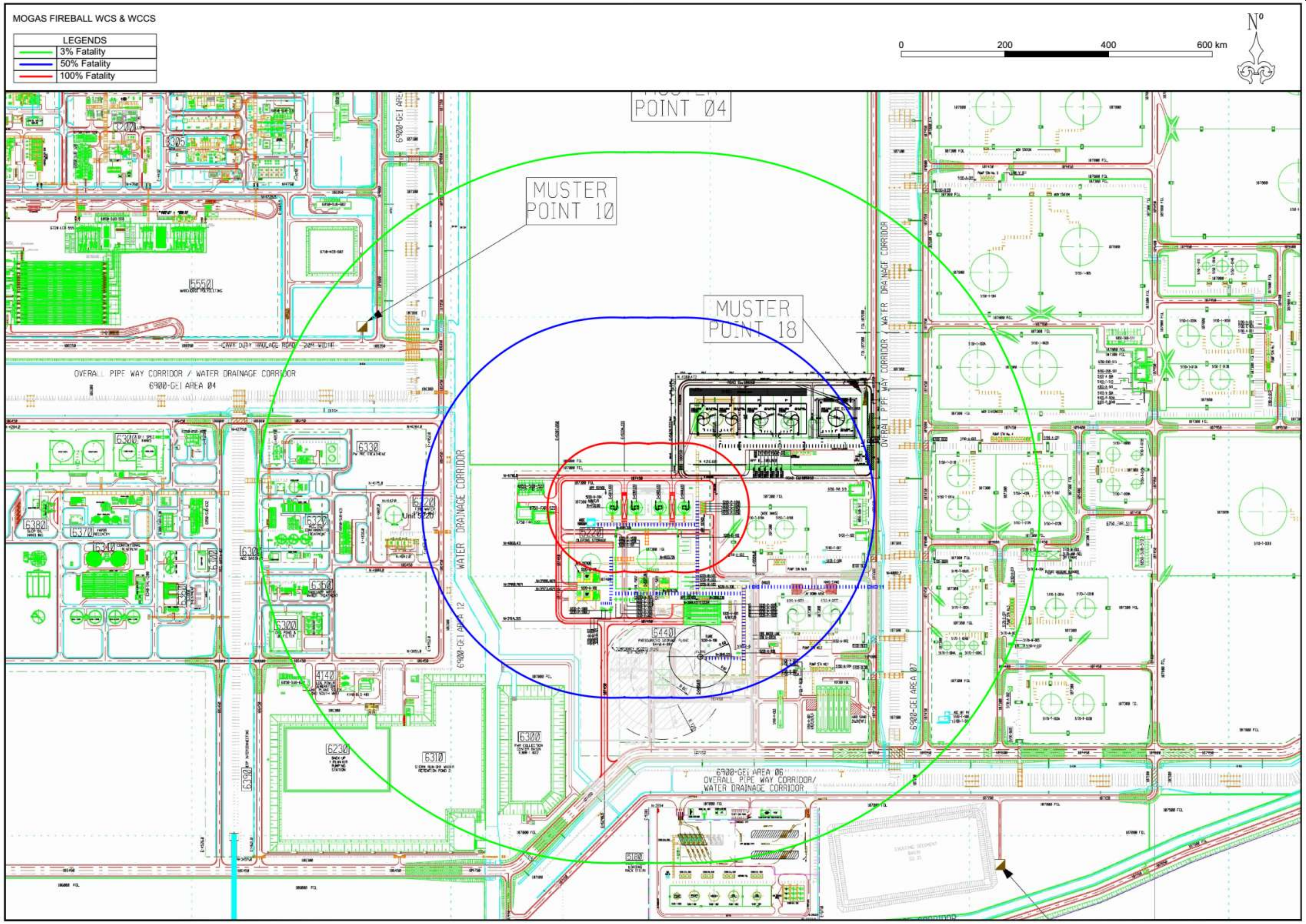

Figure E3: WCS and WCCS for Fireball (BLEVE due to Catastrophic Release at Propylene storage vessel – Olefins Storage Tank)

SUB-APPENDIX 3F: WORST CASE SCENARIO (WCS) AND WORST CASE CREDIBLE SCENARIO (WCCS) FOR PETROCHEMICAL COMPLEX

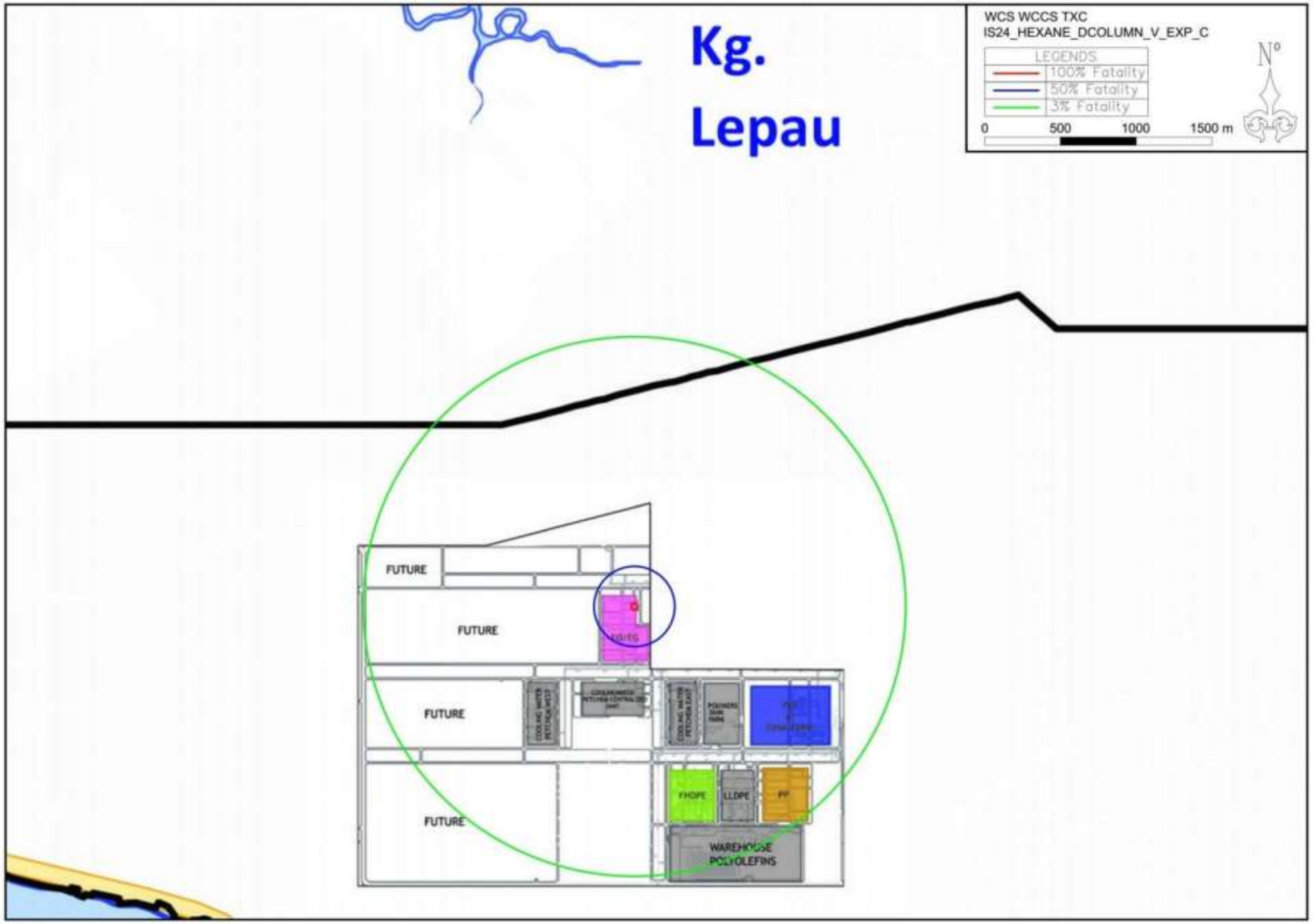

Figure F1: WCS and WCCS for Toxic Dispersion Event (Toxic Gas Dispersion due to Catastrophic Release at Carbon Dioxide Absorber – EOEG Unit, Petrochemical Complex)

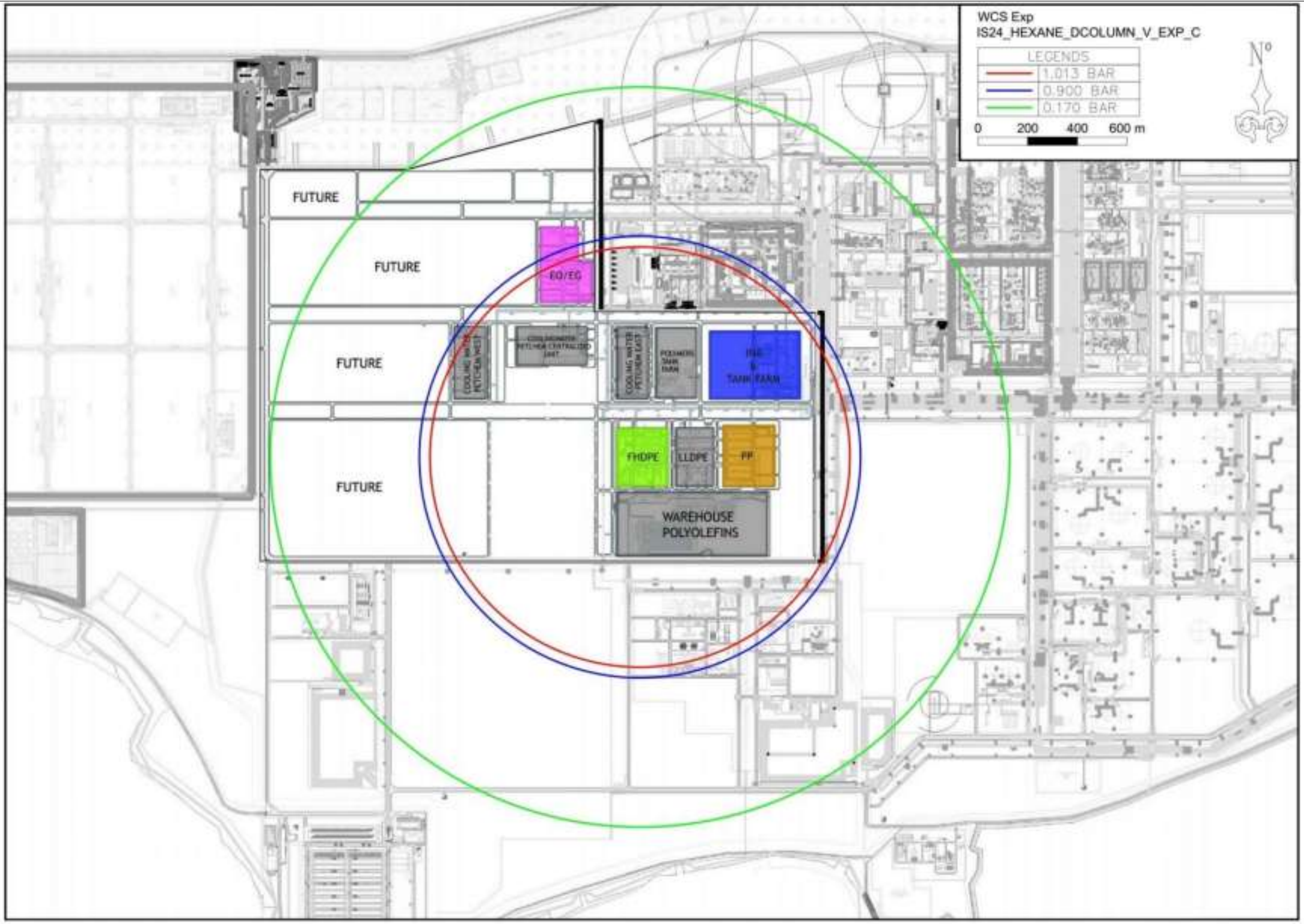

Figure F2: WCS for Explosion Event (Explosion due to Ignited Release of Catastrophic Release at Distillation Column – FHDPE Unit, Petrochemical Complex)

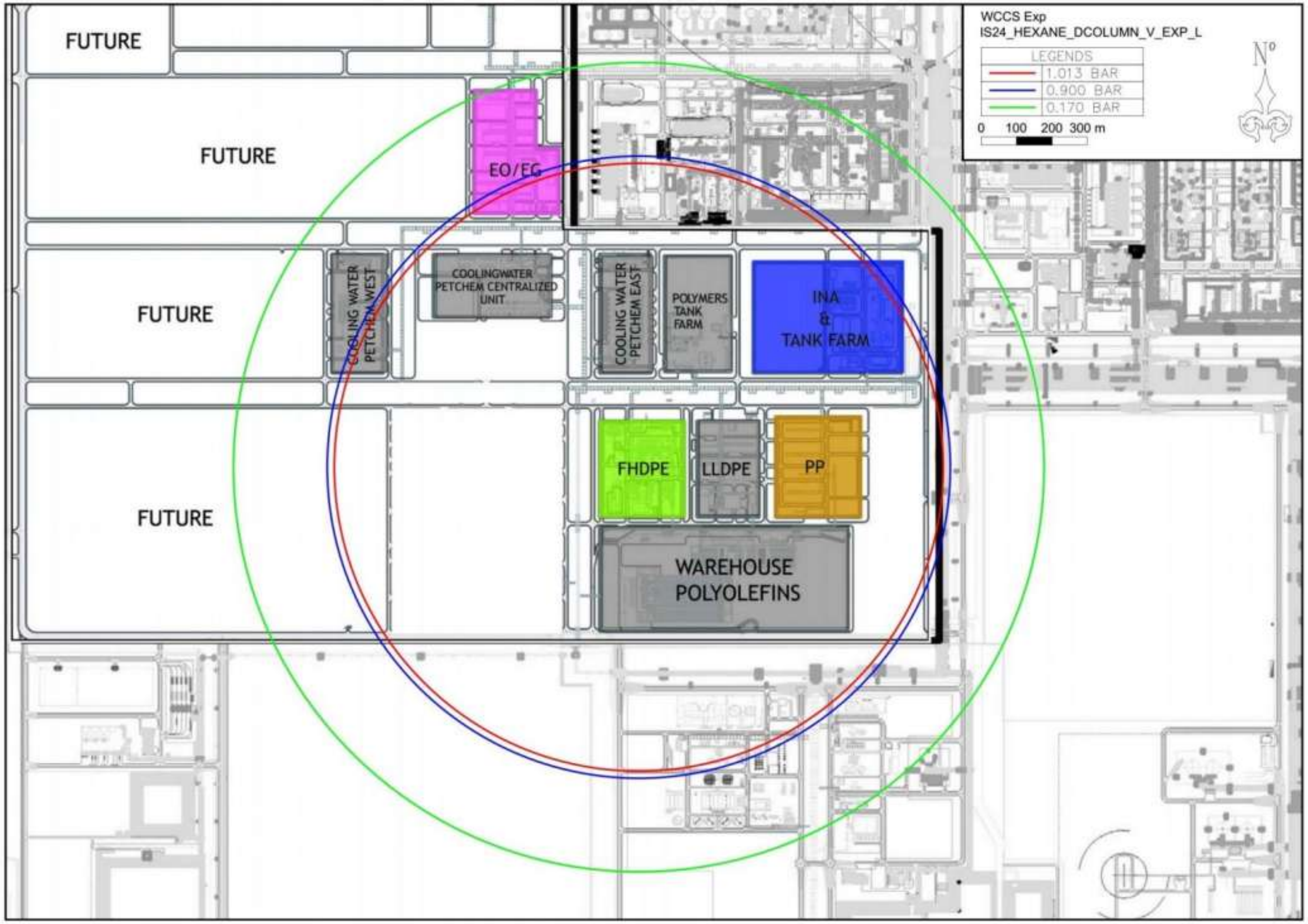

Figure F3: WCCS for Explosion Event (Explosion due to Ignited Release of Large Release at Distillation Column – FHDPE Unit, Petrochemical Complex)

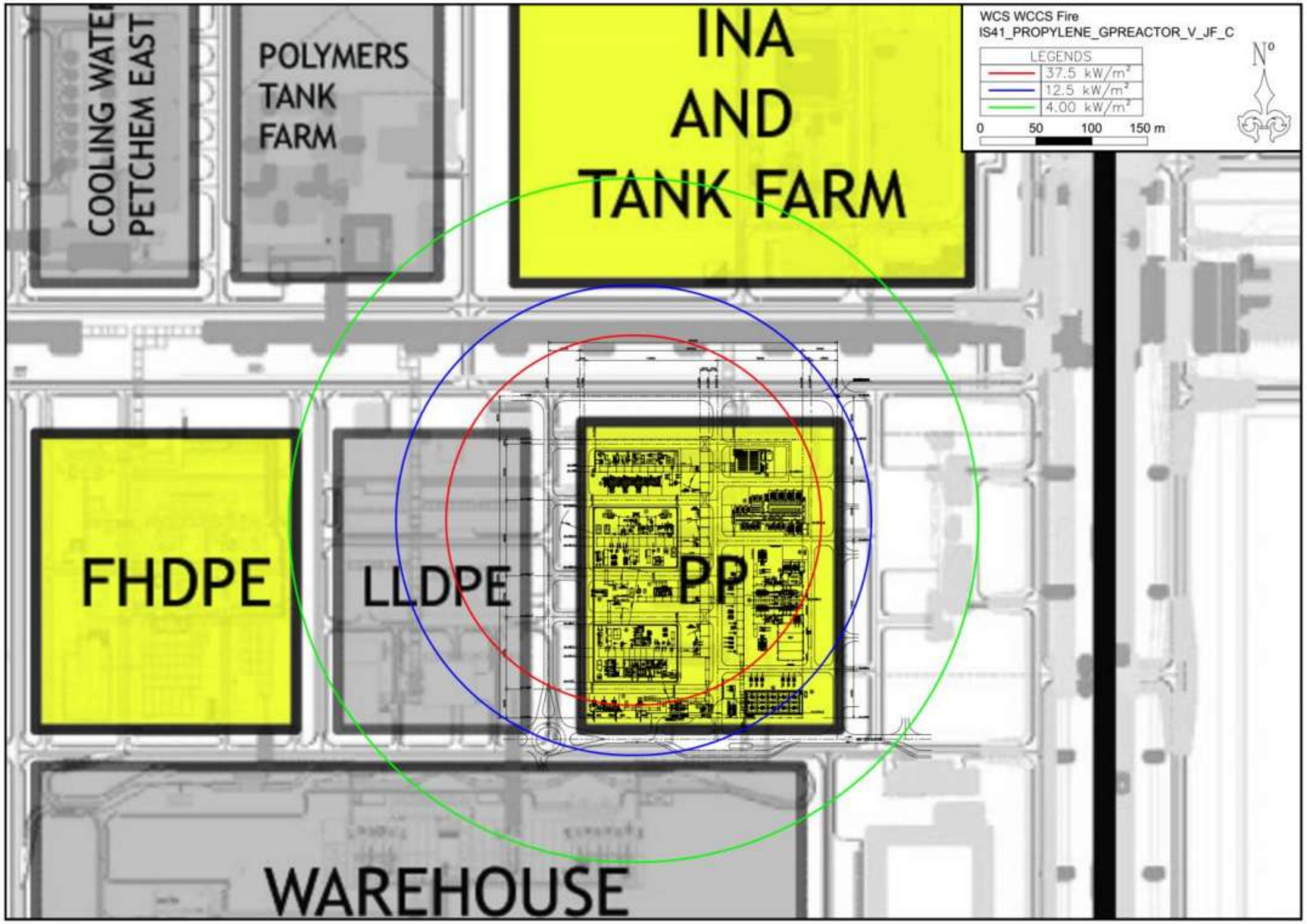

Figure F4: WCS and WCCS for Fire Event (Jet Fire due to Catastrophic Release at Gas Phase Reactor – Polypropylene Unit, Petrochemical Complex)

SUB-APPENDIX 3G: WORST CASE SCENARIO (WCS) AND WORST CASE CREDIBLE SCENARIO (WCCS) FOR REFINERY CRACKER COMPLEX

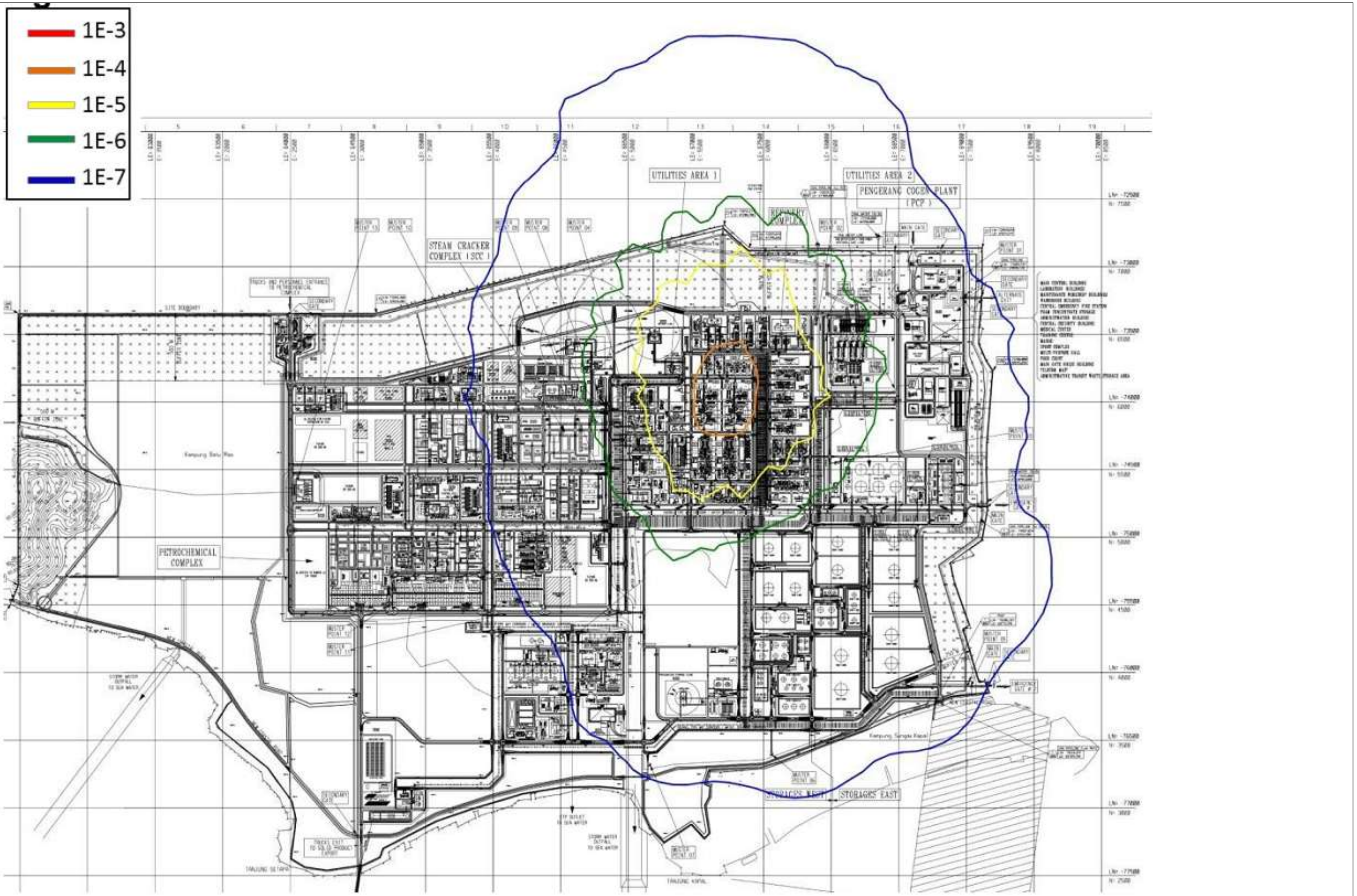

Figure G1: WCS and WCCS for Fire Event (Flash Fire at Lower Flammable Limit due to Catastrophic Release at Residue Fluid Catalytic Cracking Unit– Refinery Tank Farm, Refinery Cracker Complex)

Figure G2: WCS and WCCS for Fire Event (Jet Fire due to Catastrophic Release at LPG Intermediate Storage Vessel – Refinery Tank Farm, Refinery Cracker Complex)

Noise Dissipation Study

ADDITIONAL INFORMATION TO THE DEIA REFINERY AND PETROCHEMICAL INTEGRATED DEVELOPMENT (RAPID) PROJECT, PENGERANG JOHOR, 2012 TO INCLUDE EURO 5 MOGAS AND OLEFIN TANK UNITS

Prepared For:

PETRONAS REFINERY AND PETROCHEMICAL CORPORATION SDN. BHD.

Prepared By:

INTEGRATED ENVIROTECH SDN. BHD. (650387-K)

MARCH 2017

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1 INTRODUCTION

The RAPID Refinery Cracker Complex was originally designed to produce diesel that meets the EURO 5 specifications and MOGAS (motor gasoline) that meet EURO 4 specifications. To upgrade and meet the EURO 5 MOGAS specifications, the Refinery Cracker Complex has been expanded to include additional units as listed below :

1. 2nd Stage Cracked Naphtha Hydrotreating (CNHT 2) Unit
2. Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME) Unit
3. Isomerisation Unit
4. Additional Storage Tanks consisting of:
   i. Two Tertiary-Armyl-Methyl-Ether (TAME) storage tanks
   ii. Two Isomerate storage tanks
   iii. One Medium Cracked Naptha (MCN) Storage Tank

In addition to the above, there shall be new Olefin storage tankages located in the current Refinery Tank Farms consisting of:

1. Four mounded bullets for Butadiene Storage
2. One Ethylene Tank
3. Four spheres for Propylene Storage

Details of the additional units are described in **Volume 1, Chapter 2**. This Report present findings of the Noise Study undertaken to assess impact from the EURO 5 MOGAS units and Olefin Storage Tanks located within the Refinery Cracker Complex.

1.1 Objective

The objective of the Noise Dissipation Study was to establish and assess likely noise propagated for the new EURO 5 MOGAS Units and Olefins Storage Tankages that is added to the Refinery and Cracker Complex. The study also considers the design and layout changes that take place in the Petrochemical Complex.This study included findings on cumulative impacts from the existing Refinery and Cracker Complex (in its most current plant design configuration and layouts) combined together with new EURO 5 MOGAS Units and Olefins Storage Tankages.

2 APPROACH AND METHODOLOGY

Assessment of the resulting noise levels, equivalent continuous sound pressure level (L_{Aeq}) to the environment were compared against the DOE acceptance noise limits and baseline noise levels from the proposed process units' operations. Assessments for impact to potential noise sensitive receivers were examined on the basis of process units' noise only (i.e. reconfigured Refinery and Cracker Complex together with EURO 5 MOGAS Units and Olefins Storage Tankages), and then on a cumulative basis combined with other RAPID Components and the existing noise climate.

Noise levels and contours for sound propagation to the environment were determined within the individual process unit, individual unit boundaries, at the RAPID Complex boundary and beyond the RAPID Complex boundary to residential communities of concern.

Noise levels and propagation to the environment from the process units were established from noise modelling of the respective process units making up the Refinery, Cracker Complex, Petchem Complex and Utilities plants. Assessments for impact to potential noise sensitive receivers were examined on the basis of the Refinery and Cracker Complex, and then on a cumulative basis of all other

RAPID components (Petchem Complex and Utilities) combined with the existing noise climate (baseline noise levels at the receivers).

Further details of the approach and methodology of this study is shown in **Volume 1, Chapter 3.**

2.1 Applicable Regulatory Framework

Permissible Noise Level/Limit at RAPID Boundary and Sensitive Noise Recipient at its surrounding shall be established in reference to the approved Overall RAPID DEIA, 2012 Approval Limit (from first and revised approval) and also "Planning Guidelines for Environmental Noise Limit and Control", published by Department of Environment Malaysia (2007).

A review will be made on Baseline Noise Level measured at nearest Sensitive Recipient (which will remain around the RAPID Boundary) to determine whether it meets the limits as in the condition of approval for the approved Overall RAPID DEIA, 2012.

Further details of the applicable regulatory framework is described in **Volume 1, Chapter 3.**

2.2 Model Software

The noise modelling was undertaken using *Cadna-A* Industrial Noise Modelling software Version 3.7.123 from *Datakustik*. Noise propagation within the process units and thereafter to the RAPID Complex boundary and beyond to noise sensitive receivers of concern was undertaken.

2.3 Modelling Setup

The technical approach of the noise dissipation study involved the following:

- Separate noise model representing the entire Refinery and Cracker Complex individual process units (existing Refinery and Cracker Complex process units together with the new EURO 5 MOGAS Units and Olefins Storage Tankages) were used to determine noise propagation of combined process units of the Refinery and Cracker Complex.
- A cumulative noise model representing all process units of the Refinery and Cracker Complex (as above) combined with other process units of the Petrochemical Complex and Utilities Plant (i.e. Other Components of the RAPID Project) to compute the cumulative noise of the entire RAPID development.

2.4 Modelling Scenarios

The scenarios that were considered for noise modelling were:

a) Scenarios for **"Normal"** operations – all process units operating simultaneously under normal process conditions.
b) **"Abnormal"** conditions – emergency discharge flaring of the Petchem common flare with process units shut down during emergency.

Normal conditions for process unit operations were assumed on the basis that the equipment are operating continuously (day and night). In situations where there are multiple equipment (equipment supplied in parallel pairs and/or multiples. i.e. with spares) only the duty unit(s) shall be operating.

Abnormal conditions are on the basis that RAPID plant-wide disruptions shall result in emergency venting at full capacity of the RAPID common flare stack with an assumed sound pressure level of 135 dBA at the base of flare stack.

Noise maps for the different the following conditions are presented below:

- Case 1: Normal operations for Refinery and Cracker Complex;
- Case 2: Normal operations for combined Refinery, Cracker Complex, Petchem Complex and Utilities (entire RAPID development); and
- Case 3: Abnormal conditions for combined Refinery, Cracker Complex, Petchem Complex and Utilities.

Noise maps are presented which showed noise levels to areas in vicinity of the RAPID Complex boundary and beyond the boundary (extended beyond 5 km range).

Atmospheric conditions assumed for the modelling were averages for temperature (28 °C) and relative humidity (83 % RH) at the Project site, with no prevailing wind.

2.5 Noise Sources

Noise sources were typically process equipment and process lines of the respective process units. The noise sources were extracted from the list of equipment from the Front End Engineering Design (FEED) of the process unit. A summary of equipment types and noise sources for each process unit is listed in **Table 2.1**. The details of noise source from EURO 5 MOGAS Units and Olefins Storage Tankages are shown in **Sub-Appendix 4A**.

Table 2.1: Summary of Equipment Types and Noise Sources for EURO 5 MOGAS Units and Olefins Storage Tankages

No.	Process Unit	Equipment
1	Cracked Naptha Hydrotreating Unit, Etherification Unit, Isomerization Unit	Pumps, condensers, fans, compressors, fans, coolers, heat exchangers, reactors
2	EURO 5 MOGAS Additional Tank Farm	Pumps
3	Olefins Tank Farm	Compressors & compression packages, cooling towers, coolers, pumps, filter and dosing packages, cold flare package

The Petchem flare was also considered in the noise model under additional noise scenarios for abnormal condition.

Equipment noise for the RAPID Project was specified in Project Specification-*Equipment Noise Specification*. These specifications stipulated maximum permissible noise limit for all equipment at 85 dBA (at 1 m), and for lower capacity equipment (pumps, air coolers, etc.) of lower capacity equipment to be 82 dBA (1m). In instances where information of equipment capacities was not available, the more stringent 85 dBA criteria were assumed. Noise modelling assumptions were therefore conservative for some equipment that may eventually be installed with lower power ratings.

The sound emission levels for the respective equipment types are summarised in **Table 2.2**.

Table 2.2: Summary of Equipment Noise Emission Levels

Equipment	Rating	Noise Emission, SPL at 1 m
Compressors	All types	85 dBA
Fans and Blowers	All types	85 dBA
Pumps	<50 kW 50kW<P<200kW >200 kW	80 dBA 82 dBA 85 dBA
Air Coolers	All types	82 dBA
Heaters, Boilers, Incinerators, Gas Treatment Packages	All types	85 dBA
Cooling Towers	All types	85 dBA
Drier Package	All types	85 dBA
All other Packages	All types	82 dBA

Source: Project Specification- Equipment Noise Specification, PETRONAS 2013.

Sound power levels with noise frequency spectrum for equipment types used in the modelling were assumed to comply with the maximum noise limit criteria (at 1 m) as specified in the Project Engineering Design.

2.6 Sensitive Receptors

The identified sensitive receptors are shown in **Volume 1**, **Chapter 3** and **Chapter 4**.

3 FINDINGS

3.1 Individual Process Units

Noise levels for the proposed new process units making up the EURO 5 MOGAS Units and Olefins Storage Tankages at the RAPID Complex boundary and residential communities of interest were evaluated based on the following:

- Permissible limits for different receiving land use in accordance Schedule 1, Planning Guidelines for Environmental Noise Limits and Control at the noise sensitive receivers.
- DOE EIA Approval Limits at the RAPID Complex boundary.
- Noise levels as compared against the existing environment using measured baseline noise levels established in October 2012.
- Noise impact severity based on the noise increase above the baseline levels (existing noise climate) as per DOE Guidelines.

a) New EURO 5 MOGAS Unit

Results of noise levels are tabulated in **Table 3.1**. Key findings are summarised as follows:

- Noise emissions are fairly confined within the process unit area at the respective cracked naptha unit, hydrotreating unit, etherification unit and isomerization unit. pumps and extruder areas and chilled water packages locations.

- The maximum steady state equivalent L_{Aeq} noise levels at the units' boundaries were typically 64 dBA to 67 dBA on the east and south boundaries, 66 dBA to 68 dBA on the north, and 60 dBA to 73 dBA on the west boundaries. At the Storage units, the noise levels were lower at 49 dBA to 59 dBA at the respective boundaries.

- Noise emissions from these process units propagated to the RAPID boundary was predicted to be less than 37 dBA at the west and east boundaries, and less than 35 dBA at the south, and up to 45 dBA L_{Aeq} at localized locations on the north boundary.

- Noise emissions during operations stage of the process unit were predicted to be negligible to all identified sensitive receptors at the RAPID Complex boundary

Table 3.1: Steady State Equivalent L_{Aeq} Noise Levels from EURO 5 MOGAS Unit

Location	Maximum Steady State L_{Aeq}			
	North	West	South	East
At Cracked Naptha Hydrotreating Unit Boundary	66 dBA	72 dBA	68 dBA	64 dBA
At Etherification Unit Boundary	68 dBA	73 dBA	67 dBA	67 dBA
At Isomerization Unit Boundary	66 dBA	60 dBA	67 dBA	64 dBA
At Storage Units Boundary	59 dBA	49 dBA	59 dBA	57 dBA
At RAPID Complex Boundary	<45 dBA	<37 dBA	<35 dBA	<37 dBA

b) Olefins Storage Tankages

Results of noise levels are tabulated in **Table 3.2**. Key findings are summarised below.

- Noise emissions from the Olefin Tank Farm units' boundaries were determined to be typically 41 to 56 dBA on the north boundary, 49 dBA to 64 dBA on the east, 45 dBA to 59 dBA on the south and 41 dBA to 48 dBA on the west boundary.

- Noise emissions from this process unit propagated to the RAPID boundary was predicted to be less than 35 dBA at the north, east and west boundaries, and less than 36 dBA at the south unit.

- This implied that the unit noise on its own has no impact to all receivers beyond the RAPID boundary.

Table 3.2: Steady State Equivalent L_{Aeq} Noise Levels from Olefins Storage Tankages

Location	Maximum Steady State L_{Aeq}			
	North	West	South	East
At Olefin Tank Farm Unit Boundary	56 dBA	48 dBA	59 dBA	64 dBA
At RAPID Complex Boundary	<35 dBA	<35 dBA	<35 dBA	<35 dBA

3.2 Cumulative Refinery and Cracker Complex

Results for noise propagation of the Refinery and Cracker Complex process units including the new EURO 5 MOGAS Units and Olefins Storage Tankages are presented in noise maps (at elevation of 4 m) for normal operating conditions (**Sub Appendix 4B**).

Noise emissions from the Refinery and Cracker Complex units on its own propagated to sensitive receptors are tabulated in **Table 3.3.** Assessment of the noise emissions perceived at sensitive receptors inclusive of the prevailing ambient noise are given in **Table 3.5 and Table 3.6.** The tabulation includes existing baseline noise levels (daytime and night time) and DOE Guidelines and EIA compliance limits for comparisons.

- Noise propagated to these receivers (normal operations with no Petchem flare) from the Refinery and Cracker Complex, inclusive of the proposed

EURO 5 MOGAS Units and Olefins Storage Tankages were below 35 dBA to all noise sensitive areas, except for Kg. Lepau with noise level of 54.7 dBA.

- The Refinery and Cracker Complex noise emissions when added to the existing baseline noise of the respective receivers had resultant noise maintained at the receivers' current ambient levels at all receivers, except Kg. Lepau that had an increase of 8.1 dBA daytime and 7.3 dBA night time.

The resultant noise of the Refinery and Cracker Complex process units when assessed against Schedule 1 DOE Noise Guideline noise limits confirmed compliance to the recommended limits for residential land use at all sensitive receptors, with the exception of Kg. Lepau. There were also other locations (Kg. Rengit and Kg. Pasir Gogok) with noise levels above the DOE Guidelines levels due to existing high ambient noise levels at these receptors and not from the Refinery and Cracker Complex.

Table 3.3: Summary of Noise Levels from Refinery & Cracker Complex and Other RAPID Components at Sensitive Receptors - Normal Conditions

No.	Sensitive Receptor	Equivalent Noise L_{eq} (dBA)	
		Refinery and Cracker Plant	Cumulative from Refinery, Cracker Complex, Petchem Complex and Utilities
N1	Tg. Pengelih	<35	<35
N2	Pengelih Naval Base	<35	<35
N3	Kg. Pengerang	<35	<35
N4	Kg. Sg. Kapal	<35	<35
N5	Taman Rengit Jaya	<35	<35
N6	Kg. Sg. Buntu	<35	<35
N7	Kg. Bukit Buloh	<35	<35
N8	Kg. Sg. Rengit	<35	<35
N9	Kg. Bukit Gelugor	<35	<35
N10	Kg. Lepau	54.7	54.7
N11	Kg. Pasir Gogok	<35	<35

Table 3.4: Summary of Noise Levels from Refinery & Cracker Complex and Other RAPID Components at Sensitive Receptors - Abnormal Conditions

No.	Sensitive Receptor	Equivalent Noise L_{eq} (dBA)
		Cumulative from Refinery, Cracker Complex, Petchem Complex and Utilities
N1	Tg. Pengelih	<35
N2	Pengelih Naval Base	61.3
N3	Kg. Pengerang	62.7
N4	Kg. Sg. Kapal	62.7
N5	Taman Rengit Jaya	38.1
N6	Kg. Sg. Buntu	<35
N7	Kg. Bukit Buloh	<35
N8	Kg. Sg. Rengit	<35
N9	Kg. Bukit Gelugor	<35
N10	Kg. Lepau	74.0
N11	Kg. Pasir Gogok	<35

Table 3.5 Summary of Predicted Cumulative Noise Level from RAPID Refinery and Cracker Complex Noise Levels during Day Time - Normal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliance Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery & Cracker Complex L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	55.6	<35	55.6	0	55	58.6
N2	Pengelih Naval Base	55.6	<35	55.6	0	55	58.6
N3	Kg. Pengerang	50.5	<35	50.6	0	55	55
N4	Kg. Sg. Kapal	51.9	<35	52.0	0	55	55
N5	Taman Rengit Jaya	51.9	<35	51.9	0	55	55
N6	Kg. Sg. Buntu	49.1	<35	49.1	0	55	55
N7	Kg. Bukit Buloh	43.4	<35	43.5	0	55	55
N8	Kg. Sg. Rengit	70.7	<35	70.7	0	55	73.7
N9	Kg. Bukit Gelugor	45.2	<35	45.2	0	55	55
N10	Kg. Lepau	47.3	54.7	55.5	8.1	55	55
N11	Kg. Pasir Gogok	72.1	<35	72.1	0	55	75.1

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.
The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

Table 3.6 Summary of Predicted Cumulative Noise Level from RAPID Refinery and Cracker Complex Noise Levels during Night Time - Normal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliances Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery & Cracker Complex L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	48.1	<35	48.1	0	45	51.1
N2	Pengelih Naval Base	48.1	<35	48.1	0	45	51.1
N3	Kg. Pengerang	46.2	<35	46.2	0	45	49.2
N4	Kg. Sg. Kapal	52.3	<35	52.3	0	45	55.3
N5	Taman Rengit Jaya	51.7	<35	51.7	0	45	54.7
N6	Kg. Sg. Buntu	46.2	<35	46.2	0	45	49.2
N7	Kg. Bukit Buloh	42.7	<35	42.7	0	45	45
N8	Kg. Sg. Rengit	61.5	<35	61.5	0	45	64.5
N9	Kg. Bukit Gelugor	42.3	<35	42.3	0	45	45
N10	Kg. Lepau	48.3	54.7	55.6	7.3	45	51.3
N11	Kg. Pasir Gogok	61.9	<35	61.9	0	45	64.9

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.
The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

3.3 Cumulative RAPID Complex

Cumulative noise impact of the Refinery and Cracker Complex (inclusive of the new EURO 5 MOGAS Units and Olefins Storage Tankages) with Other RAPID Components (i.e. Petrochemical Complex, Utilities and other supporting facilities) were also examined.

Noise studies for the RAPID Petrochemical Complex were undertaken in a Detailed EIA followed up an Addendum Study based on most current plant re-configurations and had been documented in the respective DEIA and Addendum Study Reports. The modelling undertaken herein for a cumulative RAPID Complex (i.e. Refinery and Cracker Complex (inclusive of the new EURO 5 MOGAS Units and Olefins Storage Tankages combined with Other RAPID components) provided noise propagation maps for the entire RAPID Complex.

Noise propagation maps (at elevation of 4 m) for normal and abnormal operating conditions are given in **Sub Appendix 4B**. **Table 3.3** tabulate noise levels of the cumulative RAPID Complex under normal operating conditions, and **Table 3.4** under abnormal conditions with emergency Petchem flare.

Assessment of the noise emissions perceived at sensitive receptors inclusive of the prevailing ambient noise for normal conditions are given in **Table 3.7** and **Table 3.8**; and for abnormal conditions given in **Table 3.9** and **Table 3.10.** The tabulation includes existing baseline noise levels (daytime and night time) and DOE Guidelines and EIA compliance limits for comparisons.

Observations and key findings for the cumulative noise of the RAPID Complex (Refinery, Cracker Complex, Petchem Complex, Utilities and other supporting facilities) are summarised as follows.

a) Normal Operating Conditions

- Cumulative noise propagated to these receivers (normal operations with no Petchem flare) from the Refinery, Cracker Complex (inclusive of the proposed EURO 5 MOGAS Units and Olefins Storage Tankages), Petchem Complex and Utilities were below 35 dBA to all noise sensitive areas, except for Kg. Lepau with noise level of 54.7 dBA attributable to process units of the Refinery (but not the EURO 5 MOGAS Units and Olefins Storage Tankages) at the northern boundary.
- The RAPID Complex noise emissions when added to the existing baseline noise of the respective receivers had resultant noise maintained at the receivers' current ambient levels at all receivers, except Kg. Lepau that had an increase of 8.1 dBA daytime and 7.3 dBA night time.
- The resultant noise of the Refinery and Cracker Complex process units when assessed against Schedule 1 DOE Noise Guideline noise limits confirmed compliance to the recommended limits for residential land use at all sensitive receptors, with the exception of Kg. Lepau. There were also other locations (Kg. Rengit and Kg. Pasir Gogok) with noise levels above the DOE Guidelines levels due to existing high ambient noise levels at these receptors and not from the Refinery and Cracker Complex.
- For normal operating condition, the cumulative noise level from RAPID Complex (Refinery, Cracker Plant, Petrochemical Complex and utilities) were below EIA Approval noise limits (*Pindaan Syarat Kelulusan Laporan EIA Terperinci* dated 7th January 2013) at all RAPID boundaries.

b) Abnormal Conditions

- Noise propagated under abnormal conditions mainly due to emergency flaring from the RAPID Common Flare resulted in noise levels of 74 dBA at Kg Lepau (due to proximity of this receptor to the

RAPID development), and 61 dBA to 63 dBA at Pengelih Naval Base, Kg. Pengerang and Kg. Sg Kapal. At other sensitive receptors noise levels under abnormal conditions were below 35 dBA to 40 dBA.

- The above mentioned receptors are anticipated to have resultant noise levels during these abnormal conditions to be significantly higher than the respective prevailing ambient noise levels (i.e. significant noise level increase above baseline levels) daytime and night time.
- The noise levels under abnormal conditions when assessed against EIA Approval noise limits (*Pindaan Syarat Kelulusan Laporan EIA Terperinci* dated 7th January 2013) showed that all sensitive receptors were below the EIA Approval limits, except for Pengelih Naval Base, Kg. Pengerang, Kg. Sg. Kapal, Kg. Sg Rengit and Kg. Lepau.
- In general, the operation of RAPID Petrochemical Plants and RAPID Complex has insignificant increase from the baseline level to the surroundings and at identified sensitive receptor locations;
- The projected cumulative noise level from RAPID Complex (Petrochemical Plants and other RAPID components) received by the receptors ranges from 39.1 dBA (at Tg Pengelih) to 55.2 dBA (at Kg Lepau);
- Noise level generated by the RAPID Petrochemical Plants when they are in operation is predicted to be below the required compliance noise level at the sensitive receptors locations except for Kg Lepau, which is closest to the nothern RAPID site boundary.
- ▪ The projected noise generated level generated by the Petrochemical Plant operation to Kg Lepau exceeds the compliance limit at night time by 3.0 dBA i.e. 54.3 dBA compared to the compliance limit of 51.3 dBA;
- When RAPID Complex is in full operation, the projected cumulative noise level for daytime is expected to be below the required compliance limit at the sensitive receptor locations except for noise level at Kg Lepau where the noise level is higer by 0.8 dBA from the compliance noise limit.

- It is to be noted that the above noise impact occurs during abnormal conditions when the RAPID Common flare is in operation which happens only during upset or emergency conditions. Under such circumstances, flaring is also typically short duration.

Table 3.7 Summary of Predicted Cumulative Noise Level from RAPID Refinery, Cracker Plant, Petrochemical Complex and Utilities during Day Time - Normal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliance Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery, Cracker Complex, Petchem Complex and Utilities L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	55.6	<35	55.6	0	55	58.6
N2	Pengelih Naval Base	55.6	<35	55.6	0	55	58.6
N3	Kg. Pengerang	50.5	<35	50.6	0	55	55
N4	Kg. Sg. Kapal	51.9	<35	52.0	0	55	55
N5	Taman Rengit Jaya	51.9	<35	51.9	0	55	55
N6	Kg. Sg. Buntu	49.1	<35	49.1	0	55	55
N7	Kg. Bukit Buloh	43.4	<35	43.5	0	55	55
N8	Kg. Sg. Rengit	70.7	<35	70.7	0	55	73.7
N9	Kg. Bukit Gelugor	45.2	<35	45.2	0	55	55
N10	Kg. Lepau	47.3	54.7	55.5	8.1	55	55
N11	Kg. Pasir Gogok	72.1	<35	72.1	0	55	75.1

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.
The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

Table 3.8 Summary of Predicted Cumulative Noise Level from RAPID Refinery, Cracker Plant, Petrochemical Complex and Utilities during Night Time - Normal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliances Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery, Cracker Complex, Petchem Complex and Utilities L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	48.1	<35	48.1	0	45	51.1
N2	Pengelih Naval Base	48.1	<35	48.1	0	45	51.1
N3	Kg. Pengerang	46.2	<35	46.2	0	45	49.2
N4	Kg. Sg. Kapal	52.3	<35	52.3	0	45	55.3
N5	Taman Rengit Jaya	51.7	<35	51.7	0	45	54.7
N6	Kg. Sg. Buntu	46.2	<35	46.2	0	45	49.2
N7	Kg. Bukit Buloh	42.7	<35	42.7	0	45	45
N8	Kg. Sg. Rengit	61.5	<35	61.5	0	45	64.5
N9	Kg. Bukit Gelugor	42.3	<35	42.3	0	45	45
N10	Kg. Lepau	48.3	54.7	55.6	7.3	45	51.3
N11	Kg. Pasir Gogok	61.9	<35	61.9	0	45	64.9

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.
The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

Table 3.9 Summary of Predicted Cumulative Noise Level from RAPID Refinery, Cracker Plant, Petrochemical Complex and Utilities during Day Time - Abnormal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliance Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery, Cracker Complex, Petchem Complex and Utilities L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	55.6	<35	55.6	0	55	58.6
N2	Pengelih Naval Base	55.6	61.3	62.3	6.7	55	58.6
N3	Kg. Pengerang	50.5	62.7	63.0	12.5	55	55
N4	Kg. Sg. Kapal	51.9	62.7	63.0	11.1	55	55
N5	Taman Rengit Jaya	51.9	38.1	52.1	0.2	55	55
N6	Kg. Sg. Buntu	49.1	<35	49.1	0	55	55
N7	Kg. Bukit Buloh	43.4	<35	43.5	0	55	55
N8	Kg. Sg. Rengit	70.7	<35	70.7	0	55	73.7
N9	Kg. Bukit Gelugor	45.2	<35	45.2	0	55	55
N10	Kg. Lepau	47.3	74.0	74.0	26.7	55	55
N11	Kg. Pasir Gogok	72.1	<35	72.1	0	55	75.1

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.
The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

Table 3.10 Summary of Predicted Cumulative Noise Level from RAPID Refinery, Cracker Plant, Petrochemical Complex and Utilities during Night Time - Abnormal Operating Conditions

Location	Sensitive Receptors	Baseline Noise Levels, Oct 2012 (dBA)	Noise Level from Refinery and Cracker Complex (dBA)			DOE Noise Guideline Level*	Compliances Noise Level# (+3 dBA to the Baseline if higher than the regulated DOE limit)
			Noise Level from Refinery, Cracker Complex, Petchem Complex and Utilities L_{Aeq}	Noise level at Receptors L_{Aeq}	Noise Increment		
N1	Tg. Pengelih	48.1	<35	48.1	0	45	51.1
N2	Pengelih Naval Base	48.1	61.3	62.3	13.4	45	51.1
N3	Kg. Pengerang	46.2	62.7	63.0	16.6	45	49.2
N4	Kg. Sg. Kapal	52.3	62.7	63.0	10.8	45	55.3
N5	Taman Rengit Jaya	51.7	38.1	52.1	0.2	45	54.7
N6	Kg. Sg. Buntu	46.2	<35	49.1	0	45	49.2
N7	Kg. Bukit Buloh	42.7	<35	43.5	0	45	45
N8	Kg. Sg. Rengit	61.5	<35	70.7	0	45	64.5
N9	Kg. Bukit Gelugor	42.3	<35	45.2	0	45	45
N10	Kg. Lepau	48.3	74.0	74.0	25.7	45	51.3
N11	Kg. Pasir Gogok	61.9	<35	61.9	0	45	64.9

Note: * Schedule 1 Maximum Permissible Sound Level (L_{Aeq}) by Suburban Residential Area for Planning and New Development of the Planning Guidelines for Environmental Noise Limits and Control, DOE, 2007.# The compliances noise level at the receptors is taken as baseline + 3 dBA if the current baseline is higher than the DOE Noise Guidelines Level (Schedule 3 Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate, DOE, 2007.

4 MITIGATION MEASURES

4.1 Potential Impact

- Potential impact under normal plant operations are typically marginal noise increase to Kg, Lepau with nominal increase in the ambient noise levels not likely to result in significant nuisance to the surrounding communities.
- Under abnormal conditions, there is a temporary noise disturbance which are transient (short duration) during the RAPID Complex emergency flaring for Plant safety.

4.2 Mitigating Measures

The proposed noise mitigation measures are:

- Specification in the design that requires for use of acoustic enclosures for high noise-generating equipment. These are usually for compression package systems and turbine driven generators (if used). Other high noise equipment (chillers, etc.) could also be installed within an enclosed room / area. Major noise sources and/or equipment at these other RAPID components shall be fitted with acoustics enclosures, silencers or acoustic lagging as appropriate.
- Noise from Petchem flare during normal plant operations shall be mitigated through design and selection of the flare system that specify for use of low noise flare types and/or pressure reduction devices.

SUB-APPENDIX 4A: LIST OF NOISE SOURCES FROM EURO 5 MOGAS UNITS AND OLEFINS STORAGE TANKAGES

CRACKED NAPHTHA HYDROTREATING UNIT: 2ND STAGE HYDRODESULFURIZATION SECTION (CNHT2)

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
1410-R-004	2ND STAGE HDS REACTOR	REACTOR										75
1410-E-027 A/B/C/D	2ND STAGE HDS REACTOR FEED/EFFLUENT EXCHANGER	EXCHANGER										75
1410-E-028	2ND STAGE HDS REACTOR FEED/EFFLUENT EXCHANGER	EXCHANGER										75
1410-E-030 A/B	2ND STAGE HDS STABILIZER FEED/BOTTOMS EXCHANGER	EXCHANGER										75
1410-E-031	2ND STAGE HDS STABILIZER REBOILER	EXCHANGER										75
1410-E-034	2ND STAGE HDS PRODUCT TRIM COOLER	EXCHANGER										75
1410-E-029	2ND STAGE HDS REACTOR EFFLUENT AIR CONDENSER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1410-E-032	2ND STAGE HDS STABILIZER OVERHEAD AIR CONDENSER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1410-E-033	2ND STAGE HDS PRODUCT AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1410-F-002	2ND STAGE HDS REACTOR HEATER		63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
1410-P-025 A/B	2ND STAGE HDS FEED PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-026 A/B	2ND STAGE HDS WASHING WATER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-027 A/B	2ND STAGE HDS QUENCH PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-028 A/B	2ND STAGE HDS STABILIZER REFLUX PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-029 A/B	2ND STAGE HDS SOUR WATER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-030 A/B	2ND STAGE HDS PRODUCT PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-P-031 A/B	2ND STAGE HDS LEAN AMINE PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1410-K-003 A/B	2ND STAGE HDS RECYCLE GAS COMPRESSOR	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85

ETHERIFICATION (TAME) UNIT

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
1440-E-001	FEED PREHEATER	EXCHANGER										75
1440-E-002	INTERSTAGE AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-003	INTERSTAGE WATER COOLER	EXCHANGER										75
1440-E-004	2ND REACTOR EFFLUENT/METHANOL COLUMN TOP EXCHANGER	EXCHANGER										75
1440-E-005	TAME FRACTIONATOR FEED/BOTTOM EXCHANGER	EXCHANGER										75
1440-E-006	TAME FRACTIONATOR REBOILER	EXCHANGER										75
1440-E-007	TAME PRODUCT AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-008	TAME PRODUCT WATER COOLER	EXCHANGER										75

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
1440-E-009	TAME FRACTIONATOR AIR CONDESER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-010	3RD REACTOR PRE-HEATER	EXCHANGER										75
1440-E-011	RAFFINATE COLUMN FEED AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-012	RAFFINATE COLUMN FEED WATER COOLER	EXCHANGER										75
1440-E-013 A/B	METHANOL COLUMN FEED / BOTTOM EXCHANGER	EXCHANGER										75
1440-E-014	RECYCLED WATER AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-015	RECYCLED WATER WATER COOLER	EXCHANGER										75
1440-E-016	METHANOL COLUMN REBOILER	EXCHANGER										75
1440-E-017	METHANOL COLUMN AIR CONDENSER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1440-E-018	ATMOSPHERIC FLASH STEAM CONDENSER	EXCHANGER										75
1440-E-019	POLLUTABLE FLASH STEAM CONDENSER	EXCHANGER										75
1440-P-001 A/B	LCN FEED PUMPS	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-002 A/B	TAME PRODUCT PUMPS	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-003 A/B	TAME FRACTIONATOR REFLUX PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-004 A/B	METHANOL COLUMN REFLUX PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-005 A/B	RECYCLED WATER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-006 A/B	TAA WITHDRAWING PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-007 A/B	METHANOL MAKE-UP PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-008 A/B	METHANOL DRAIN PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-009 A/B	HC DRAIN PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-010	DEFINING PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-011 A/B	WATER EFFLUENT BOOSTER PUMPS	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-012 A/B	ATMOSPHERIC STEAM CONDENSATE PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-P-013 A/B	POLLUTABLE STEAM CONDENSATE PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1440-R-001	1ST REACTOR	REACTOR										75
1440-R-002	2ND REACTOR	REACTOR										75
1440-R-003	3RD REACTOR	REACTOR										75
1440-M-001	FEED/METHANOL STATIC MIXER	MOTOR	56.3	73.9	86.1	98.3	102.4	102.4	95.6	82.1	95.0	85
1440-S-001 A/B	FEED FILTERS	FILTER										75
1440-S-003 A/B	1ST REACTOR RESIN FILTER	FILTER										75
1440-S-005 A/B	2ND REACTOR RESIN FILTER	FILTER										75
1440-S-007 A/B	3RD REACTOR RESIN FILTER	FILTER										75
1440-S-008 A/B	METHANOL GUARD POT FILTER	FILTER										75
1440-S-009	RAFFINATE COALESCER PRE-FILTER	FILTER										75

ISOMERIZATION UNIT

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m dB(A)
			63	125	250	500	1000	2000	4000	8000	AP	
1450-E-001	SULFUR GUARD BED FEED/EFFLUENT EXCHANGER	EXCHANGER										75
1450-E-003	SULFUR GUARD BED AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1450-E-004	H2 PURIFICATION FEED / EFFLUENT EXCHANGER	EXCHANGER										75
1450-E-005	H2 PURIFICATION TRIM COOLER	EXCHANGER										75
1450-E-007	1ST ISOM. FEED / EFFLUENT EXCHANGER	EXCHANGER										75
1450-E-008	1ST ISOM. REACTOR FEED HEATER	EXCHANGER										75
1450-E-009	STABILIZER FEED / BOTTOM EXCHANGER	EXCHANGER										75
1450-E-010	STABILIZER AIR CONDENSER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1450-E-011	STABILIZER REBOILER	EXCHANGER										75
1450-E-012	ISOMERATE AIR COOLER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1450-E-013	ISOMERATE TRIM COOLER	EXCHANGER										75
1450-E-014	CAUSTIC RECYCLE HEATER	EXCHANGER										75
1450-E-015	WATER MAKE UP TRIM COOLER	EXCHANGER										75
1450-E-016	DRYER REGENERANT VAPORIZER	EXCHANGER										75
1450-E-017	DRYER REGENERANT AIR CONDENSER	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
1450-E-018	DRYER REGENERANT TRIM COOLER	EXCHANGER										75
1450-E-021	LIGHT HC SLOP AIR COOLER	EXCHANGER										75
1450-E-022	LIGHT HC SLOP TRIM COOLER	EXCHANGER										75
1450-E-023	ATMOSPHERIC FLASH STEAM CONDENSER	EXCHANGER										75
1450-E-024	POLLUTABLE FLASH STEAM CONDENSER	EXCHANGER										75
1450-E-025 A/B	NEUTRALISATION COOLER	EXCHANGER										75
1450-P-001 A/B	FEED PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-002 A/B	CHLORIDING AGENT INJECTION PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-003 A/B	STABILIZER REFLUX PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-004 A/B	CAUSTIC CIRCULATION PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-005 A/B	WATER CIRCULATION PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-006 A/B	CAUSTIC MAKE UP PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-007 A/B	SPENT CAUSTIC PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-008 A/B	ATMOSPHERIC STEAM CONDENSATE PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-009 A/B	POLLUTABLE STEAM CONDENSATE PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-010 A/B	LIGHT HC SLOP PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-011 A/B	FLARE KO DRUM PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-012 A/B	CAUSTIC CLOSED DRAIN PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-013 A/B	CAUSTIC NEUTRALIZATION CIRCULATION PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-P-014 A/B	ISOM COC LIFTING PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
1450-P-015 A/B	ISOM / TAME ACC PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-R-001	H2 PURIFICATION REACTOR	REACTOR										75
1450-R-002 / 003	1ST AND 2ND ISOMERIZATION REACTOR	REACTOR										75
1450-M-001	FRESH CAUSTIC MIXER	MOTOR	56.3	73.9	86.1	98.3	102.4	102.4	95.6	82.1	95.0	85
1450-H-001	H2 PURIFICATION HEATER	HEATER	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
1450-H-002	DRYER REGENERANT SUPERHEATER (1)	HEATER	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
1450-A-001	REACTOR FEED HEATER DESUPERHEATER											75
1450-A-002	STABILIZER REBOILER DESUPERHEATER											75
1450-A-003	REGENERANT VAPORIZER DESUPERHEATER											75
1450-A-004	ISOM/TAME ACC SLOP OIL SKIMMER PACKAGE											75
1450-A-005	ACIDE DOSING PACKAGE	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
1450-J-001	START-UP EJECTOR											

ADDITIONAL EURO 5 MOGAS TANK FARM

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
5150-P-024 A/B	TAME TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-025 A/B	ISOMERATE TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-026 A/B	MCN TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-140 A/B	METHANOL TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-007 A/B	LIGHT SLOPS DRAIN DRUM PUMP (HC)	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-008 A/B	LIGHT SLOPS DRAIN DRUM PUMP (WATER)	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-009 A/B	TAME SLOPS DRAIN DRUM PUMP (HC)	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5150-P-010 A/B	TAME SLOPS DRAIN DRUM PUMP (WATER)	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5100-A-510	TANK FARM AREA ACC SLOP OIL SKIMMER PACKAGE											75
5100-P-515 A/B	TANK FARM AREA ACC PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5100-P-516 A/B	MCN STORAGE ACC PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5100-P-517 A/B	POTABLE WATER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5100-P-518 A/B	IMPOUNDING BASIN ACC PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85

OLEFINS STORAGE TANKAGES

Source		Type	Sound Power Level (A-WEIGHTED)									SPL @ 1m
			63	125	250	500	1000	2000	4000	8000	AP	dB(A)
5220-A-101	COOLING TOWER PACKAGE	FAN	85.2	86.8	86.0	88.7	88.4	87.4	82.6	75.1	95.7	85
5220-A-102	REFRIGERANT COMPRESSOR PACKAGE	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-A-103	IBC INHIBITOR INJECTION PACKAGE	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-A-105	ETHYLENE BOG COMPRESSOR PACKAGE	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-A-106	COLD FLARE PACKAGE	FLARE	77.2	81	81	87	90.7	90.7	91.4	82.5	95.0	85
5220-A-107	CHEMICAL DOSING PACKAGE	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-A-108	SIDE STREAM FILTER PACKAGE	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-E-101 A/B	BUTADIENE COOLER	EXCHANGER										75
5220-E-102	PROPYLENE COOLER	EXCHANGER										75
5220-E-103 A/B/C	2ND STAGE ETHYLENE BOG COMPRESSOR DISCHARGE COOLER	EXCHANGER										75
5220-E-104 A/B/C	3RD STAGE ETHYLENE BOG COMPRESSOR DISCHARGE COOLER	EXCHANGER										75
5220-E-105	ETHYLENE BOG CONDENSER	EXCHANGER										75
5220-E-106 A/B	REFRIGERANT COMPRESSOR DISCHARGE COOLER	EXCHANGER										75
5220-K-101 A/B/C	1ST STAGE ETHYLENE BOG COMPRESSOR	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-K-102 A/B/C	2ND STAGE ETHYLENE BOG COMPRESSOR	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-K-103 A/B/C	3RD STAGE ETHYLENE BOG COMPRESSOR	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-K-104 A/B	REFRIGERANT COMPRESSOR	COMPRESSOR	63.6	71.9	76.5	82.1	86.8	91.4	90.5	84.9	95.0	85
5220-P-101 A/B	BUTADIENE LOADING PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-P-102 A/B	BUTADIENE CIRCULATION / TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-P-103 A/B	ETHYLENE TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-P-104 A/B	PROPYLENE EXPORT PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-P-105 A/B	PROPYLENE TRANSFER PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-P-106 A/B	COOLING TOWER CIRCULATION PUMP	PUMP	55.4	67.7	77.7	84.4	91.1	88.9	84.4	75.5	95.0	85
5220-R-101	BUTADIENE RUNDOWN PIG LAUNCHER	PIPE										75
5220-R-102	BUTADIENE LOADING LINE PIG LAUNCHER	PIPE										75

SUB-APPENDIX 4B: NOISE CONTOUR MAP

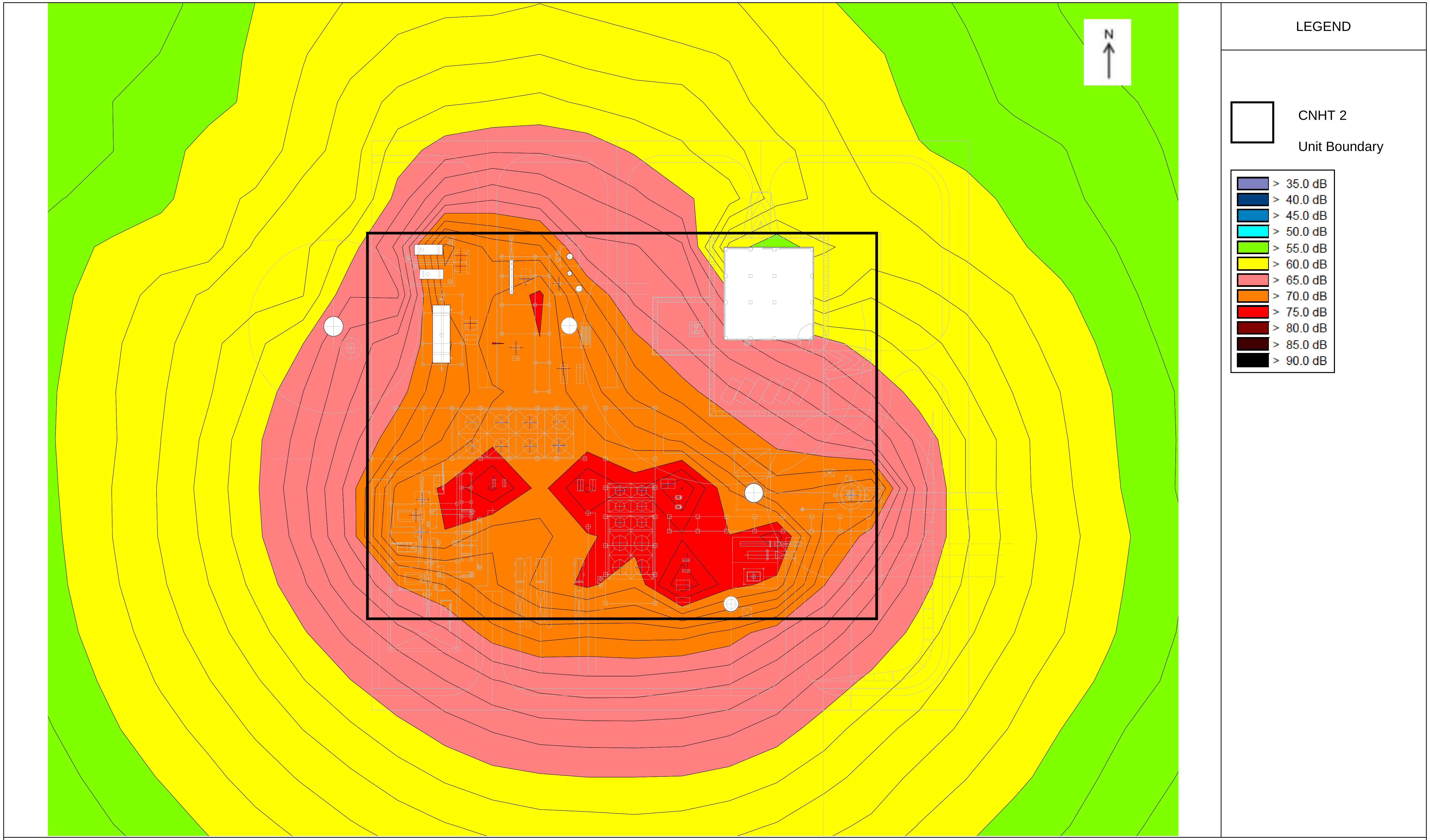


Figure 1: Noise Contour Generated from CNHT 2 Unit

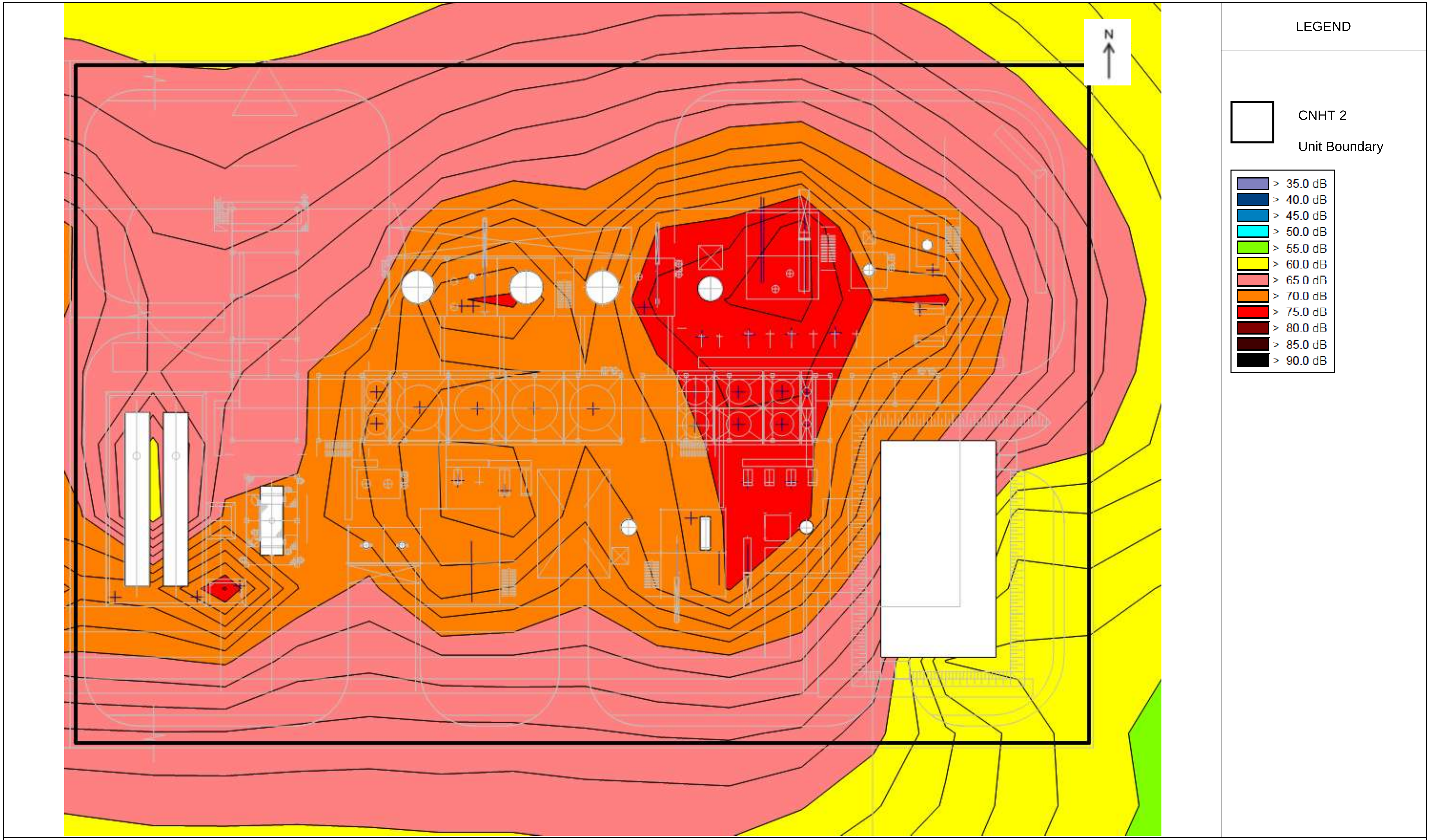


Figure 2: Noise Contour Generated from Etherification (TAME) Unit

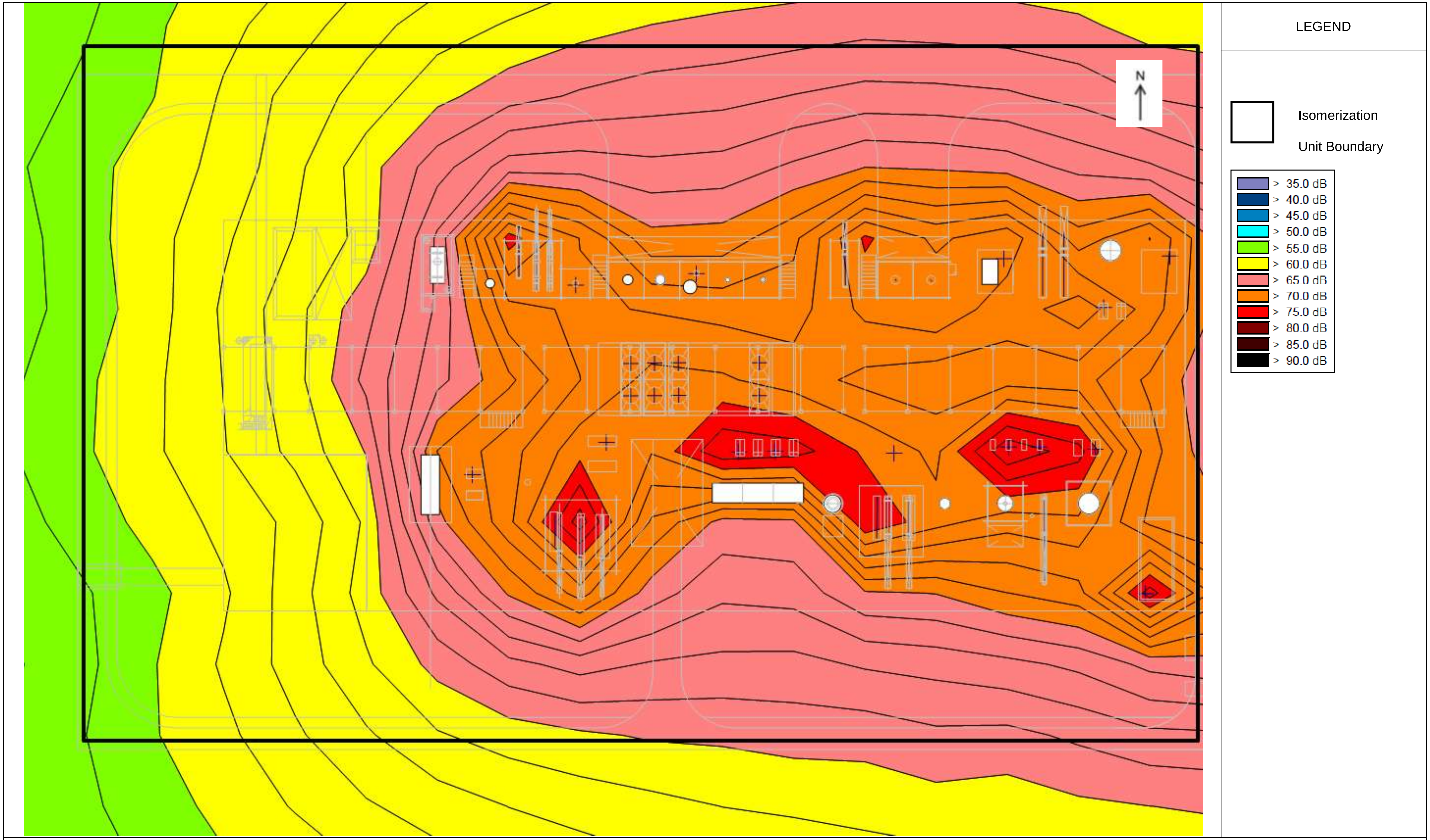


Figure 3: Noise Contour Generated from Isomerization Unit

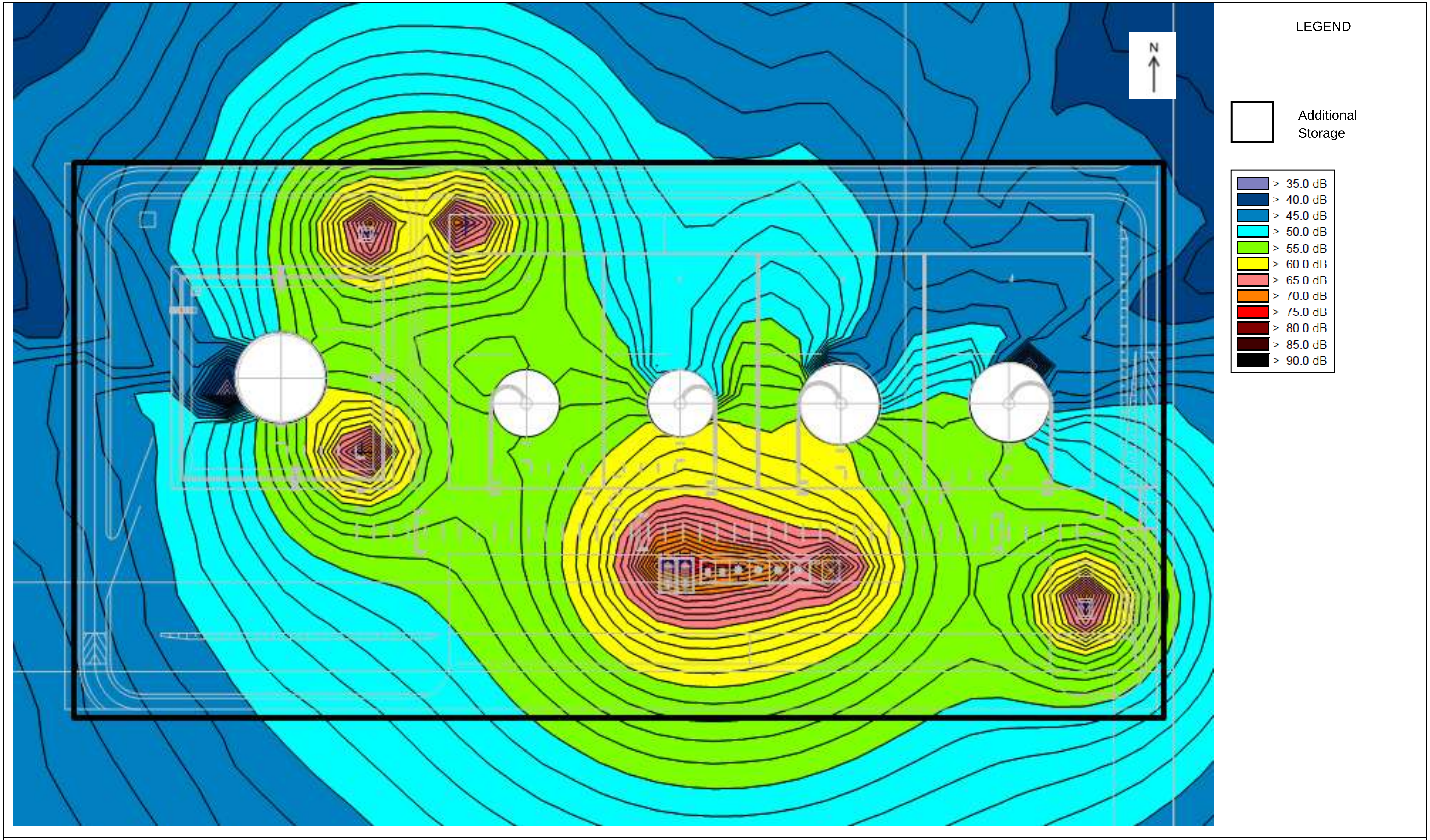


Figure 4: Noise Contour Generated from the Additional Storage Unit

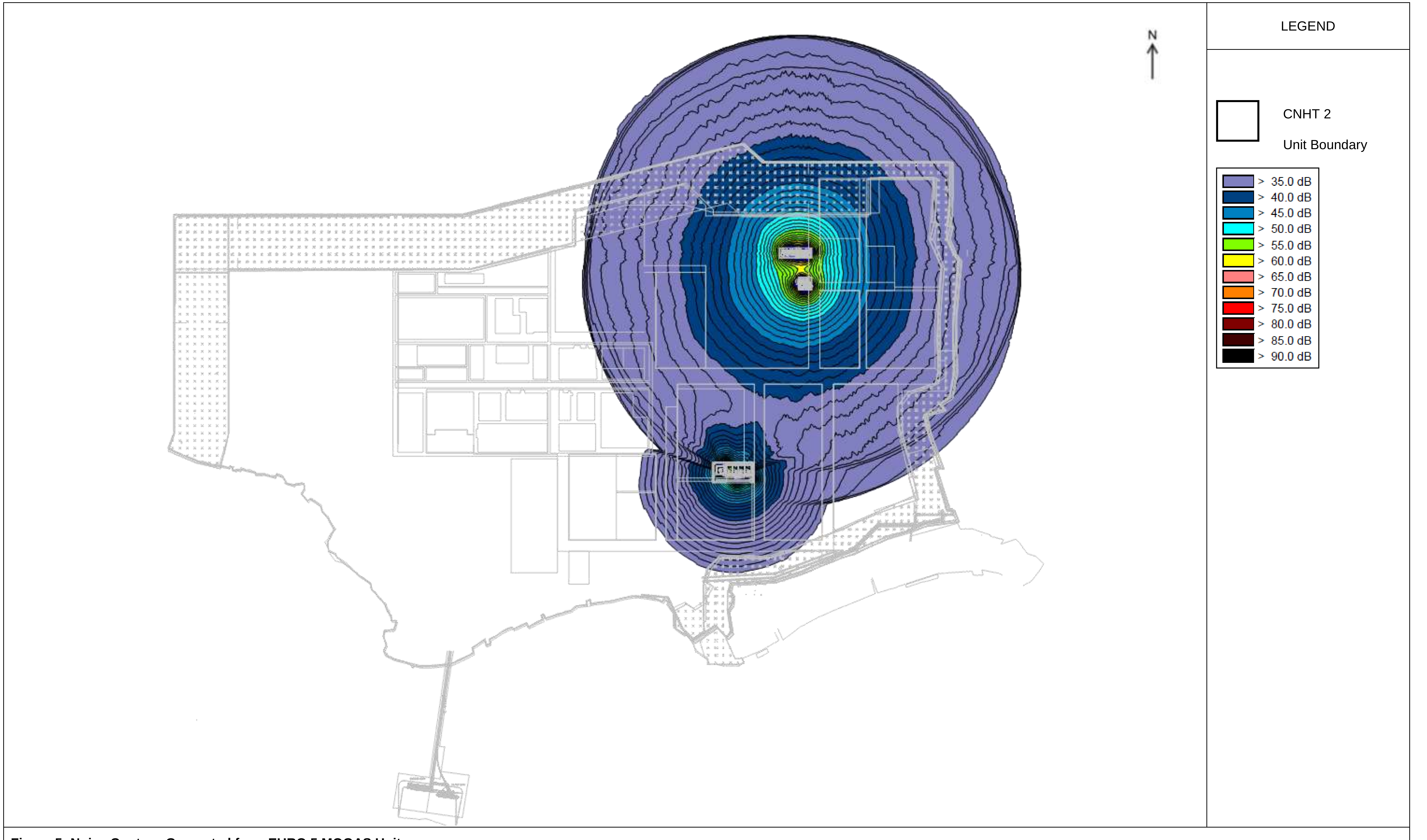


Figure 5: Noise Contour Generated from EURO 5 MOGAS Units

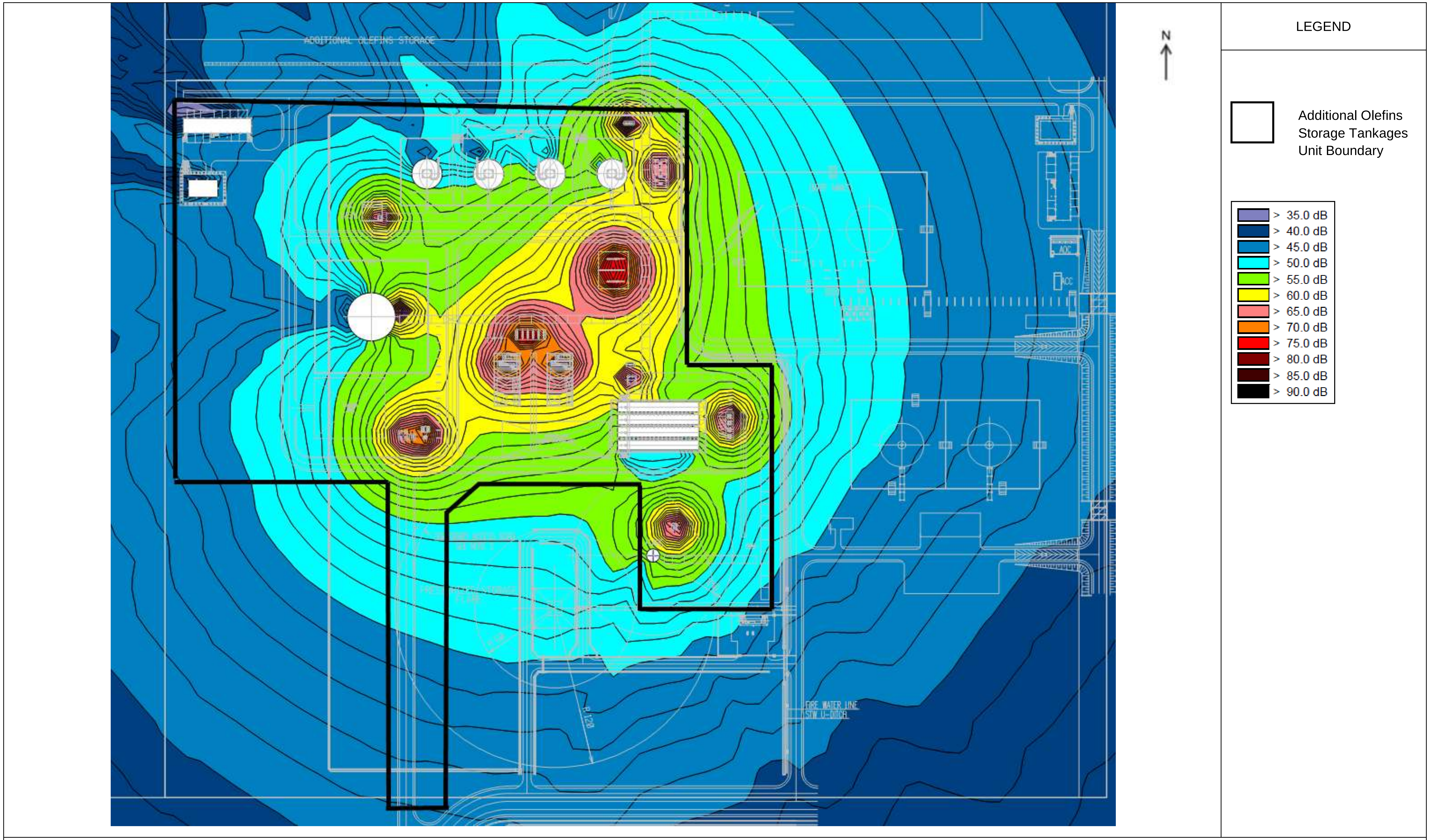


Figure 6: Noise Contour Generated from Additional Olefins Storage Tankages

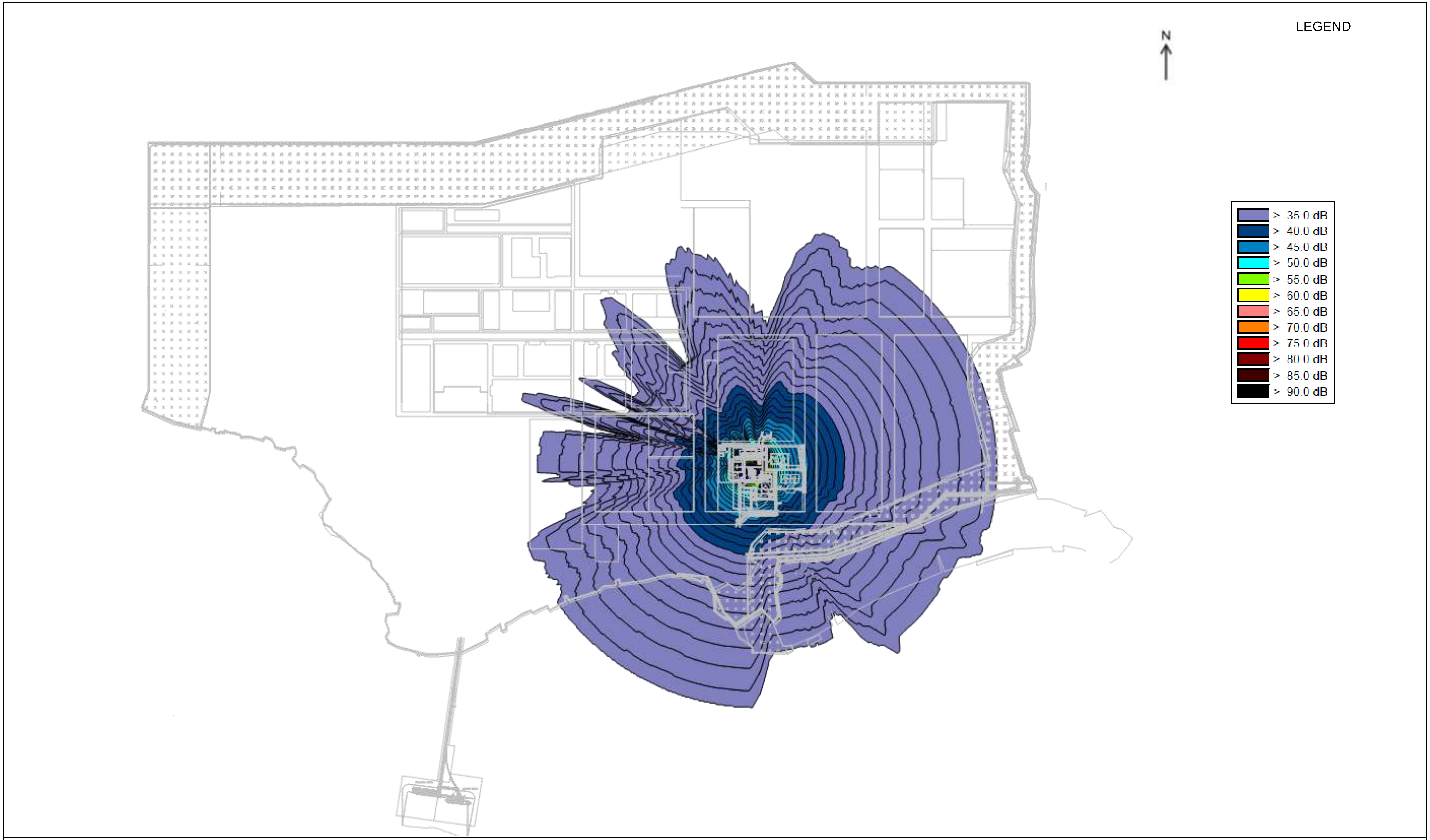


Figure 7: Noise Contour Generated from Olefins Storage Tankages

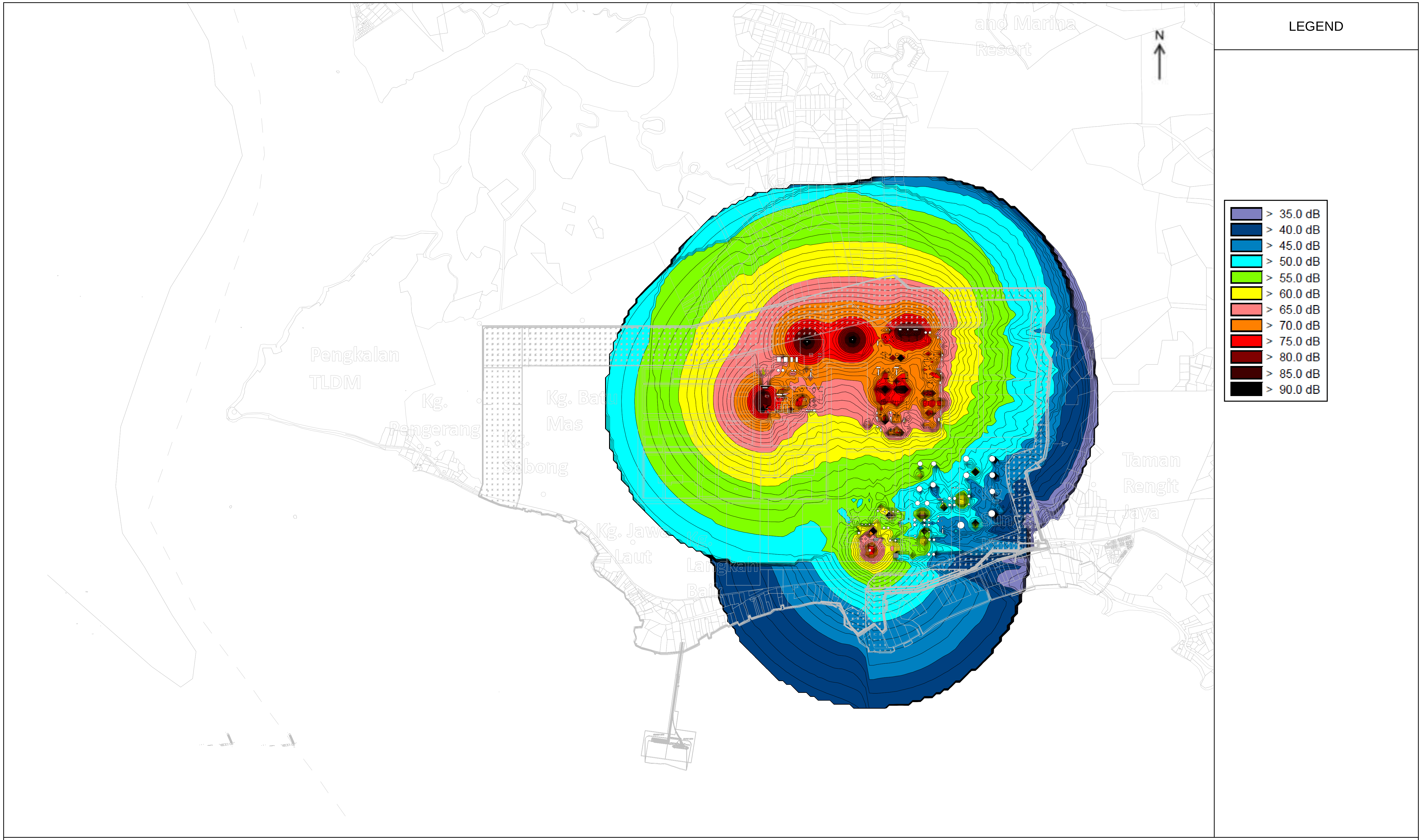


Figure 8: Noise Contours from Refinery and Cracker Complex - Normal operations.

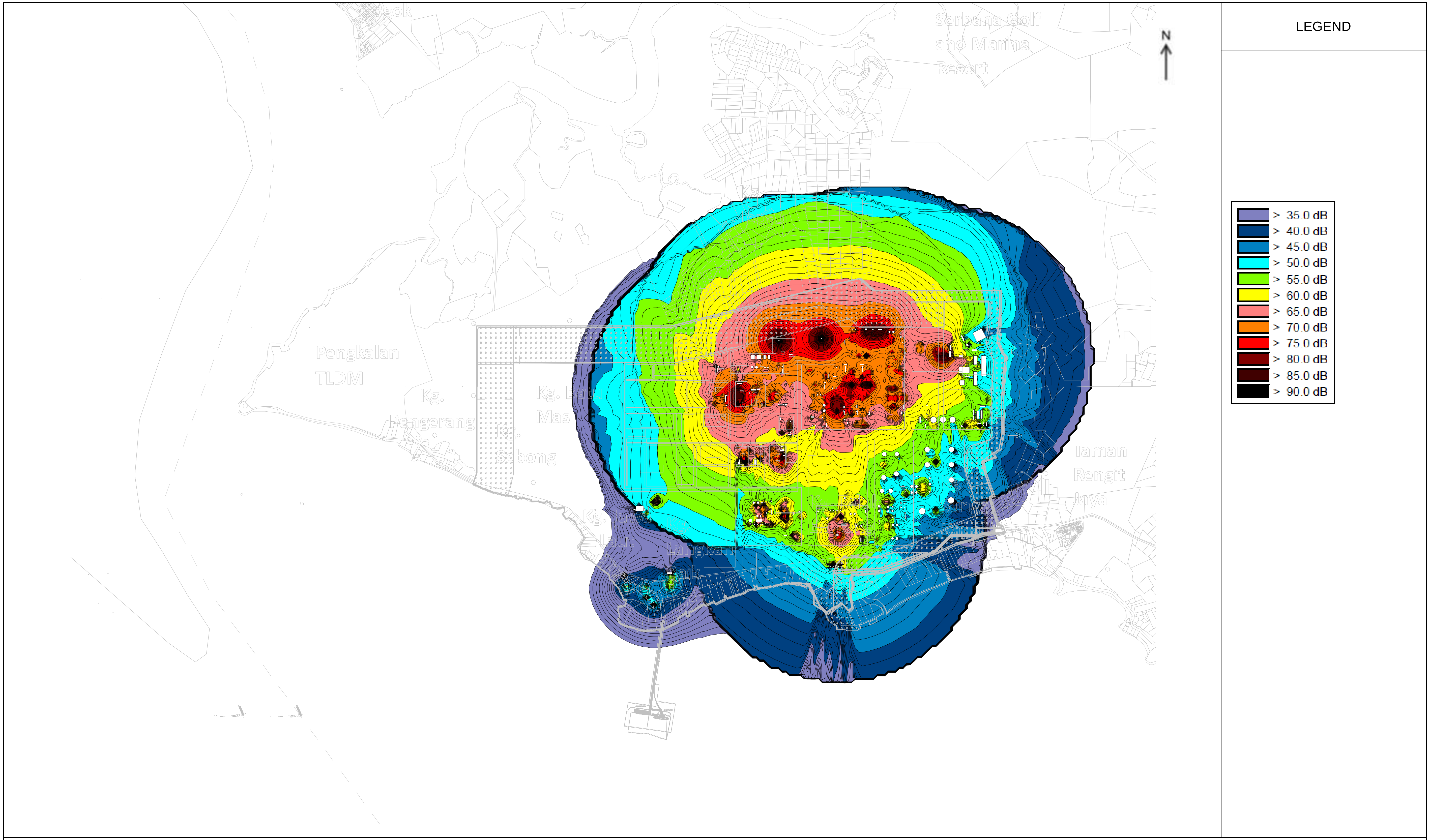


Figure 9: Noise Contours from Cumulative Refinery, Cracker Complex, Petchem Complex and Utilities– Normal Operations

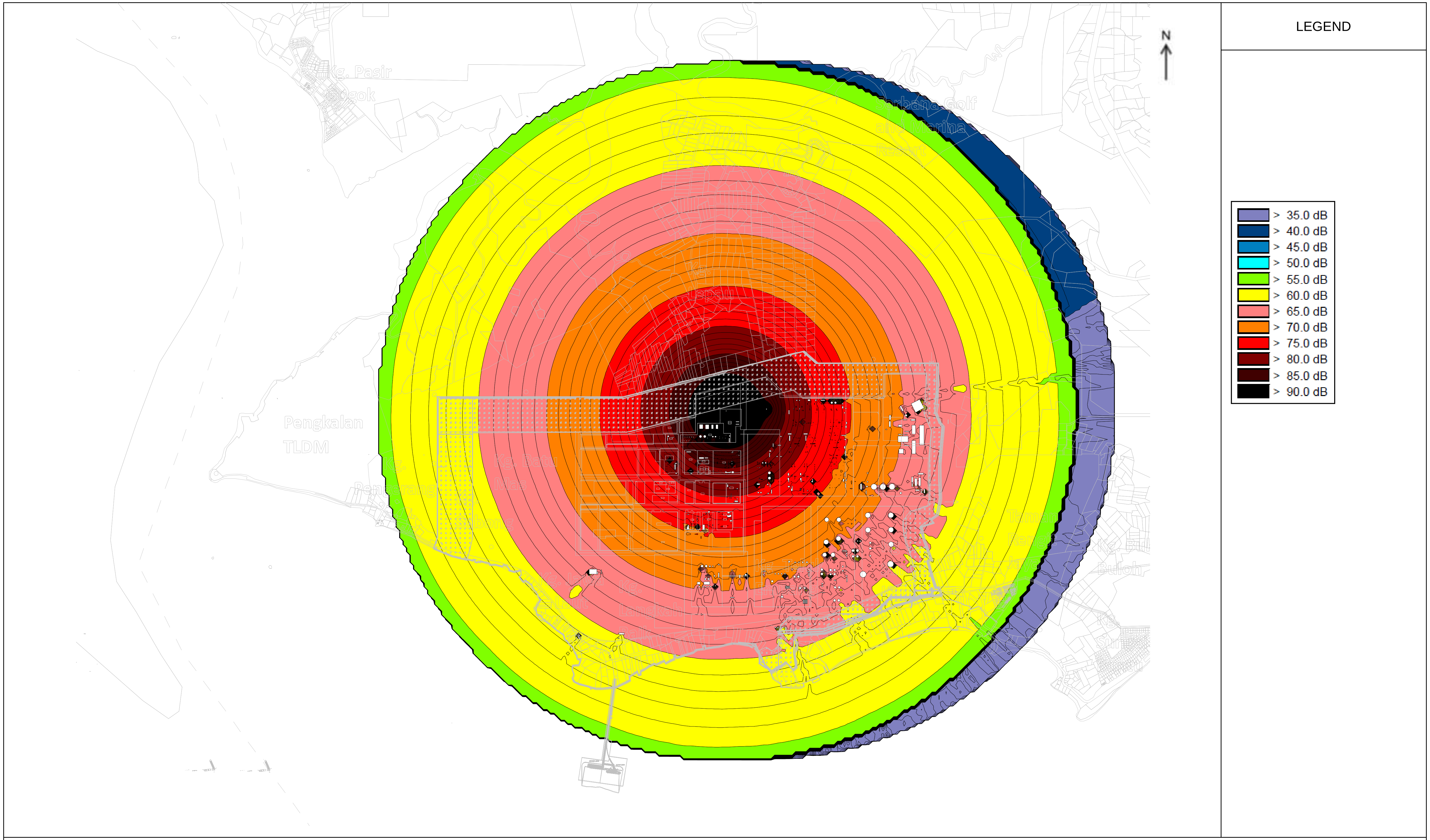
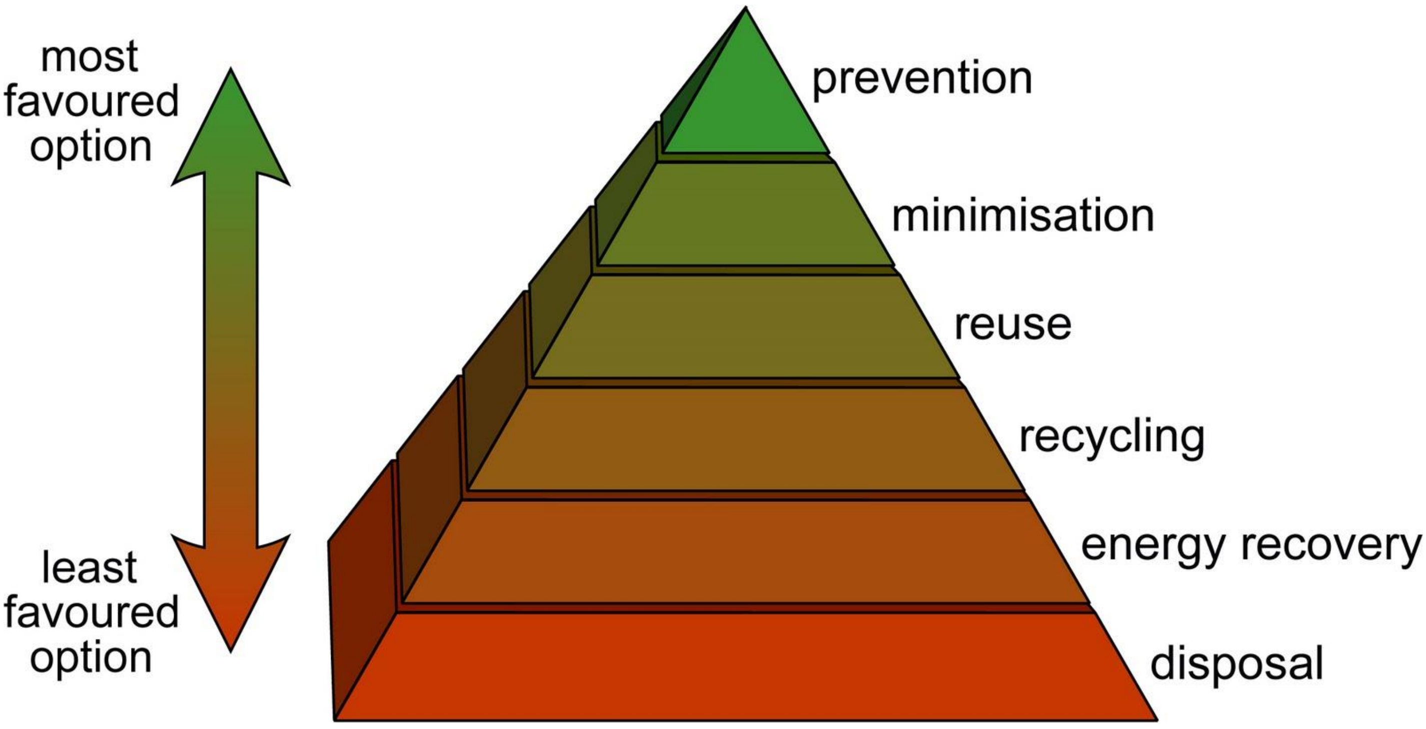


Figure 10: Noise Contours from Cumulative Refinery, Cracker Complex, Petchem Complex and Utilities – Abnormal Conditions



Waste Management Study

ADDITIONAL INFORMATION TO THE DEIA REFINERY AND PETROCHEMICAL INTEGRATED DEVELOPMENT (RAPID) PROJECT, PENGERANG JOHOR, 2012 TO INCLUDE EURO 5 MOGAS AND OLEFIN TANK UNITS

Prepared For:

PETRONAS REFINERY AND PETROCHEMICAL CORPORATION SDN. BHD.

Prepared By:

INTEGRATED ENVIROTECH SDN. BHD. (650387-K)

MARCH 2017

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1 INTRODUCTION

The waste management study in this report describe the generation, handling, storage and disposal of the scheduled waste from the EURO 5 MOGAS Units and Olefins Storage Tankages operation and identify the potential impacts to the surrounding environmental from the schedule waste management. The study will also propose the relevant and applicable mitigation measures to prevent the impacts onto the environment components.

1.1 SCOPE OF STUDY

The Waste Management Study under this report will highlight the schedule waste management to be adopted for the EURO 5 MOGAS Units and Olefins Storage Tankages upon operation. This will include the generation, handling, storage and disposal of the waste. The study scope shall only be limited to management of the scheduled wastes generated from the operations at the EURO 5 MOGAS and Olefins Storage Tankages in the process area.

The domestic and non-scheduled waste shall not be included as this report as these type of waste will be generated outside of the Refinery and Cracker Complex areas, at the centralized Administration Building located at the northeast of the RAPID complex. All of the domestic and non-scheduled waste generated from the main Administration and Control Building will be stored in the vicinity of the buildings for easy removal by the licensed contractor.

1.2 REVIEW OF LEGISLATIVE REQUIREMENTS AND GUIDELINES

The development of the waste handling and management study will be guided by the relevant legislative requirements and guidelines. A list of key legislation and guidelines are provided below:

a) Environmental Quality Act 1974 – Act 127

b) Solid Waste and Public Cleansing Management Act 2007

c) Environmental Quality (Scheduled Waste) Regulations, 2005 (Amendment 2007)

d) Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Regulations, 1989 (Amendment 2006)

e) Environmental Quality (Prescribed Conveyance) (Scheduled Waste) Order, 2005

f) Guidelines for Packaging, Labelling and Storage of Scheduled Wastes in Malaysia 2014

2 WASTE MANAGEMENT PHILOSOPHY

In RAPID DEIA 2012, the RAPID Complex operating philosophy is such that all of the waste generated from the RAPID Complex is to be send and managed at the centralised waste management facility in RAPID Complex known as RAPID Resource and Recovery Facility (RRF). The proposed facility will collect, store and treat the waste from the transit and temporary storages located in the operating plants with the objective to reduce the schedule waste volume for disposal at licensed schedule waste disposal facility.

Due to the revised number of the petrochemical plants, the waste volume to be sent to the RAPID Resource and Recovery Facility (RRF) had decreased significantly hence does not provide the economics for the RAPID Resource and Recovery Facility (RRF) to be constructed in RAPID. Hence, each of the operating plants in RAPID Complex including the Refinery and Cracker Complex has to manage their own waste and the waste is to be stored within their operating premise prior to disposal by licensed schedule waste operator.

The propose schedule waste segregation at the schedule waste storage area shall be by the following type of wastes so as to ensure waste compatibility and that they do not react with each other causing safety concerns:

Table 2-1: Proposed SW Segregation at the Schedule Waste Storage

Cell No	Category of Waste
Cell No. 1	Toxic (Solid)
Cell No. 2	Corrosive (Solid)
Cell No. 3	Combustible (Liquid)
Cell No. 4	Combustible (Solid)
Cell No. 5	Flammable (Solid + Liquid)
Cell No. 6	Toxic Liquid

The scheduled waste volume which will be generated continuously at frequency of less than a year (daily, weekly, monthly, quarterly and once in 6 months) will be taken as the basis of waste storage area sizing. Waste storage area design is also limited by DOE's requirement for storage to be 20 tonnes or less or 180 days storage, whichever is first. In the event where DOE storage requirements are exhausted, the waste need to be removed on a more frequent basis.

Schedule waste generated from turn around or scheduled maintenance activities is not considered for the sizing of the schedule waste storage. These waste will be managed separately during the plant turnaround or scheduled maintenance.

The typical layout of the proposed scheduled waste storage and the allocation of cells for the waste separation is as in **Figure 2-1**. The location of the main scheduled waste storage for the Refinery and Cracker Complex shall be at location indicated in **Figure 2-2** near to the Sulphur Solidification Unit (SSU). All of the scheduled waste generated from EURO 5 MOGAS unit, Olefin Storage Tank and other Refinery Cracker Units shall be sent to this location for collection and disposal by a DOE licensed 3rd party scheduled waste operator.

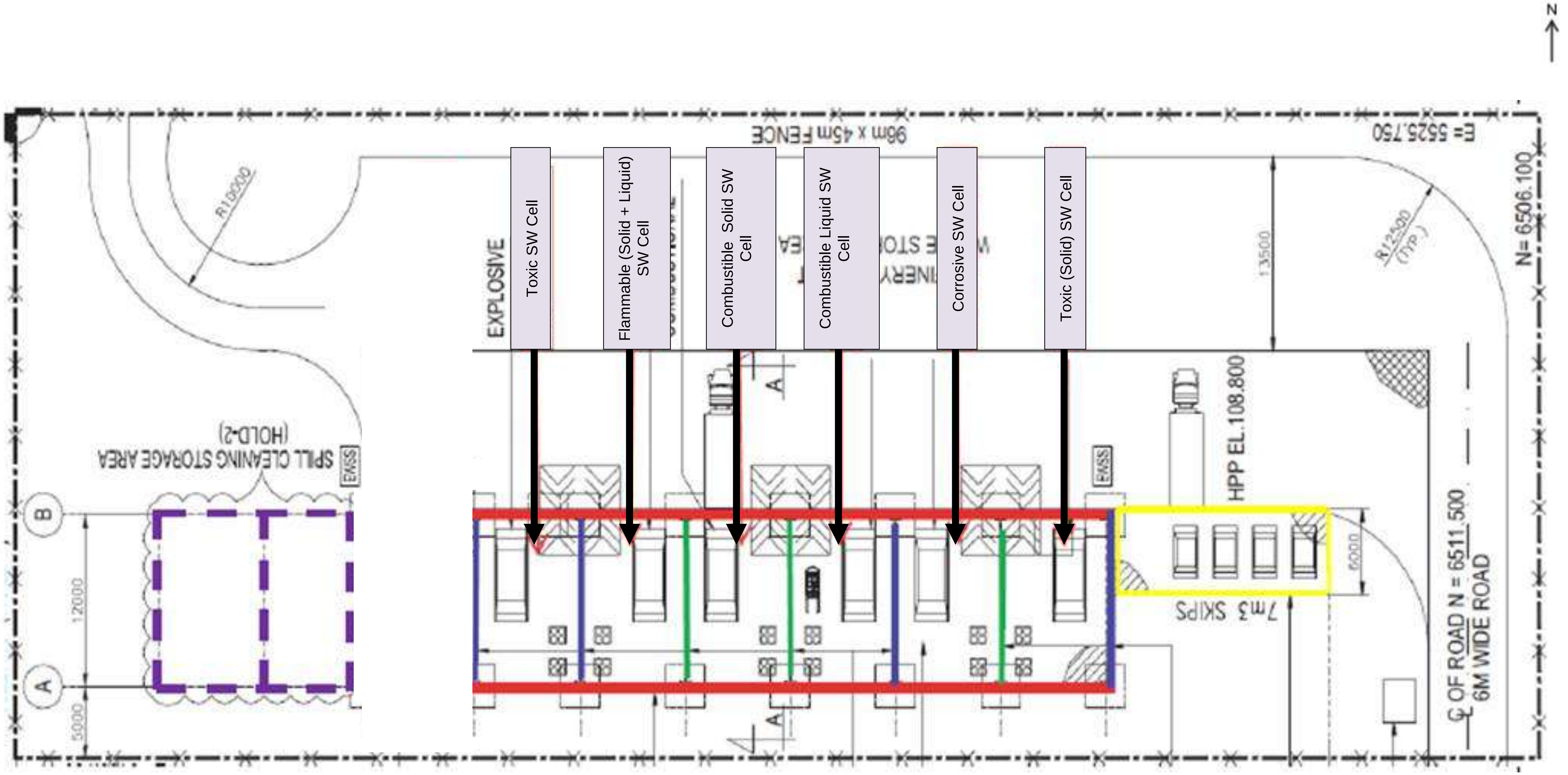


Figure 2-1: Proposed Schedule Waste Storage Area Layout Design

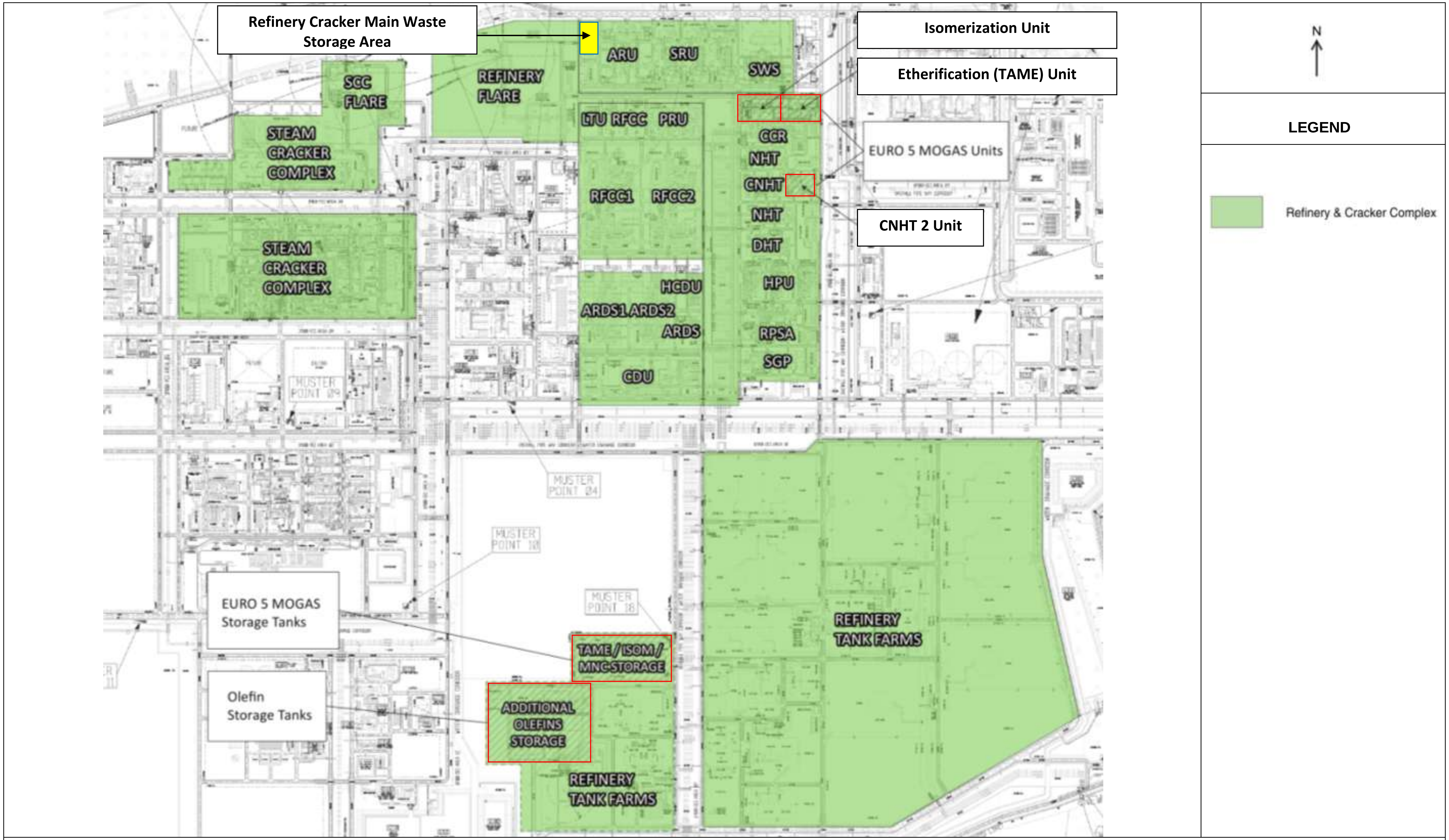


Figure 2-2: Refinery Cracker Complex Main Waste Storage Area

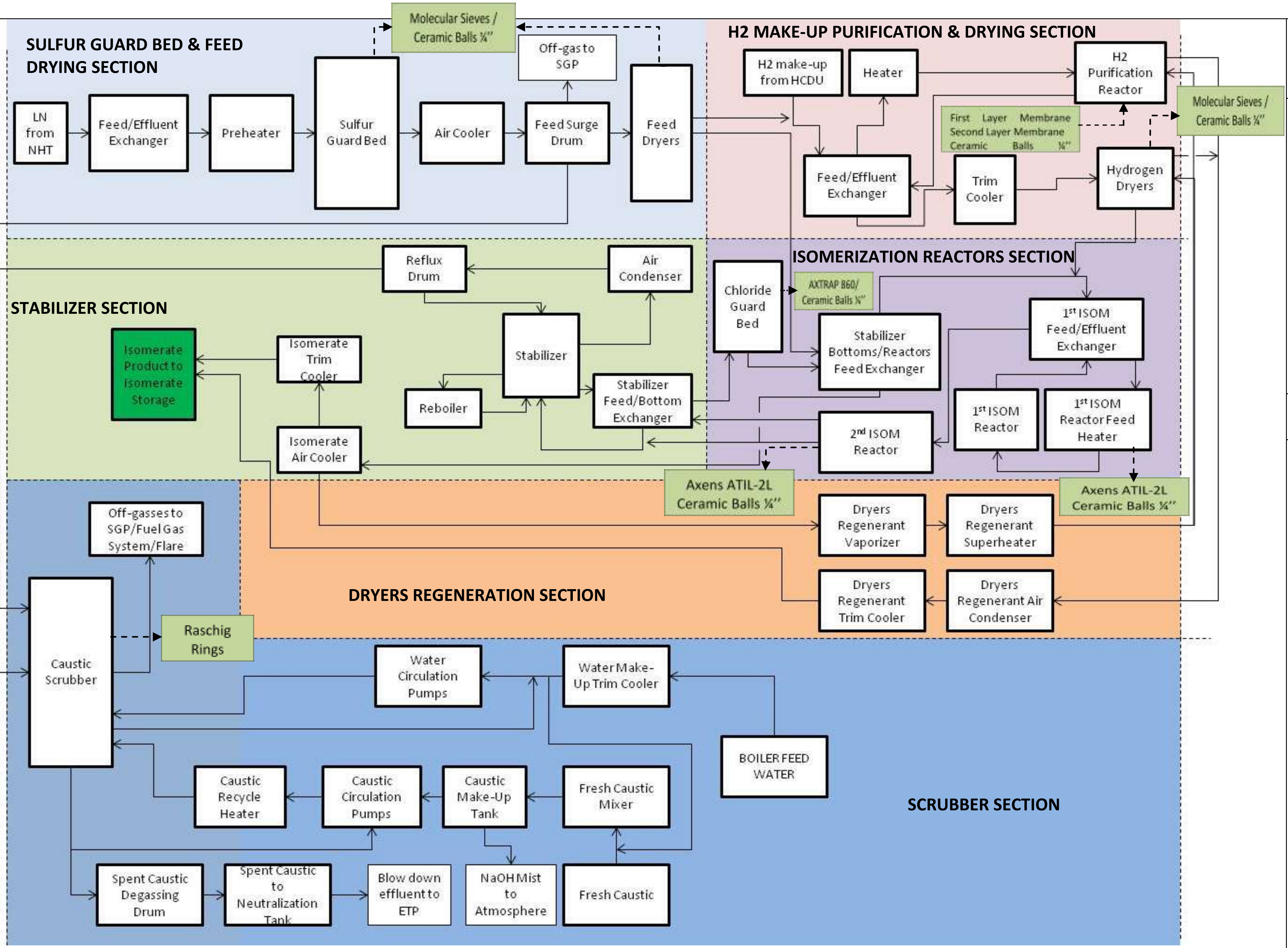
3 INVENTORY OF SCHEDULED WASTE

The details of schedule waste generated from the EURO 5 MOGAS Units and Olefins Storage Tankages covered in this report are as per the following sub sections.

3.1 EURO 5 MOGAS Units

The scheduled waste generated from the EURO 5 MOGAS Units shall be stored temporarily at the Refinery Main Waste Storage Area (**Figure 2-2**) prior to being sent to the DOE Licensed Scheduled Waste Facility. The scheduled waste generated from EURO 5 MOGAS Units which shall be recycled or reused are not being considered in this study.

The scheduled waste generated from EURO 5 MOGAS units shall be sent to the DOE Licensed Scheduled Waste Facility and described in **Figure 3-1, Figure 3-2, Table 3-1** and **Table 3-2.**



LEGEND

Product

Scheduled Waste

ABBREVIATION

ETP - Effluent Treatment Plant

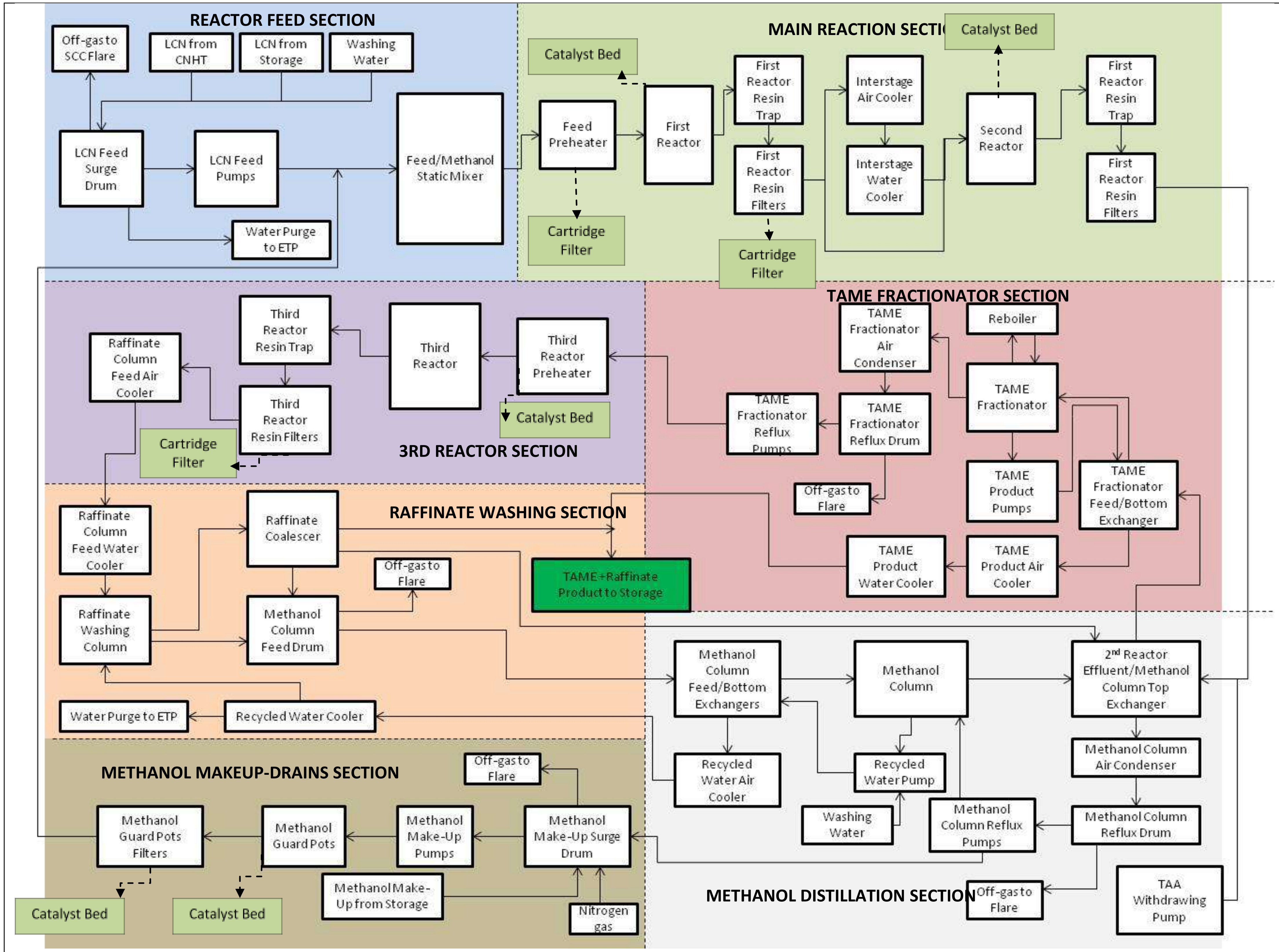
HCDU - Hydrogen Collection & Distribution Unit

LN - Light Naptha

NHT - Naphta Hydrotreating Unit

SGP - Saturated Gas Plant Unit

Figure 3-1: Sources of Scheduled Waste from Isomerization Unit



LEGEND

- Product
- Scheduled Waste

ABBREVIATION

ETP - Effluent Treatment Plant
LCN - Light Cracked Naptha
SCC - Steam Cracker Complex
TAME - Tertiary-Armyl-Methyl-Ether

Figure 3-2: Sources of Scheduled Waste from Etherification (TAME) Unit

Table 3-1: Scheduled Waste Inventory for Isomerization Unit

No	Source	Description of Scheduled Waste Scheduled	Waste Code Scheduled Waste Category as per First Schedule, Regulation 2, Environmental Quality (SW) Regulations 2005	Estimated Quantity (metric tonne, MT)	Frequency of generation		Packaging	Final Destination
					Normal operation	Turnaround and Schedule Maintenance		
1	Sulfur Guard Bed	Ceramic Balls 1/4"	SW 409	0.00046		4 years	Container/Drum	DOE Licensed Scheduled Waste Facility
2	Sulfur Guard Bed	Molecular Sieves	SW 409	6.417		3 years	Container/Drum	
3	Sulfur Guard Bed	Ceramic Balls 1/4"	SW 409	0.00056		4 years	Container/Drum	
4	Feed Dryers	Molecular Sieves	SW 409	6.417		3 years	Container/Drum	
5	Feed Dryers	Ceramic Balls 1/4"	SW 409	0.00056		4 years	Container/Drum	
6	H2 Purification Reactor	First layer Membrane	SW 409	1.015		5 years	Container/Drum	
7	H2 Purification Reactor	Second layer Membrane	SW 409	0.00133		5 years	Container/Drum	
8	H2 Purification Reactor	Ceramic Balls 1/4"	SW 409	0.00032		4 years	Container/Drum	DOE Licensed Scheduled Waste Facility
9	Hydrogen Dryers	Molecular Sieves	SW 409	0.00250		3 years	Container/Drum	
10	Hydrogen Dryers	Ceramic Balls 1/4"	SW 409	0.00012		4 years	Container/Drum	
11	Hydrogen Dryers	Molecular Sieves	SW 409	0.00250		3 years	Container/Drum	
12	Hydrogen Dryers	Ceramic Balls 1/4"	SW 409	0.00012		4 years	Container/Drum	
13	Chloride Guard Bed	Spent Catalyst	SW202	6.417		3 years	Container/Drum	
14	Chloride Guard Bed	Ceramic Balls 1/4"	SW 409	0.00060		4 years	Container/Drum	
15	2nd ISOM Reactor	Spent Catalyst	SW202	0.02060		4 years	Container/Drum	

No	Source	Description of Scheduled Waste Scheduled	Waste Code Scheduled Waste Category as per First Schedule, Regulation 2, Environmental Quality (SW) Regulations 2005	Estimated Quantity (metric tonne, MT)	Frequency of generation		Packaging	Final Destination
					Normal operation	Turnaround and Schedule Maintenance		
16	2nd ISOM Reactor	Ceramic Balls 1/4"	SW 409	0.00068		4 years	Container/Drum	DOE Licensed Scheduled Waste Facility
17	2nd ISOM Reactor	Spent Catalyst	SW202	0.02060		4 years	Container/Drum	
18	2nd ISOM Reactor	Ceramic Balls 1/4"	SW 409	TBC		4 years	Container/Drum	
19	Caustic Scrubber	Spent Support Material	SW411	1.4m^3		5 years	TBC	
Total Estimated Quantity (During Turnaround & Scheduled Maintenance)						**Approximately 20.31 Tonnes**		

Table 3-2: Scheduled waste Inventory for Etherification TAME Unit

No	Source	Description of Scheduled Waste Scheduled	Waste Code Scheduled Waste Category as per First Schedule, Regulation 2, Environmental Quality (SW) Regulations 2005	Estimated Quantity (Metric Tonne, MT)	Frequency of generation		Packaging	Final Destination
					Normal operation	Turnaround and Schedule Maintenance		
1	First reactor	Catalyst bed (Sulfonic acid resin/amberlyst)	SW202	110.88		18month	TBC	DOE Licensed Scheduled Waste Facility
2	Feed filter	Catridge filter (Polyproplene cartridge 99% +1% oil)	SW410	TBC	TBC		TBC	
3	Feed filter	Catridge filter (Polyproplene cartridge 99% +1% oil)	SW410	TBC	TBC		TBC	
5	First reactor resin filter	Cartridge Filter	SW410	TBC	TBC		TBC	
6	First reactor resin filter	Cartridge Filter	SW410	TBC	TBC		TBC	

No	Source	Description of Scheduled Waste Scheduled	Waste Code Scheduled Waste Category as per First Schedule, Regulation 2, Environmental Quality (SW) Regulations 2005	Estimated Quantity (Metric Tonne, MT)	Frequency of generation		Packaging	Final Destination
					Normal operation	Turnaround and Schedule Maintenance		
7	Second reactor filter	Cartridge Filter	SW410	TBC	TBC		TBC	
8	Second reactor filter	Cartridge Filter	SW410	TBC	TBC		TBC	
9	Second reactor	Catalyst Bed	SW202	110.88		2 years	Sealed drum	
10	Third reactor resin filter	Cartridge Filter	SW410	TBC	TBC		TBC	DOE Licensed Scheduled Waste Facility
11	Third reactor resin trap	Cartridge Filter	SW410	TBC	TBC		TBC	
12	Third reactor	Catalyst Bed	SW202	TBC	TBC		Sealed drum	
13	Third reactor resin filter	Cartridge filter with carbon steel (Polyphenylene Sulphide)	SW410	TBC	TBC		TBC	
14	Third reactor resin filter	Cartridge filter with carbon steel (Polyphenylene Sulphide)	SW410	TBC	TBC		TBC	
15	Methanol Guard Pots	Catalyst Bed	SW202	1.771		Every year	Sealed drum	DOE Licensed Scheduled Waste Facility
16	Methanol Guard Pots	Catalyst Bed	SW202	1.771		Every year	Sealed drum	
17	Methanol Guard filter	Catalyst Bed	SW202	$5m^3$		Every year	Sealed drum	
18	Methanol Guard filter	Catalyst Bed	SW202	$5m^3$		Every year	Sealed drum	
Total Estimated Quantity (During Turnaround & Scheduled Maintenance)					**Approximately 225.302 Tonnes**			

3.1.1.1 Additional Olefins Storage

For the storage tanks, the scheduled waste generated is expected only during turnaround and tank maintenance where tank cleaning are carried out. Schedule waste during the maintenance and turnaround is not to be stored in the Refinery Main Waste Storage Area and to be managed separately.

4 IMPACT ASSESSMENT AND MITIGATION MEASURES

Impacts from EURO 5 MOGAS and Olefins Storage Tankages were assessed for the operations phase of the project development.

4.1 Potential Impact

During the plant operational, it will involve daily storage, handling, transport and disposal of various types of wastes which any accidental spillage may impact the quality of the surface water, marine water and soil and groundwater. To some extent, the reactivity of the toxic and hazardous waste to be managed may cause worker's and community safety and health impact.

From the assessment of the RAPID Complex design philosophy, the impacts associated with the storage, transfer, handling, transport and disposal of the scheduled wastes during operational phase is expected to be minor and mostly contained from impacting the surrounding environment.

4.2 Mitigation Measures

The mitigation measures proposed to minimise the impacts to the environment from waste management during the operations phase in terms of waste handling practices are provided in the following sections:

4.2.1 Scheduled Wastes Storage Requirements

a) The storage area shall be sheltered to prevent any intrusion from rainfall and to contained and flammable and explosion within the cell without spreading to the next cell via a firewall design.

b) Adequate ventilation shall be provided where volatile wastes are stored.

c) Appropriate bins/skips should be provided at suitable locations in the storage area.

d) Adequate access to be provided to ensure easy manoeuvrability of the trucks to remove the schedule waste by licensed operator.

4.2.2 Segregation between incompatible scheduled wastes

a) Waste shall be stored in a manner that prevents the mixing or contact between incompatible wastes, and allows for inspection between containers to monitor leaks or spills (e.g. sufficient space or physical separation such as walls or containment curbs between incompatible wastes).

b) Flammable substances must be kept separate from sources of ignition or oxidising agent.

c) Acid must be kept away from substances with which they may react, producing dangerous compound.

d) Strong corrosive agent must be kept away from gas cylinders or other containers.

e) Pressurized aerosol cans must be collected separately in a single, suitable marked container

4.2.3 Drainage

a) Scheduled waste storage area shall be isolated from any drainage system.

b) Each of the cell shall be provided with individual pit to collect any potential spillage. The spillage shall be emptied out from the pit and removed as scheduled waste.

4.2.4 Waste Spillage Containment

a) Containment of the spill from waste storage area should be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment and this include the types of paving to prevent seepage into groundwater and soil.

b) The design philosophy of the Refinery and Cracker Complex waste storage area has include the bunding to contain 110% of potential total spillage. All spillage within the specific type of wastes storage area will be directed and contain in a pit separated from any drainage network and pits is to be emptied out as scheduled waste by the licensed contractor.

4.2.5 Packaging and Labelling.

The mitigation measures proposed to minimise the impacts to the environment from waste management during the operations phase in terms of packaging and labelling practices is provided below:

a) An appropriate container should be selected according to the characteristics of the scheduled wastes. The characteristic of scheduled wastes shall be compatible with the type of material used for the container to prevent any reaction which will deteriorate the container.

b) The container used should be in good condition (free from any damage such as tear or hole).

c) For identification and warning purposes, containers of scheduled wastes shall be clearly labelled in accordance with the Third Schedule of the Environmental Quality (Scheduled Wastes) Regulations 2005 and marked with the scheduled wastes code as specified in the First Schedule of the Environmental Quality (Scheduled Wastes) Regulations 2005.

4.2.6 Surveillance Monitoring.

Groundwater and soil monitoring should be conducted periodically at the individual units to ensure that no contamination of groundwater has occurred during the operations of the plant.

4.2.7 Residual Impact

Residual impacts are defined as impacts which may remain even after the mitigating measures are adopted into the design and management of the project. These impacts may or may not have any detrimental effect to the surrounding environment. With the implementation of all mitigation and management measures which include the proper storage and handling, packaging and labelling as per the DOE Guidelines, no residual impact from waste management is expected to arise from the operation phase of the proposed Project.

5 CONCLUSION

In conclusion, with the current waste management philosophy adopted in the Refinery and Cracker Complex, the amount of scheduled waste generated is estimated to be approximately **7,562.8 tonnes per year** during the normal operation while approximately **4,723.7 tonnes** will be generated during the turn around and scheduled maintenance activities. Based on **Table 5-1** and **Table 5-2**, the current estimation of scheduled waste's amount to be generated from Refinery & Cracker Complex during normal operation is higher compared to the estimation in RAPID DEIA 2012. This is contributed by the change of RAPID Waste Management Philosophy from having a RAPID centralized waste management centre to each of the operating plants in RAPID Complex has to manage their own waste and waste to be stored within their operating premise prior to disposal by licensed schedule waste operator.

Table 5-1: Estimated Amount of SW Generated from Units in Refinery and Cracker Complex

No	Units	RAPID DEIA 2012		Current Refinery Cracker Complex	
		Normal Operation (tonnes/year)	Scheduled Maintenance and Turnaround (tonnes)	Normal Operation (tonnes/year)	Scheduled Maintenance and Turnaround (tonnes)
1	Residue Fluidized Cracker Unit (RFCC)	-	-	7562.8	6.11
2	LPG Treating Unit (LTU)	-	-	-	7.6
3	Atmospheric Residue Desulphurization (ARDS)	-	-	-	3089.6
4	Crude Distillation Unit (CDU)	-	-	-	0.0001
5	Operator Shelter Building (OSB) - Common Area nearby CDU	-	-	-	0.065
6	Saturated Gas Plant (SGP)	-	-	-	0.55
7	Diesel Hydrotreating (DHT)	-	-	-	24.08
8	Kerosene Hydrotreating (KHT)	1.0185	-	-	3.29
9	Cracker Naphta Hydrotreating Unit (CNHT)	-	-	-	31.74
10	Naphta Hydrotreating Unit (NHT)	-	-	-	6.34
11	Continuous Catalytic Reformer Unit (CCR)	-	-	-	67.18
12	Hydrogen Production Unit (HPU)	-	-	-	57.47
13	Amine Regeneration Unit (ARU)	-	-	-	165.45
14	Sulphur Recovery Unit (SRU)	-	-	-	523.14
15	Sour Water Stripping Unit (SWS)	-	-	-	17.72
16	Hydrogen Collection and Distribution Unit (HCDU)	-	-	-	-

No	Units	RAPID DEIA 2012		Current Refinery Cracker Complex	
		Normal Operation (tonnes/year)	Scheduled Maintenance and Turnaround (tonnes)	Normal Operation (tonnes/year)	Scheduled Maintenance and Turnaround (tonnes)
17	Refinery Pressure Swing Adsorption	-	-	-	-
18	Refinery Tank Farm	-	-	-	472.95
19	Olefins Storage Tankages	-	-	-	-
20	Additional EURO 5 MOGAS Storages	-	-	-	-
21	2nd Stage Cracked Naphta Hydrotreating (CNHT) Unit	-	-	-	-
22	C5/C6 Isomerization Unit	-	-	-	20.31
23	Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME)	-	-	-	225.302
24	Steam Cracker Complex (SCC)	-	-	-	4.77
TOTAL		1.0185	-	7562.8	4,723.7

Table 5-2: Estimated Amount of SW Generated from Refinery and Cracker

Complex	RAPID DEIA 2012		Current Refinery Cracker Complex	
	Normal Operation	Scheduled Maintenance and Turnaround	Normal Operation	Scheduled Maintenance and Turnaround
Refinery Complex	1.0185 tonnes per year	-	7562.8 tonnes per year	4,723.7 tonnes
Steam Cracker Complex	Fully recovered	**-**		

Note: Some of the amount of SW generated is yet to be determine at this stage. The details of the SW list are provided in the inventory list.

With the establishment of waste handling and management procedures and controls, impacts from waste storage, transfer, handling, transport and disposal are not expected to be significant. Furthermore, groundwater and soil monitoring should be conducted periodically at the individual units to ensure that no contamination of groundwater has occurred during the operations of the plant.

Chemical Handling Study

ADDITIONAL INFORMATION TO THE DEIA REFINERY AND PETROCHEMICAL INTEGRATED DEVELOPMENT (RAPID) PROJECT, PENGERANG JOHOR, 2012 TO INCLUDE EURO 5 MOGAS AND OLEFIN TANK UNITS

Prepared For:

PETRONAS REFINERY AND PETROCHEMICAL CORPORATION SDN. BHD.

Prepared By:

INTEGRATED ENVIROTECH SDN. BHD. (650387-K)

MARCH 2017

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ABBREVIATIONS

%	-	Percentage
°C	-	Degree Celsius
3R	-	Reduce, reuse and recycle
ALARP	-	As Low As Reasonably Practicable
CPL	-	Classification, Packaging and Labelling
CSDS	-	Chemical Safety Data Sheets
DEIA	-	Detail Environmental Impact Assessment
DOE	-	Department of Environment
DOSH	-	Department of Occupational Safety and Health
ETP	-	Effluent Treatment Plant
FIBC	-	Flexible Intermediate Bulk Containers
HCD	-	Hydrocarbon Discharge
HP	-	High Pressure
HPN	-	High Pressure Nitrogen
IBCs	-	Intermediate Bulk Containers
MSDS	-	Material Safety Data Sheet
OSH	-	Occupational Safety And Health
PTS	-	Petronas Technical Standards
RAPID	-	Refinery And Petrochemical Integrated Development Project
SOP	-	Standard Operating Procedure
USECHH	-	Use and Standards Exposure of Chemicals Hazardous to Health

1.0 INTRODUCTION

The units within Refinery & Cracker Complex as in DEIA RAPID 2012 are maintained. The RAPID Refinery Cracker Complex was originally designed to produce diesel that meet the EURO 5 specifications and MOGAS (motor gasoline) that meet EURO 4 specifications. To upgrade and meet the EURO 5 MOGAS specifications, Refinery Cracker Complex has been expanded to include additional units as listed below :

1. 2nd Stage Cracked Naphta Hydrotreating (CNHT 2) Unit
2. Etherification Unit Tertiary-Armyl-Methyl-Ether (TAME) Unit
3. Isomerization Unit
4. Additional Storage Tanks which consist of:
    i. Two Tertiary-Armyl-Methyl-Ether (TAME) storage tanks
    ii. Two Isomerate storage tanks
    iii. One Medium Cracked Naptha (MCN) Storage Tank

Besides that, there will be new olefin storage tankages located in the current refinery tank farms which consists of:

1. Four mounded bullets for Butadiene Storage
2. One Ethylene Tank
3. Four sphere for Propylene Storage

Details of the additional units are described in **Volume 1, Chapter 2**. This additional information report conducted studies to assess the impacts from these new process units and tank farms in the Refinery and Cracker Complex.

1.1 Scope of Study

The objective of the Chemical Handling Study is to present the chemical management philosophy for the EURO 5 MOGAS Units and Olefins Tankages which include the storage and handling of chemicals at the Centralized Chemical Warehouse

Impacts on the handling and management of the chemical spillage and leakage at process areas within each of the process units will not be covered under this section. This is due to all areas where identified to have potential spillage or leakages of chemicals will either be contained and managed as scheduled waste or routed for treatment at the Centralised Effluent Treatment Plant (ETP), depending on the toxicity of the chemicals as specified in the MSDS.

2.0 REGULATORY REQUIREMENTS

2.1 Malaysian Regulations and Guidelines

A review of key legislative requirements related to the chemical handling was conducted and a summary of the key regulations and guidelines are provided in **Table 2-1**.

Table 2-1: Summary of Key Regulations and Guidelines for Chemical Handling

Regulations and Guidelines	Summary of Requirements
The Environmental Quality (Prohibition on the Use of Chlorofluorocarbons and Other Gases as Propellants and Blowing Agents) Order, 1993	Provides a list of controlled substances that are banned by the Department of Environment (DOE) for use as propellants (for manufacturing, trade and industry of aerosol and portable fire extinguishers) and blowing agents (for manufacturing, trade or industry involved in production of polystyrene foam, thermoformed plastic packaging and moulded flexible polyurethane foam). The list of controlled substances are:

Regulations and Guidelines	Summary of Requirements
	• Trichlorofluoromethane • Dichlorodifluoromethane • Trichlorotrifluoroethane • Dichlorotetrafluoroethane • Chloropentafluoroethane • Bromochlorodifluoromethane • Bromotrifluoromethane • Dibromotetrafluoroethane • Chlorotrifluoromethane • Pentachlorofluoroethane • Tetrachlorodifluoroethane • Heptachlorofluoropropane • Hexachlorodifluoropropane • Pentachlorotrifluoropropane • Tetrachlorotetrafluoropropane • Trichloropentafluoropropane • Dichlorohexafluoropropane • Chloroheptafluoropropane • Carbon Tetrachloride • 1,1,1- trichloroethane (methyl chloroform)
The Environmental Quality (Refrigerant Management) Regulations, 1999	Provides a list of ‘refrigerant environmentally hazardous substances’ that are banned by the Department of Environment (DOE) for use as a refrigerant in any new installation of building chillers, refrigeration systems, vehicle air conditioners or air conditioning equipment. The list of refrigerants that are prohibited are: • Trichlorofluoromethane • Dichlorodifluoromethane • Trichlorotrifluoroethane • Dichlorotetrafluoroethane • Chloropentafluoroethane

<table>
<tr><th>Regulations and Guidelines</th><th>Summary of Requirements</th></tr>
<tr><td>The Environmental Quality (Halon Management) Regulations, 1999</td><td>This regulation stipulates the prohibition on the use of portable Halon fire extinguishers and the installation of new fixed Halon fire extinguishing systems. The list of Halons that are prohibited are as follows:
• Bromochlorodifluoromethane
• Bromotrifluoromethane
• Dibromotetrafluoroethane</td></tr>
<tr><td>Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations, 2013 (CLASS)</td><td>This regulation stipulates the requirements related to classification of chemicals, packaging requirements, chemical labelling requirements including the minimum dimensions of a label, responsibility on supplying information on chemicals in the form of a chemical safety data sheet (CSDS)/MSDS and minimum information required to be shown on a CSDS/MSDS.</td></tr>
<tr><td>Occupational Safety and Health (Prohibition of Use of Substance) Order, 1999</td><td>This order prescribes a list of substances and the extent to which their use is prohibited. These are listed below:
<table>
<tr><th>Description of Substance</th><th>Extent to which use of substance is prohibited</th></tr>
<tr><td>4-Aminodiphenyl;
Benzidine;
2-Naphthylamine;
4-Nitrodiphenyl;
Their salts; and any substance containing any of their compounds in any other substance in a total concentration exceeding 0.1%t</td><td>Manufacture and use for all purposes including any manufacturing process in which the substances described is formed, except for research or analytical purposes</td></tr>
<tr><td>Crocidolite</td><td>All purposes except for research and analytical purposes.</td></tr>
<tr><td>Benzene;
Carbon disulphide;
Carbon tetrachloride and
n-Hexane</td><td>Cleaning and degreasing</td></tr>
<tr><td>White phosphorus</td><td>Use in the manufacture of</td></tr>
</table></td></tr>
</table>

Regulations and Guidelines	Summary of Requirements
	matches
Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations, 2000	This regulation stipulates the requirements for development of a register of chemicals hazardous to health, permissible exposure limits, labelling and re-labelling, assessment of risk to health, actions to control exposure, monitoring of exposure, and provision of CSDS, warning signs and record keeping requirements.
Guidelines on Storage of Hazardous Chemicals: A Guide for Safe Warehousing of Packaged Hazardous Chemicals, 2005 issued by the Department of Occupational Safety and Health	This guideline provides measures on the design, construction, operation and maintenance of storage areas and buildings used for storing packaged hazardous chemicals when they are contained in packages such as drums, gas cylinders, bottles, boxes, intermediate bulk containers (IBCs) and sacks.

Spent chemicals are classified as scheduled waste and therefore, shall be managed in accordance to the Environmental Quality (Scheduled Waste) Regulations, 2005.

3.0 STUDY APPROACH AND METHODOLOGY

The Chemical Handling Study will be conducted based on the following approach:

a) Review of key legislative requirements and guidelines and the chemical management philosophy adopted by the Refinery and Cracker Complex;

b) Characterisation of chemicals utilised by the EURO 5 MOGAS Units and Olefins Storage Tankages via review of Material Safety Data Sheets (MSDS). The review of MSDS will also serve to identify the toxicity effect of these chemicals to the aquatic environment. Additionally, a qualitative assessment of potential impacts from odour based on a review of toxicity data will also be conducted;

c) Development of a chemical inventory for the EURO 5 MOGAS Units and Olefins Storage Tankages;

3.1 Definitions

A list of key definitions provided by the Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations, 2013 (CLASS) and the Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations, 1996 and used throughout this study is provided below:

- "Chemicals" means the entire chemical used in the process plants apart from hydrocarbon, feedstock product and catalyst.
- "Hazardous chemical" means any chemical which possess any of the properties categorised in Schedule I of the Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations, 1997, and any chemicals which is specified in Schedule 1 or Schedule 2 (Part 1) of the Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations, 1996, or for which relevant information exists to indicate that the chemical is hazardous.
- "Flammables" are those chemicals, which have low flash points i.e. they are easy to catch fire.
- "Oxidising chemicals" or oxidisers are those chemicals, which can react violently with flammable and combustible materials.
- "Toxic" is those chemicals and preparations, which if inhaled or ingested or penetrated into the skin may involve serious acute or chronic health risks or even death.
- When a chemical / hazardous substance is no longer used for its original purpose and is intended for disposal, but still has hazardous properties, it is considered a hazardous waste (or more commonly referred to as “scheduled waste”).

3.2 Assumptions and Limitations

The assumptions and limitations in the development of the Chemical Handling Study in this report are :

a) The study assesses the potential impacts of chemical management and handling from the chemical warehouse and the Refinery & Cracker Complex to the environment. This study does not include an assessment of impacts from these chemicals to human health and surrounding communities;

b) Impacts on the handling and management of the chemical spillage and leakage where usage of chemical packages within each of the process units will not be covered under this section. This is due to all areas where identified to have potential spillage or leakages of chemicals will either be contained and managed as scheduled waste or routed for treatment at the Centralised Effluent Treatment Plant (ETP), depending on the toxicity of the chemicals.

3.3 Chemical Handling and Management Philosophy

The operational phase of the EURO 5 MOGAS Units and Olefins Storage Tankages will involve the use of various chemicals for the operations of the process units, utility systems as well as during regular maintenance and plant start-up/ shutdown and turnaround. The typical use of chemicals may include but not limited to the followings:

a) Chemicals used for equipment maintenance such as solvents, oils, fuel and paints; and
b) Chemicals utilised in chemical injection packages to enhance the processes.

RAPID Complex operating philosophy is such that all of the chemicals delivered via bulk container by trucks/land transportation for use in the RAPID Complex (including Refinery and Cracker Complex) is to be delivered and managed at the common chemical storage warehouse, which location is as indicated in **Figure 3-1** below. All of the chemicals delivered via the vessel/marine transportation shall be piped from the terminal into the chemical tanks located in the plant tank farm area.

The propose common chemical storage warehouse shall be design to store and segregated chemicals according to the types of chemical and their reactivity with each other. Chemicals shall be segregated based on the reactivity to prevent them from reacting with each other causing safety and health concerns. The RAPID Complex chemical segregation philosophy is guided by the PETRONAS policy and technical standards as shown in **Figure 3-2.**

Material Safety Data Sheets (MSDS) shall be provided for all chemicals in accordance with the requirements of Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations, 2013 (CLASS).

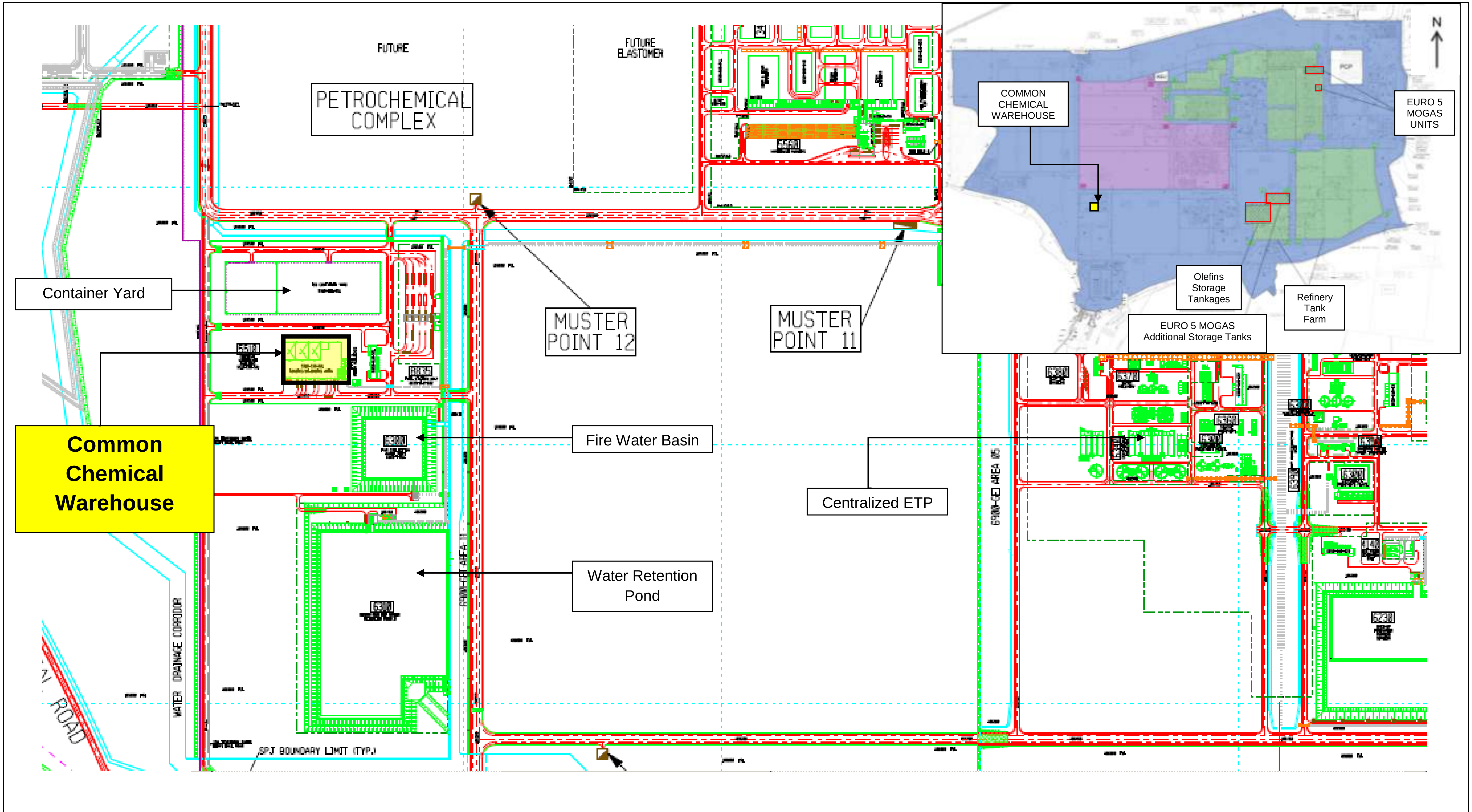

Figure 3-1: Common Chemical Storage Warehouse Location Within RAPID Plot Plan Layout.

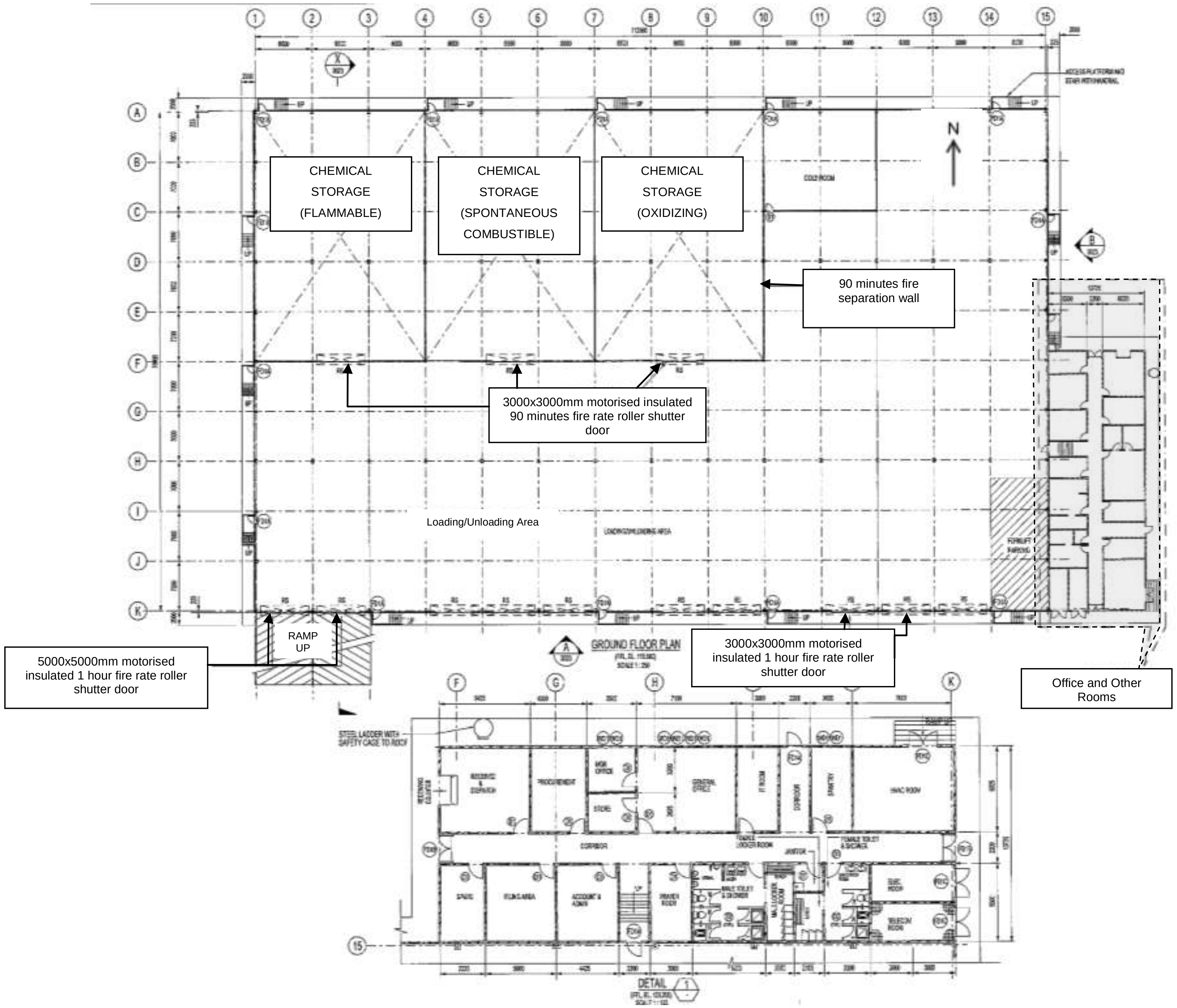

Figure 3-2: Proposed Layout of the Common Chemical Storage Warehouse

The chemical types and their reactivity that determine the design of the separate cells in the chemical warehouse are :

a) Toxicants (In the event of a fire these can contaminate firefighting water):
- Separate from other flammable products and aerosols
- Segregate oxidising agents and corrosives
- Segregate flammable from non-flammable toxicants

b) Aerosols (These can explode in a fire, thereby increasing the danger to fire fighters and the risk of fire spread)
- Separate from toxicants and flammables
- Segregate oxidising agents and corrosives

c) Flammables (These will not normally contaminate firefighting water if they are non-toxic but by definition will greatly increase the risk of a toxicant fire if stored in the same area as toxicants)
- Separate from toxicants and aerosols
- Segregate oxidising agents and corrosives

d) Oxidising Agents (These can react violently with other products stored in the warehouse)
- Segregate from toxicants, aerosols, flammables and corrosives

e) Corrosives (Leakage from packages containing corrosives can damage other packages with potentially hazardous consequences)
- Segregate from toxicants, aerosols, flammables and oxidising agents

f) Combustibles (These generally constitute low fire risk and reactivity hazards. They can therefore be used to enhance segregation, e.g. to provide a barrier between other groups of products which require segregation)

3.3.1 Chemical/ Hazardous Waste Disposal

Spent chemical at each of the EURO 5 MOGAS Units and Olefins Storage Tankages shall be treated as scheduled waste and to be stored at the scheduled waste storage area as described in **VOLUME 2, Appendix 5A**. The waste is to be disposed by a licensed scheduled waste operator.

3.3.2 Spill Stream Drainage

In RAPID, the drainage design philosophy is developed to cater for the following spillage and leak scenario:

- Chemicals that are defined as very toxic or toxic based on MSDS specification, either to physical and biological environment or the biological treatment in the effluent treatment plant, shall be fully contained in sump or pit. The collection sumps or pits are not to be connected to any drainage network in RAPID complex or find its way to the surrounding water bodies.
- Chemicals which are defined as non- toxic shall be connected to the Accidentally Chemical Containment Drainage (ACC) routed to the Centralized Effluent Treatment Plant for treatment.

At the centralized Chemical Warehouse, design of the chemical storage area is such a way that the spillage within the specific type of chemical storage area will be directed and contain in a pit to be removed as scheduled waste by licensed contractor and any spillage from different storage cell cannot be mixed due to chemical reactivity and safety requirement. Chemical list for chemicals utilised at the EURO 5 MOGAS Units and Olefins Storage Tankages are shown in **Table 3-1 and Table 3-2.** The chemical list provide information on the key hazards, characteristics/ appearance, toxicity and ecology as well as the chemical incompatibility of chemicals utilised.

Table 3-1: EURO 5 MOGAS Unit Chemical Inventory

No	Name of Chemical	Appearance	Characteristics	Health Effect	Ecological effects
1	PROPANE	Colorless liquid under pressure. Faint hydrocarbon odor unless odorant is added.	Toxic, Flammable	May cause damage to nervous system and heart	Water quality standards and physical properties affecting water contamination potential. Toxicity to aquatic organisms.
2	ISOBUTANE	Colorless liquid under pressure. Faint hydrocarbon odor unless odorant is added.	Toxic, Flammable	May cause damage to central nervous system	No known significant effects or critical hazards
3	n-BUTANE	Colorless liquid under pressure. Faint hydrocarbon odor unless odorant is added.	Toxic, Flammable	Acute Toxicity	No known significant effects or critical hazards
4	n-PENTANE	Clear, Colorless liquid with sweet petroleum odor.	Toxic, Flammable	Acute oral toxicity	Toxic to aquatic life
5	METHANOL	Clear, Colorless, Flammable, Poisonous liquid, Pungent odor	Toxic, Flammable	Irritation in case of skin or eye contact, hazardous if inhaled. Can cause damage to human organs	Toxic to aquatic life. Biodegrades easily in water
6	N-HEPTANE	Colorless watery liquid with a gasoline-like odor	Toxic, Flammable	Irritation in case of skin or eye contact, hazardous if inhaled or ingested	Toxic to aquatic life.
7	1-DECENE	Colorless watery liquid with a pleasant odor. Floats on water.	Toxic, Flammable	May cause skin dessication.May cause fatality if ingested or inhaled	Very toxic to aquatic life with long lasting effects
8	DIMETHYL ETHER	Colorless. Liquid. (volatile, mobile liquid) Sweetish. Pungent. Ethereal	Flammable	May cause drowsiness or dizziness	No known significant effects or critical hazards
9	TERTIARY AMYL METHYL ETHER	Liquid, strong odour, colorless	Flammable	Irritation in case of skin or eye contact, hazardous if inhaled or ingested	No known significant effects or critical hazards
10	TERTIARY AMYL ALCOHOL	Liquid, pungent and unpleasant odor, colorless	Flammable	Irritation in case of skin or eye contact, hazardous if inhaled or ingested. Can cause damage to internal organs	No known significant effects or critical hazards

Table 3-2: Olefins Tankages Chemical Inventory

No	Name of Chemical	Appearance	Characteristics	Health Effect	Ecological effects
1	TERTIARY BUTYL CATECHOL (TBC)	Colorless light yellow liquid with phenolic odor. Flammable liquid and vapor.	Flammable	Acute Toxicity	Highly toxic to fish
2	SODIUM HYPOCHLORITE	Green to Yellowish Liquid, odor chlorine-like	Non-Flammable, Toxic	Irritation in case of skin or eye contact, hazardous if inhaled or ingested	It is toxic to fish and aquatic organisms.

4.0 SAFETY AND ENVIRONMENTAL DESIGN REQUIREMENTS

The common chemical warehouse design takes into account the followings health and safety requirements to ensure the operation of the warehouse does not cause any environment, worker's and public's safety and health concern.

a) All of the spillages from each of the segregated storage cell has its own collection pits to contain the potential chemical spillage. The collected spill at the pits shall be treated as schedule waste and to be stored in the schedule waste storage facility;

b) A groundwater and soil monitoring locations shall be established on operation commences to monitor any potential contamination to the groundwater and soil for preventive actions to be taken;

c) Specific storage requirement and safety systems shall be provided in the design of the warehouse and these include dedicated storage room or cells for flammable chemicals, oxidation agents, combustible chemicals, toxic chemicals and corrosive chemicals.

d) The specific storage cells will also be provided with fire rated wall and bunding. Other safety system identified includes :

- Automatic Sprinkler System
- Internal Hose Reel System
- Portable Fire Extinguisher
- Emergency Response System, namely chemical spill kit, first aid kit, wind sock, safety shower and eye wash station and cabinet / locker for protective equipment and clothing.

e) Hazardous shall be defined to ensure electrical equipment is of appropriate design, sources of ignition are segregated from sources of flammable gas and locating the best location of clean air inlets for ventilation systems or combustion equipment;

5.0 RESIDUAL IMPACTS

The design and management philosophy of the chemical used in RAPID Refinery & Cracker Complex is such any spillage and leakages will be contained accordingly based on the definition of the chemical toxicity to environment and human health under MSDS. As such any spills or leakages of spent chemical shall be treated as scheduled waste and the impact shall be evaluated under the scheduled waste management.

Any chemical which is defined as nontoxic under MSDS, the leakages or spillage is to be routed to the centralized effluent treatment plant for treatment. As such the residual impact shall be evaluated under the effluent discharge from this centralized effluent treatment plant.

6.0 CONCLUSION

The selection of the chemicals to be used shall avoid prohibited chemical list. With the implementation of all mitigation and management measures described above, impact from chemical handling and management to the environmental components are expected to be insignificant.

7.0 REFERENCES

Environmental Quality Act, 1974 (Act 127)

Environmental Quality (Prohibition on the Use of Chlorofluoro-carbons and Other Gases as Propellants and Blowing Agents) Order, 1993

Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations, 2013 (CLASS)

Environmental Quality (Refrigerant Management) Regulations, 1999

Environmental Quality (Halon Management) Regulations, 1999

Occupational Safety and Health (OSH) Use and Standards Exposure of Chemicals Hazardous to Health (USECHH) Regulations, 2000

Guidelines on Storage of Hazardous Chemicals: A Guide for Safe Warehousing of Packaged Hazardous Chemicals, Department of Occupational, Safety and Health, 2005

Chemical Management Program, PETRONAS Technical Standards (Health, Safety and Environment), PTS 18.33.01 February 2016.

Effluent Dispersion Modelling

ADDITIONAL INFORMATION TO THE DEIA REFINERY AND PETROCHEMICAL INTEGRATED DEVELOPMENT (RAPID) PROJECT, PENGERANG JOHOR, 2012 TO INCLUDE EURO 5 MOGAS AND OLEFIN TANK UNITS

Prepared For:

PETRONAS REFINERY AND PETROCHEMICAL CORPORATION SDN. BHD.

Prepared By:

INTEGRATED ENVIROTECH SDN. BHD. (650387-K)

MARCH 2017

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1 Introduction

PETRONAS is planning to submit an additional information report to the RAPID DEIA 2012 for the RAPID project approved by the Department of Environment Malaysia (DOE). As part of this resubmission, DHI Water & Environment (M) Sdn Bhd has been appointed to carry out the dispersion modelling and to evaluate potential impacts of the discharged effluent from the marine outfall of the proposed Centralised Effluent Treatment Plant (ETP).

It should be noted that JPS approval is not required for this study as another cumulative hydraulic study is currently being undertaken for a separate EIA study for the RAPID Solid Product Jetty (SPJ) and approval from JPS was obtained for that EIA study. That study will include all RAPID marine structures such as Effluent Treatment Plant (ETP) outfall, Solid Product Jetty (SPJ), Storm Water Outfall (SWO) and Material Offloading Facility (MOLF) at Tanjung Setapa. Cumulative impacts from all RAPID marine structures on the effluent dispersion from the outfall shall be in reference to the studies conducted under the SPJ EIA.

This report describes the dispersion modelling study that has been carried out to assess effluent dispersion discharged from the proposed ETP outfall on the marine environment.

2 Description of the Proposed Marine Outfall

All of the effluent generated from the RAPID Complex shall be routed to be treated in the Centralised Effluent Treatment Plant (ETP) except for the non-contaminated surface runoff where it will be routed to the storm water pond prior to discharge via storm water (STW) outfall to the sea.

The Centralised ETP will be treating various types of effluent to meet the RAPID discharged effluent to meet the RAPID discharged effluent specifications prior to discharge into the ETP outfall. The outfall pipeline which is approximately 3 km in length, will be discharging from offshore into the marine waters (**Figure 2.1**).

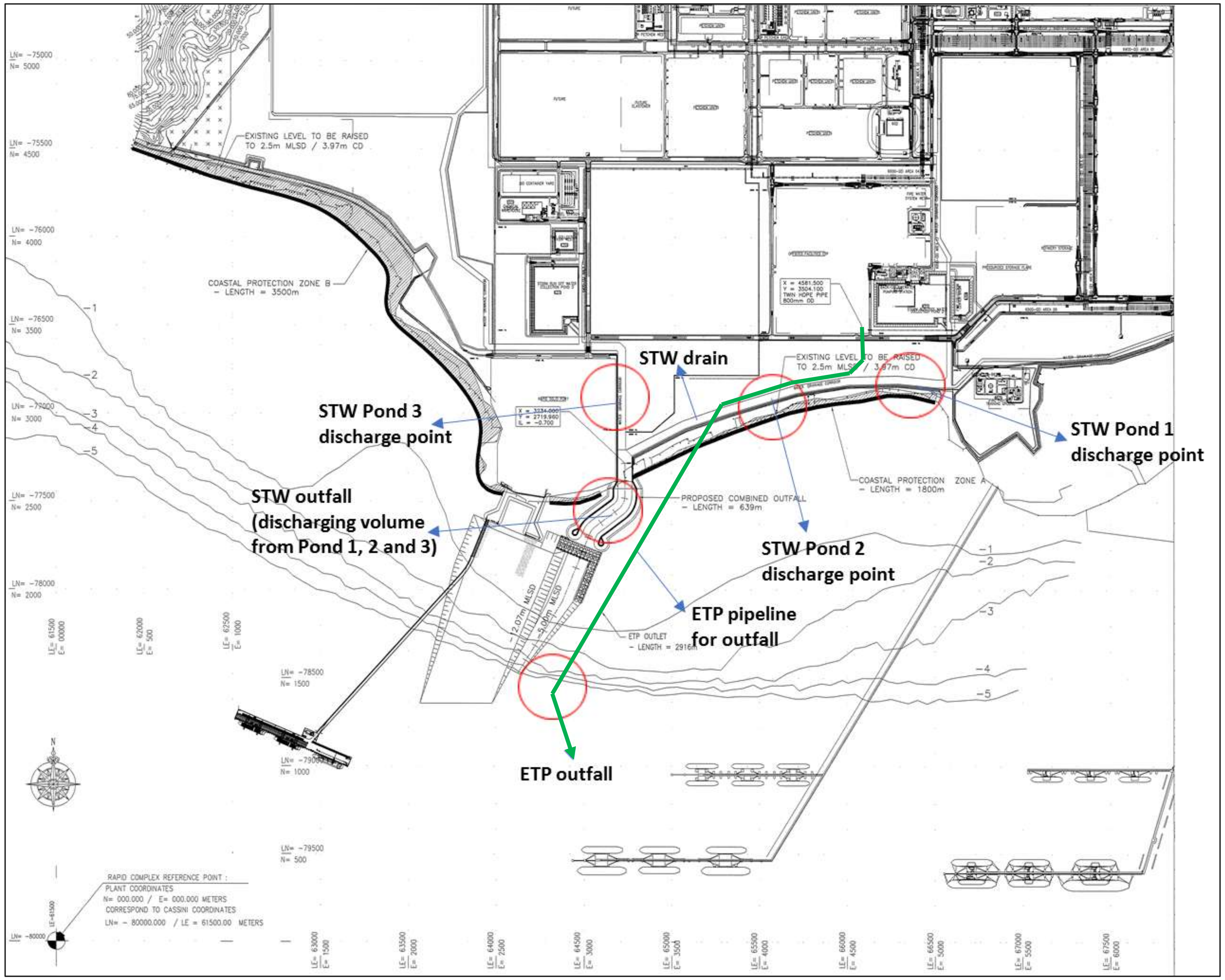

Figure 2.1: Location of the proposed outfall from RAPID complex.

In the RAPID Centralised ETP, the final treated effluent is to be discharged into the ETP Observation Pond where effluent from the pond is regulated in regards to the required discharging limit enforced by the Department of Environment (DOE) for the effluent prior to discharge into the marine outfall.

Treated effluent from the observation pond will be pumped to marine outfall at a controlled rate into the sea. At the outlet of the observation pond, automated sampling is provided to monitor the quality of the treated effluent[1]. The observation pond will be receiving effluent from the following main treatment units in the Centralised ETP[2]:

- Accidently Oily Contaminated (AOC) water – Storm water which is potentially polluted by oil from spillage and leaks
- Continuously Oily Contaminated (COC) water – Effluent polluted with hydrocarbons and dissolved organic pollution partially biodegradable including oily polluted process effluents
- Process Waste Water (PW) – effluent with low oil content
- Utilities Effluents (UE) – regulated industrial effluent from cooling towers and demineralization and polishing units
- Sanitary Waste Water (SWW) from buildings

It is known that the marine outfall will be discharging effluent regulated by pumping sequence that pumped the effluent from the observation pond after 2 hours retention in the pond. The design flow rate of the outfall is 5,355 m^3/hr[3]. Break down of the total design flow rate is shown in **Table 2.1**.

[1] RAPID-P016A-VWM-PRO-DES-6300-0001_1 (Design Basis - Unit 6300 Common Facilities)
[2] RAPID-P016A-VWM-PRO-DES-6300-0001_1 (Design Basis - Unit 6300 Common Facilities)
[3] RAPID-P016A-VWM-PRO-CAL-6300-0001_0A (Calculation Reports & Notes - Unit 6300 ETP Common Facilities)

Table 2.1: Design Flowrate from ETP tanks into the ETP Observation Pond

Treated effluent from AOC (m^3/hr)	2,041
Treated effluent from COC/PW (m^3/hr)	990
Treated effluent from SWW (m^3/hr)	16
Treated effluent from UE (m^3/hr)	1,566
Rainfall intensity of 180 mm/hr (m^3/hr)	743
Total flow rate to observation pond/ marine outfall (m^3/hr)	5,355

Block flow diagram of the effluent treatment plant to the marine outfall is shown in **Figure 2.2**. It should be noted this study will be focusing on the dispersion of effluent from the outfall into marine waters.

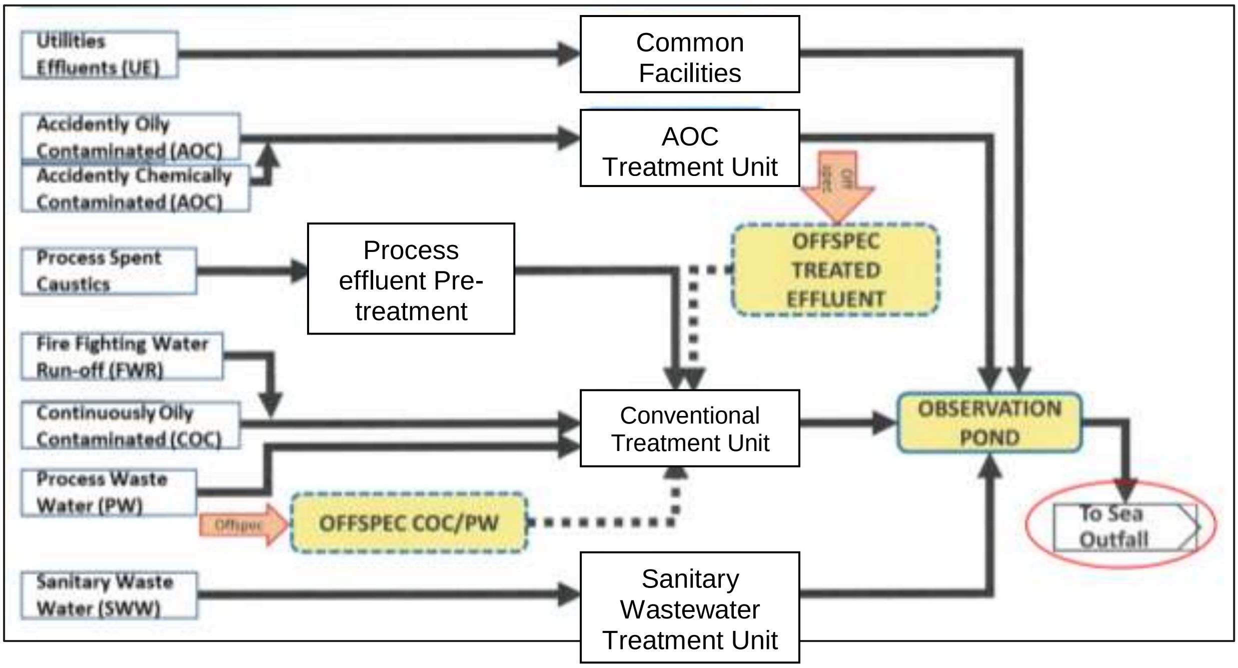

Figure 2.2 Block flow diagram of the effluent treatment plant to an outfall.

The proposed marine outfall will be located south of the site, offshore from Tanjung Setapa as shown in **Figure 2.1**. The outfall will be connected from the observation pond through buried pipeline. More information on the proposed marine outfall is presented in **Table 2.2**. A study on the selection of the suitable location for the outfall has been carried out by the PETRONAS before[4] and can be found in the similar study for the RAPID PETCHEM DEIA 2014.

Table 2.2: Engineering details of the proposed Centralised ETP outfall.

The coordinate of the proposed outfall location in UTM 47[5].	404277.7E m, 147267.9N m
Pipeline details	Twin HDPE pipeline with 800m diameter[6]
	Total length approximately 3km (1.5km installed underground at the land side and 1.5 km installed in a trenched seabed).
Discharge depth	-4 m chart datum (CD)
Design flow rate	1.49 m^3/s (for underground and submerged pipe)

The design philosophy for the effluent treatment in RAPID Centralised ETP adopts the combination of the Department of Environment (DOE) Sewage and Industrial Effluent limits and the RAPID Design Limit, whichever is more stringent as below:

- Standard B of Environmental Quality Regulation 2009 for Sewage and Industrial Effluent (Malaysian Standard B).
- RAPID Design Limit

The adopted RAPID project standard is presented in **Table 2.3** with a comparison to the Malaysian Standard B and RAPID Design Limit. Effluent released from the outfall shall be regulated not to exceed limits mentioned in this table.

[4] RAPID-P0014-S005-ENG-ERP-7650-0001_RevC
[5] RAPID-P0014-S005-ENG-ERP-7650-0001_RevC
[6] RAPID_P0014_S005_CVS_DWG_7620_0101

Table 2.3: Concentration limit for the RAPID project treatment standard.

Parameters	Unit	RAPID Project Treatment Standard	Malaysian Standard B
pH	-	5.5 to 9.0	6
Chemical Oxygen Demand (COD)	[mg/l]	150	200
Biological Oxygen Demand (BOD_5)	[mg/l]	25	50
Total Suspended Solid (TSS)	[mg/l]	30	100
Oil & Grease	[mg/l]	10	10
Total Phosphorus (P-TOT)	[mg/l]	2	-
Total Nitrogen (N-NGL)	[mg/l]	10	-
Benzene	[mg/l]	0.05	-
Phenol	[mg/l]	0.2	1
Sulphide	[mg/l]	0.5	0.5
Colour	[ADMI]	200	200
Ammoniacal Nitrogen	[mg/l]	5	5
Nitrate Nitrogen	[mg/l]	10	10
Phosphorus	[mg/l]	2	-
Total Coliform Bacteria	[MPN/100ml]	400	-

The effluent treatment philosophy for the Centralised ETP also adopts the concept of recycling treated water and allocation of off-specification tanks for further treatment prior to discharge.

3 Study Methodology and Approach

The following tasks were carried out for the effluent dispersal assessment:

- Gathering of available data from previous studies of the area;
- Modelling and implementation of calibrated 3D hydrodynamic model to describe the effluent dispersal and water exchange at the site;
- Analysis and presentation of results.

3.1 Data Gathering

The relevant information, such as bathymetric survey data and project documents have been collected in order to aid the understanding of the existing physical hydraulic condition and the description of proposed development.

3.1.1 Bathymetric Survey Data

DHI has undertaken hydraulic studies in the area and possesses calibrated models that are readily available for the effluent dispersion assessment. These models have been updated with the following bathymetric survey data from previous studies that carried out at the Pengerang area.

Table 3.1: Details of Bathymetric Survey

No.	Survey Campaign	Date of Survey
1	Pengerang Deep-water Terminal DEIA	December 2009
2	RAPID DEIA	April 2012
3	Solid Product Jetty FEED	June 2015

3.1.2 Water Quality Sampling

Water quality samples for baseline conditions were taken in November 2011 and December 2012 for RAPID PETCHEM DEIA 2014. However due to the on-going development that has been taken place close to the project area, additional set of marine water samples at six locations were taken on 6th June 2016 to represent current condition. Location of the sampling stations are shown in **Figure 3.1** while sampling coordinates is tabulated in **Table 3.3**. The samples were taken during high tide and low. Followings are few of the tested parameters used in this study and presented in **Table 3.4**.

- Nitrate as NO_3
- Phosphate as P
- Total Suspended Solids (TSS)
- Oil and Grease
- Total Nitrogen
- Ammonia
- Phenol

These parameters were compared with the Class 3 of Malaysia Marine Water Quality Standards of 29th November 2010 (MMWQS) in order to have an overview of water quality near the project area. The definition of the Malaysia Marine Water Quality Standard (MMWQS) classes are as follows:

Table 3.2: Malaysia Marine Water Quality Standard (MMWQS) Classification

MMWQS Class	Beneficial uses
Class 1	Preservation, Marine Protected areas, Marine Parks
Class 2	Marine life, Fisheries, Coral Reefs, Recreational and Marine culture
Class 3	Ports, Oil & Gas Fields
Class E	Mangroves Estuarine & River mouth Water

From **Table 3.4**, it can be observed that the ambient water quality parameters near the project area is below the limit of Class 3 except for nitrate. The average nitrate levels near the project area is approximately 1.8 mg/l which is higher than 1 mg/l limit in Class 3. This may due to the return of nutrients to the water surface from the process of upwelling or from untreated domestic wastewater and nitrate based fertilizers[7] close to the project area.

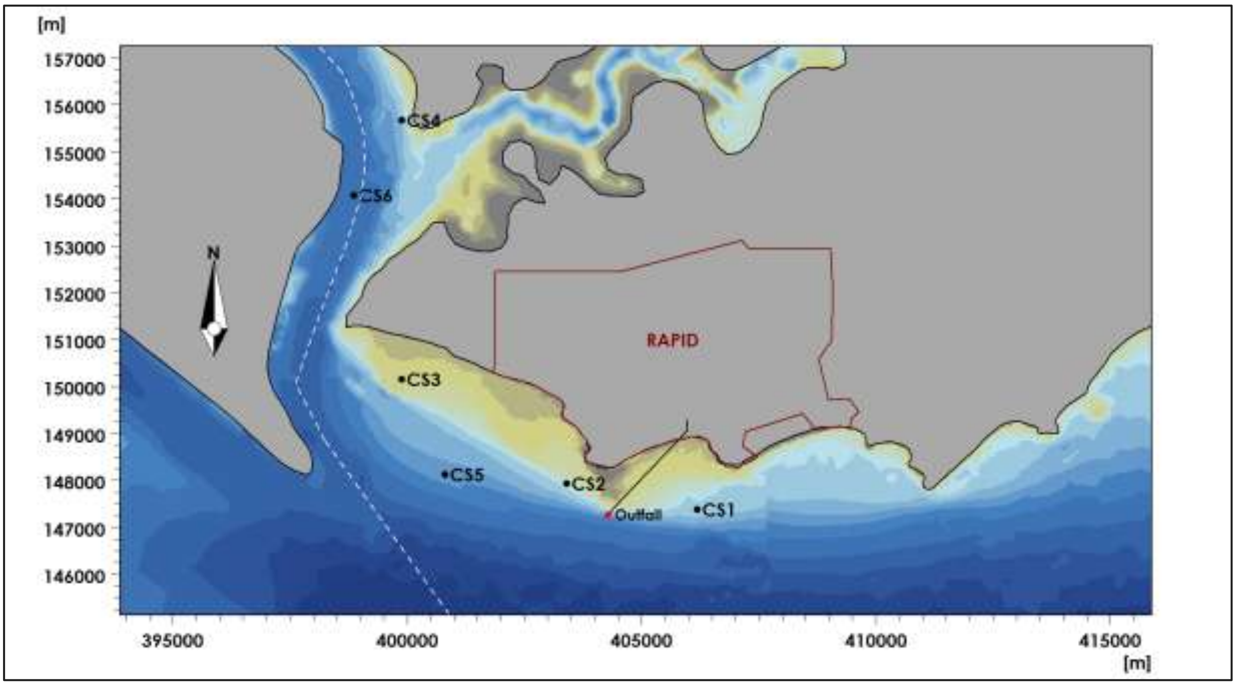

Figure 3.1: Water quality sampling stations.

Table 3.3: Coordinates of the water quality stations.

Stations	Longitude (°)	Latitude (°)
CS 1	104.1567	1.3333
CS 2	104.1317	1.3383
CS 3	104.1000	1.3583
CS 4	104.1000	1.4083
CS 5	104.1083	1.3400
CS 6	104.0908	1.3938

[7] DEIA for the Proposed Petrochemical Plants (Batch 1) in the Refinery and Petrochemical Integrated Development (RAPID) Project, Pengerang Johor.

Table 3.4: Measurement of available measured water quality parameters.

Parameters	Units	Averaged Measurement						Class 3 Limit of MMWQS
Stations		CS1	CS2	CS3	CS4	CS5	CS 6	
Nitrate as NO3	mg/l	1.9	1.8	1.6	2	1.6	1.8	1
Phosphate as P	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.67
Total Suspended Solids	mg/l	22.5	11.5	11.3	13	18.3	10.3	100
Oil and Grease	mg/l	0.04	0.04	0.04	0.04	0.04	0.04	5
Total Nitrogen	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	NA
Ammonia	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.32
Phenol	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.1

3.1.3 Reference Document

Information from the following documents has been used as reference on the proposed outfall and assessment:

- Hydraulic & Coastal Modelling Report. Detailed Environment Impact Assessment (DEIA) for the proposed Refinery and Petrochemical Integrated Development (RAPID) project at Tg. Setapa, Johor
- Malaysia Marine Water Quality and Standard (MMWQS) of 29th November 2010
- Standard B of Environmental Quality Regulation 2009 for Sewage and Industrial Effluent (Malaysian Standard B)
- RAPID-P016A-VWM-PRO-DES-6300-0001_1 (Design Basis - Unit 6300 Common Facilities)
- RAPID-P016A-VWM-PRO-CAL-6300-0001_0A (Calculation Reports & Notes - Unit 6300 ETP Common Facilities)

- RAPID-FE1-TPX-HSE-DES-0001-0006_3_S (Job Specification for Design – Environmental & Health Design Basis)

3.2 Establishment of Numerical Models

Numerical modelling has been applied in this study to support the assessments of potential dispersion impacts induced by effluents released from the proposed marine outfall. The dilution of effluent release in open waters occurs due to the mixing process mainly influenced by the ambient current flow conditions. The effluent plume will potentially be diluted and travel further away from the release point during stronger current flow conditions.

Therefore the dispersion of effluent has been modelled using MIKE 3 by DHI (3-dimensional model) to simulate the flow conditions and water levels variations in the study area. This 3D model is useful in describing the vertical flows of density differences in salinity. The release of fresh water from the outfall may produce an upward mixing process from the bottom towards the surface.

3.2.1 Model Complex

A number of different models have been developed to assess the effluent dispersion conditions:

- **MIKE 3 Hydrodynamic (HD) Model**

- The MIKE 3 HD module has been used for modelling of current flows, water levels and salinity variations. The HD module simulates water level variations and flows in response to a variety of forcing functions in oceans, lakes, estuaries, bay and coastal regions. It is applied to a wide range of hydraulics related phenomena including tidal hydraulics, wind and wave generated currents, storm surges and flood waves.

- The MIKE 3 HD module is the base computational hydrodynamics module of the entire MIKE 3 system providing the hydrodynamics basis for MIKE 3 Advection-Dispersion that will be described below.

- **MIKE 3 Advection-Dispersion (AD) Model**

- The dispersion of pollutant has been modelled using MIKE 3 AD model coupling with HD module.
- The advection-dispersion module simulates the spreading of a dissolved or suspended substance in an aquatic environment under the influence of the fluid transport and associated natural dispersion process. In the present study, the substance is pollutant described in **Table 2.3**, which is released from the proposed marine outfall and treated as conservative effluent without no decaying.
- This provides conservative input to the environment impact assessment.

3.2.2 Model Domain

The model applied in this study is based on an unstructured mesh; an approach where the bathymetry resolution can be varied depending on modelling requirements. This is a fundamental flexibility of the model that allows the spatial resolution to be increased towards sensitive areas including the nearshore areas and the area of the proposed outfall while maintaining low resolution in open areas, where the scale of processes tends to be larger.

The use of unstructured meshes also provides additional flexibility in the vertical discretization. The sigma layer system attributes a relative percentage of the actual water depth to a user defined number of layers (sum of the layer must equal to one). This means that the actual layer thickness has been used to resolve the water depth in the model domain.

In deeper waters, the element sizes are typically coarser, while in shallower waters (typically near the coastline and in the immediate area of interest) the resolution is higher. This approach has proven to be useful for the present study as the study area is characterised by its complex coastal developments and morphology. These bathymetrical complexities influence the hydraulic processes and the transformation of current and waves from offshore to near-shore waters. The varying spatial elements enable the model to represent both offshore and detailed nearshore conditions accurately in the same model, whilst maintaining a reasonable computational efficiency.

A model mesh was established from the bathymetric information obtained from digital admiralty charts and from bathymetric data collected on the site. An overview of the model domain is presented in **Figure 3.2**.

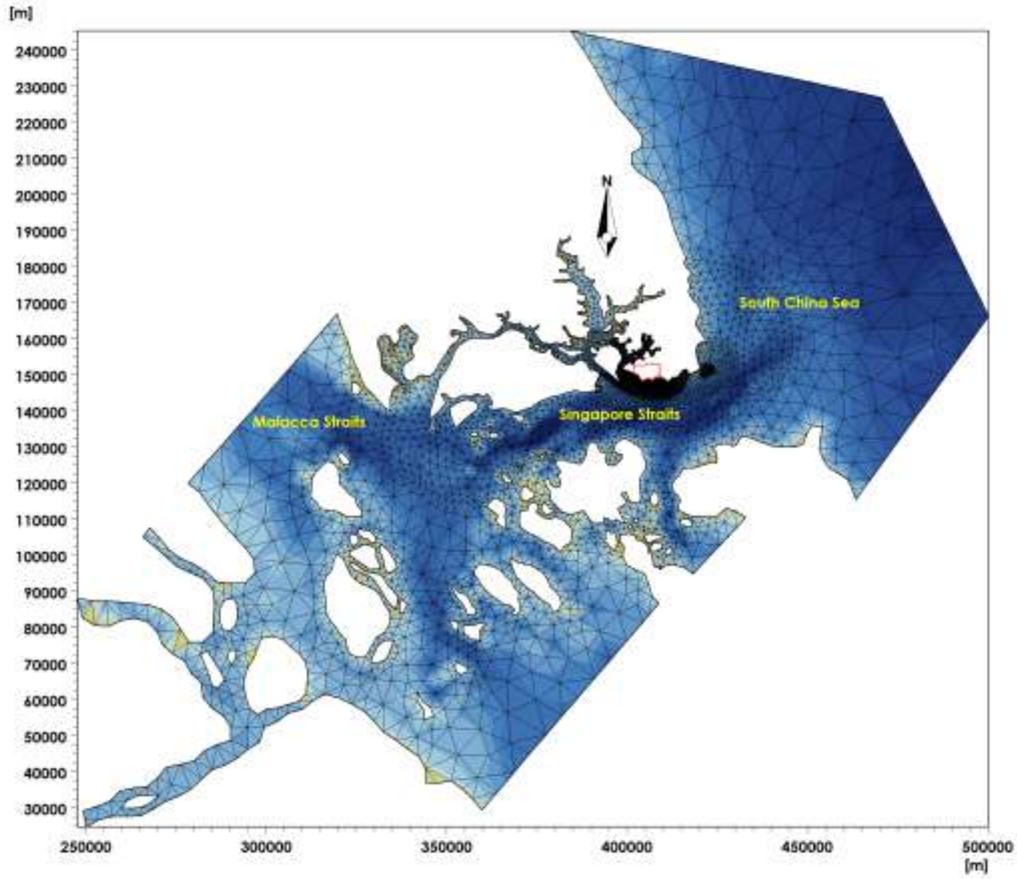

Figure 3.2: Overview of the model mesh applied for the effluent dispersion assessment. Location of the study area is outlined in red.

3.2.3 Model Setting

Layout based on this additional information report has been used in this assessment and the area close to the outfall has been updated with bathymetry data from DHI previous study. Overview of the simulated layout is shown in **Figure 3.3**.

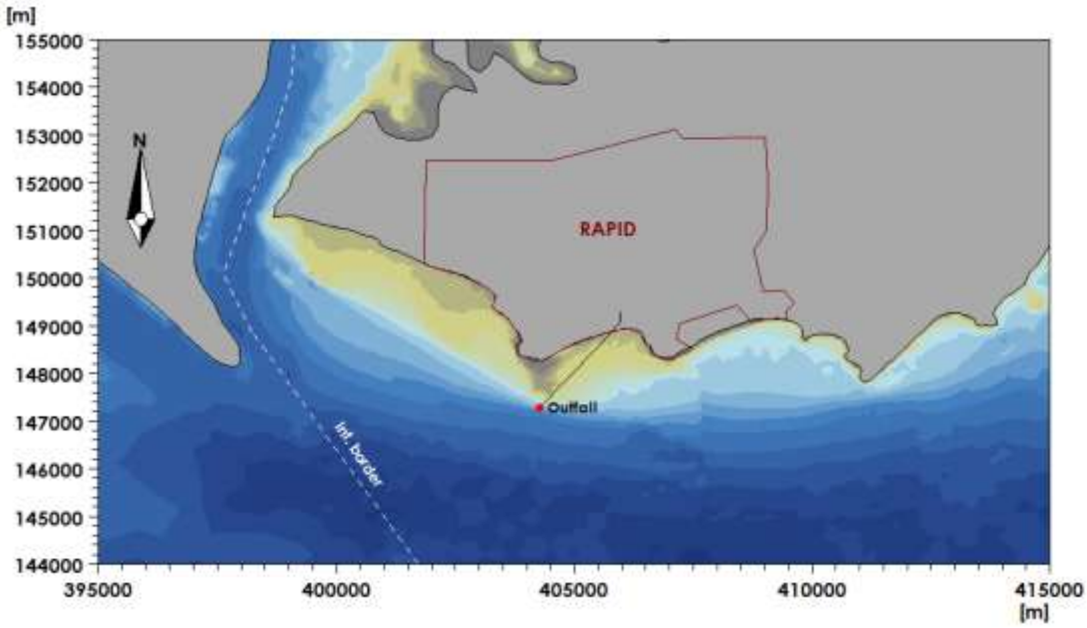

Figure 3.3: Modelled layout.

Since impacts may differ depending on the seasonal conditions, it is, therefore, important to establish realistic seasonal conditions for the quantification of impacts. Three (3) seasonal conditions have been defined to assess the potential dispersion assessment.

- **Northeast Monsoon conditions (NE)** that represent flows during Northeast Monsoon periods when winds and tidal currents interact. The wind from the N-NE is predominant during this monsoon season. The wind with the magnitude of 5 m/s coming from 20 degree has been used.
- **Southwest Monsoon conditions (SW)** that represent flows during Southwest Monsoon periods when tidal currents interact with

predominant winds from S-SE. For this, wind with the magnitude of 5 m/s coming from 180 degree was used.

- **Inter-Monsoon conditions (IM)**: Represents conditions during Inter-Monsoon events when winds are not significant therefore flows are mainly tidal driven. This scenario is also referred as pure tides.

The seasonal conditions, which include tidal conditions and seasonal weather patterns in the region, are represented in 17 days (3+14) simulation periods for simulation of both neap and spring tidal cycles. This includes 3 days of warm up to avoid any type of numerical instabilities that could occur during the initial stage of the simulations.

3.3 Assessment Approach

Assessment of the effluent dispersal will be focused on the released effluent from the proposed outfall with emphasis on the following key elements:

- Changes in Ambient Salinity
  - Salinity changes due to the discharge of combined effluent and fresh water from the outfall.
- Effluent Dispersion
  - Dispersion of effluent and capacity of water exchange in the project area. Good water exchange allows effluents to be dispersed in the marine quickly and efficiently.

4 Assessment of Effluent Dispersal

As described in section 2 of this report, treated effluent from the treatment plant will be released into the sea through the marine outfall with a flow rate of 1.49 m^3/s. Findings from the numerical modelling on changes in salinity, effluent dispersion and changes in water quality are described in the following sub section. For the presentation of results in this study, only top layer or surface water results has been selected as the results are similar with bottom layer results due to the rapid mixing in the shallow areas.

4.1 Changes in Salinity Variations in the Receiving Waters

The discharged treated effluent may change or reduce the salinity level of the ambient marine water thus changing the density in the water body within the vicinity of the outfall.

The assessment of salinity properties and its distribution has been carried out by quantifying maximum reduction in salinity distribution for the surface layer of the water column. The numerical value were calculated over a 14-day period and compared to the ambient salinity. The maximum reduction in salinity due to the mixing of fresh water with marine water is then quantified and presented in **Figure 4.1**. The figure shows the changes in salinity near the outfall after effluent release.

The predicted modelling results show that:

- Reduction in salinity is below 1.35 PSU (less than 4.5% of ambient salinity) occur only around the outfall area, further 4 km away show smaller variations of less than 1%. So the changes are considered minor and localised around the outfall and within the project area.

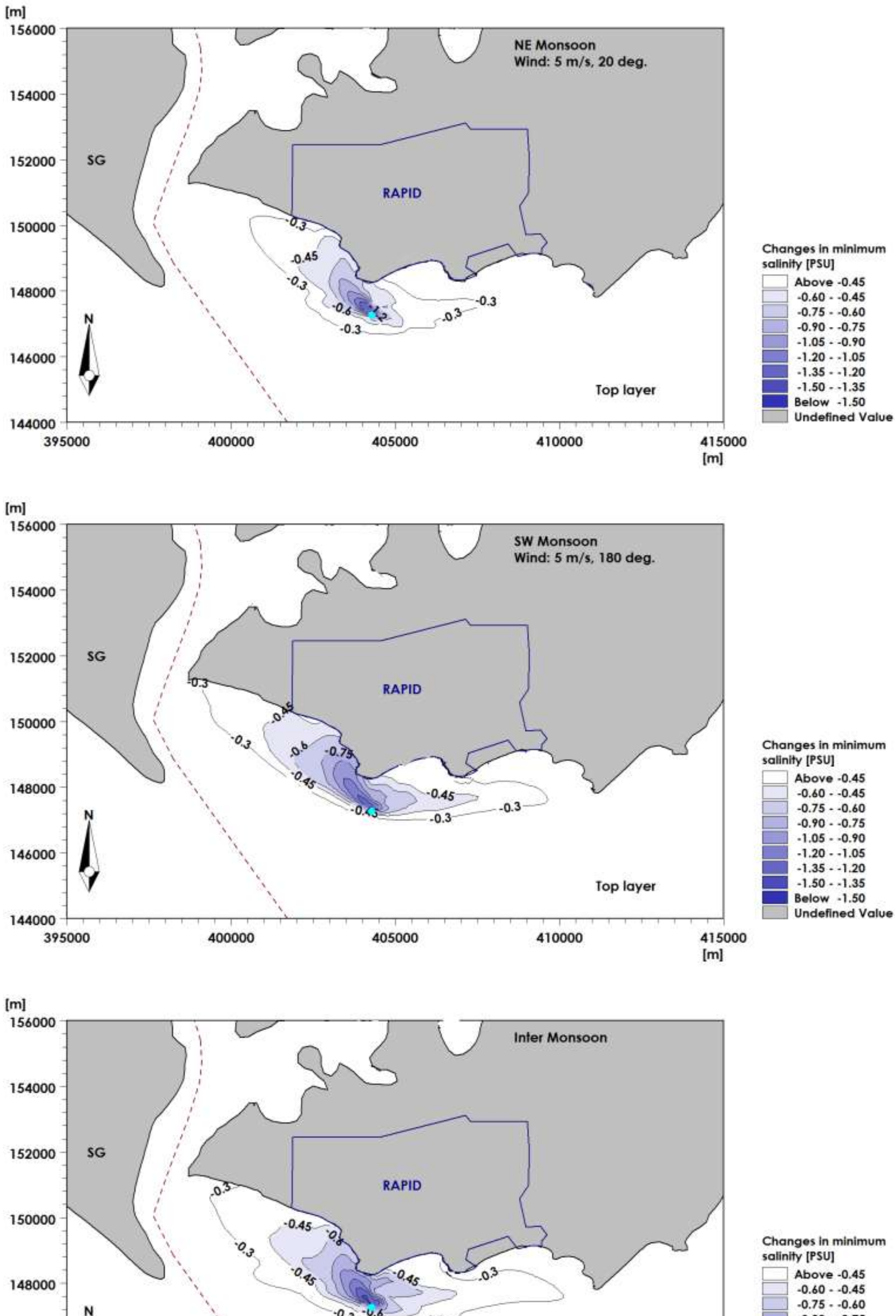

Figure 4.1: Predicted differences in minimum salinity during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

4.2 Dispersion and Dilution of Effluent

Regulated effluent load discharged from the outfall were introduced into the model domain for this assessment. Parameters of the effluent, concentration, loading is listed in the **Table 4.1** below. These parameters are assumed to be conservative (non- decaying) in the model thus providing more conservative input. Effect from the diffusers has not included in the modelling as this will be as the conservative approach. Parameters such as pH and colour listed in **Table 2.3** has not been modelled in this study due to the complexity of the model and require more computation time. Results from the modelling are presented as excess of the released effluent concentration from the background concentration. These are presented in **Figure 4.2** to **Figure 4.14**.

Table 4.1: Modelled pollutant concentration and loading.

Parameters	Flow rate	Concentration	Load per day
COD (from AOC, PW & COC, SWW)	3,044 m^3/hr	150 mg/l	10,960 kg
BOD (from AOC, PW & COC, SWW)	3,050 m^3/hr	25 mg/l	1,830 kg
TSS (from AOC, PW & COC, SWW, UE)	4,624 m^3/hr	30 mg/l	3,329 kg
Oil and Grease (from AOC, PW & COC, SWW)	3,047 m^3/hr	10 mg/l	731 kg
Total Phosphorus (from AOC, PW & COC)	3,031 m^3/hr	2 mg/l	145 kg
Total Nitrogen (from PW & COC)	990 m^3/hr	10 mg/l	238 kg
Benzene (from PW & COC)	990 m^3/hr	0.05 mg/l	1 kg
Phenol (from PW & COC)	990 m^3/hr	0.2 mg/l	5 kg
Sulphide (from PW & COC)	990 m^3/hr	0.5 mg/l	12 kg
Ammoniacal Nitrogen (from SWW)	16 m^3/hr	5 mg/l	2 kg
Nitrate Nitrogen (from SWW)	16 m^3/hr	10 mg/l	4 kg
Phosphorus (from SWW)	16 m^3/hr	2 mg/l	1 kg
Total Coliform Bacteria (from SWW)	16 m^3/hr	400 MPN/100ml	-

* Accidently Oily Contaminated (AOC), Continuously Oily Contaminated (COC), Process Waste Water (PW), Utilities Effluents (UE), Sanitary Waste Water (SWW).

For this assessment, the background concentration in the model domain has been set to zero throughout the whole modelling period and modelling results were presented as the ratio between the load in the model domain and the load in the effluent from the outfall.

In general, from the presented results, the following can be observed:

- The predicted maximum concentration of pollutant is less than 3% for all climatic conditions.
- During the NE monsoon, the dispersed pollutant concentration tend to move away from the coastline at the east side of the outfall.
- The maximum concentration reduce quickly at area 5 km away from the outfall area with an overall reduction of 97 percent. This shows that the water exchange at the outfall is expected to be good. Any potential impacts to the ambient water quality are predicted to be localised and minor.

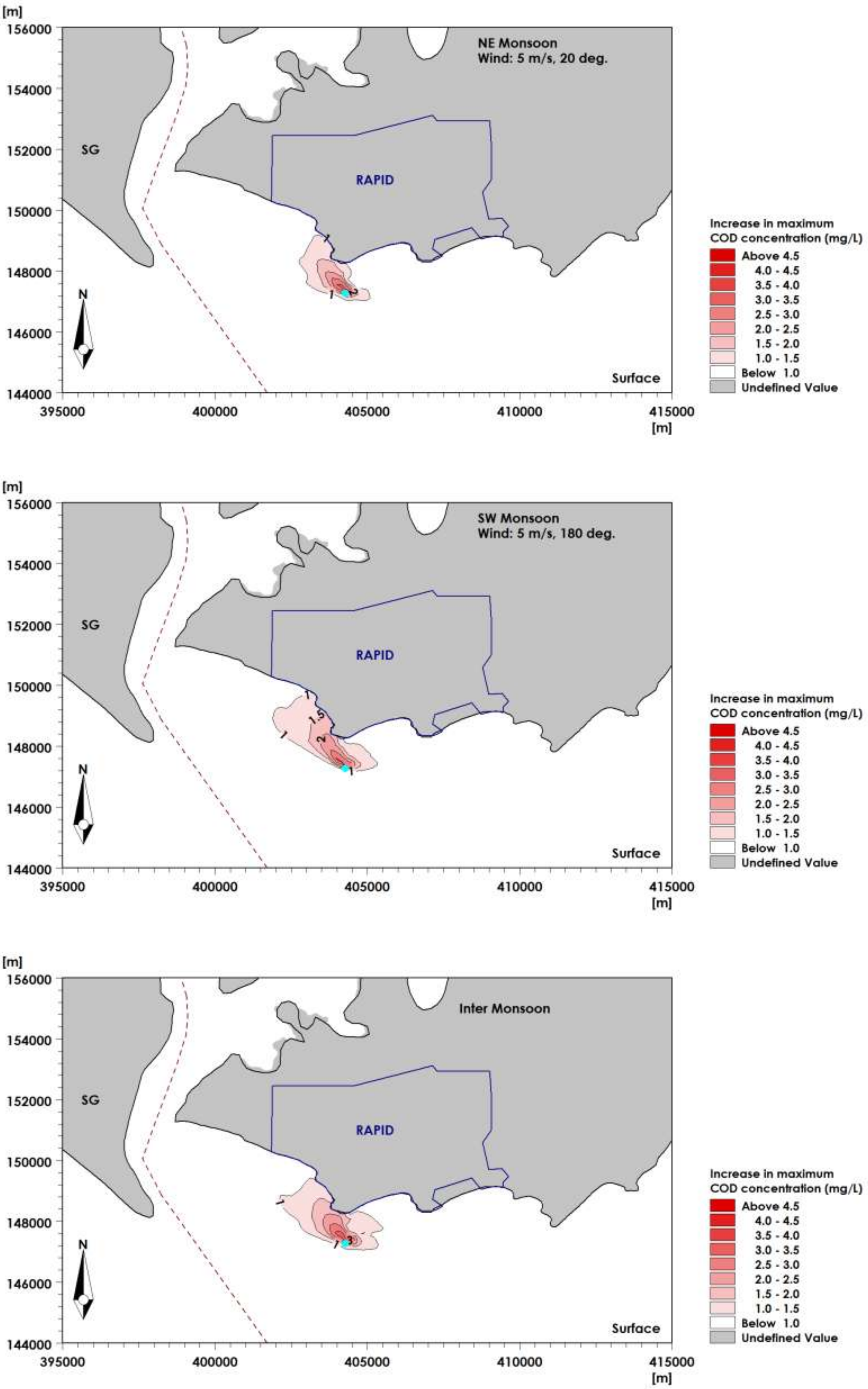

Figure 4.2: Predicted differences in maximum chemical oxygen demand (COD) during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

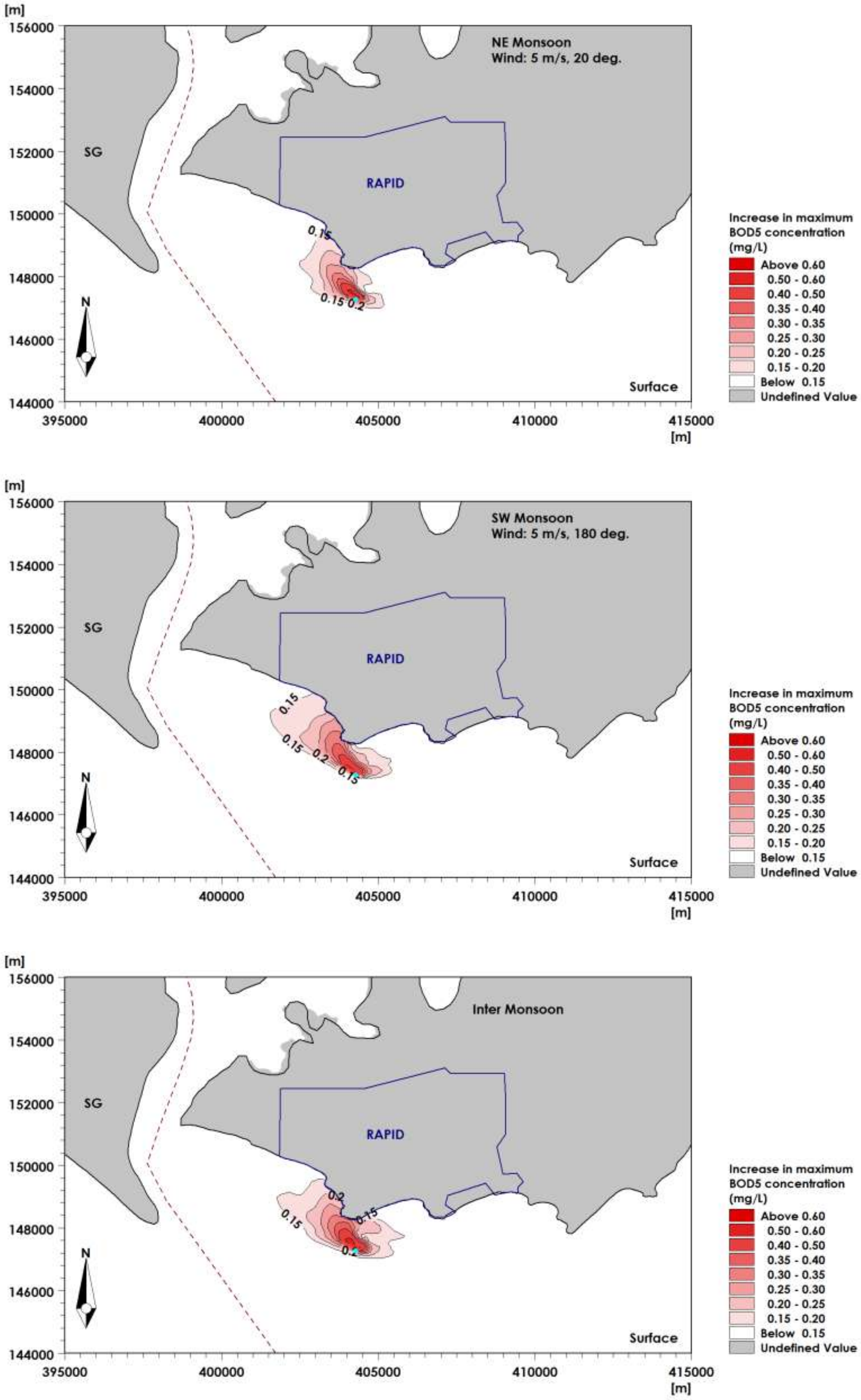

Figure 4.3: Predicted differences in maximum biological oxygen demand (BOD) during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

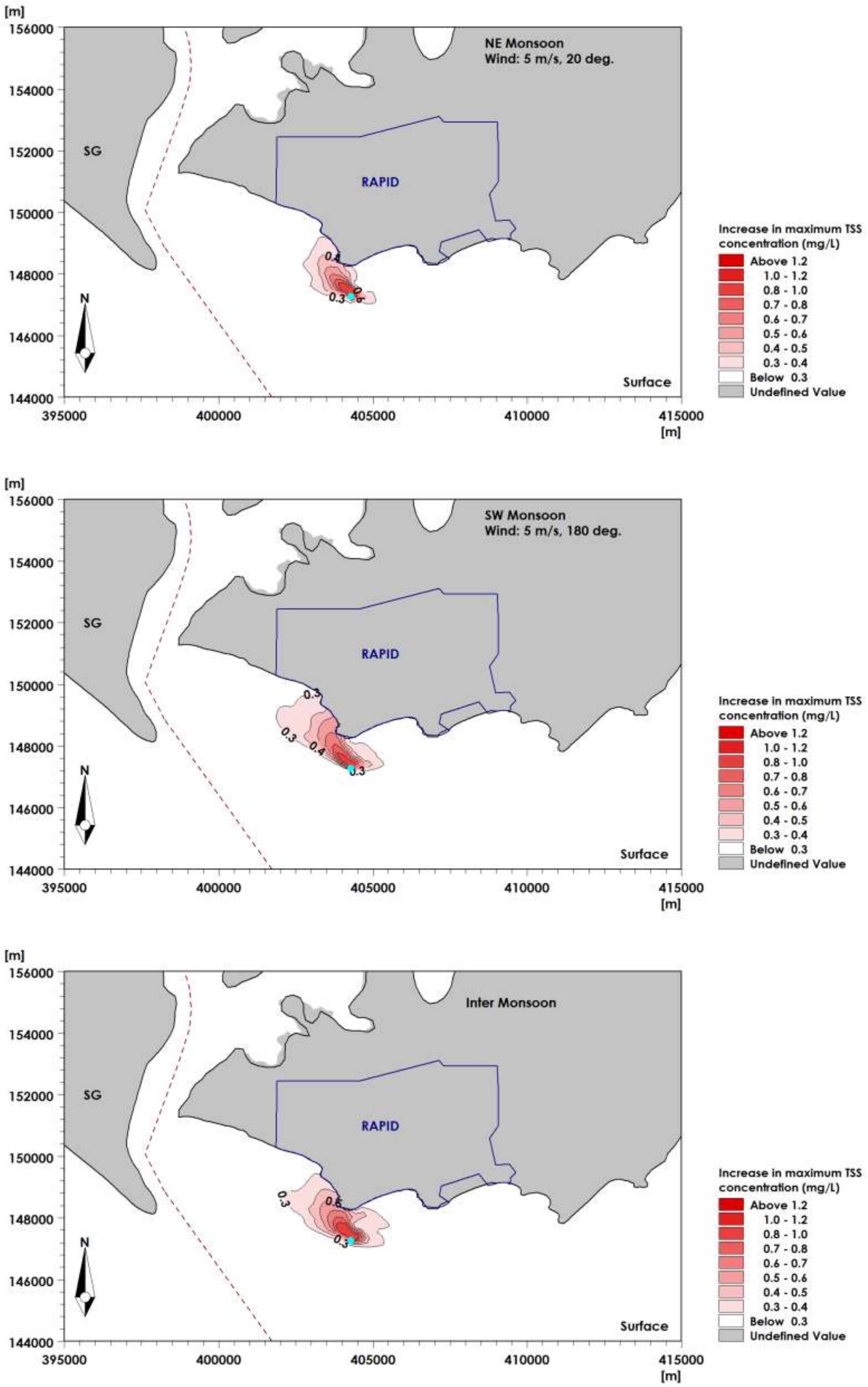

Figure 4.4: Predicted differences in maximum total suspended solids (TSS) during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

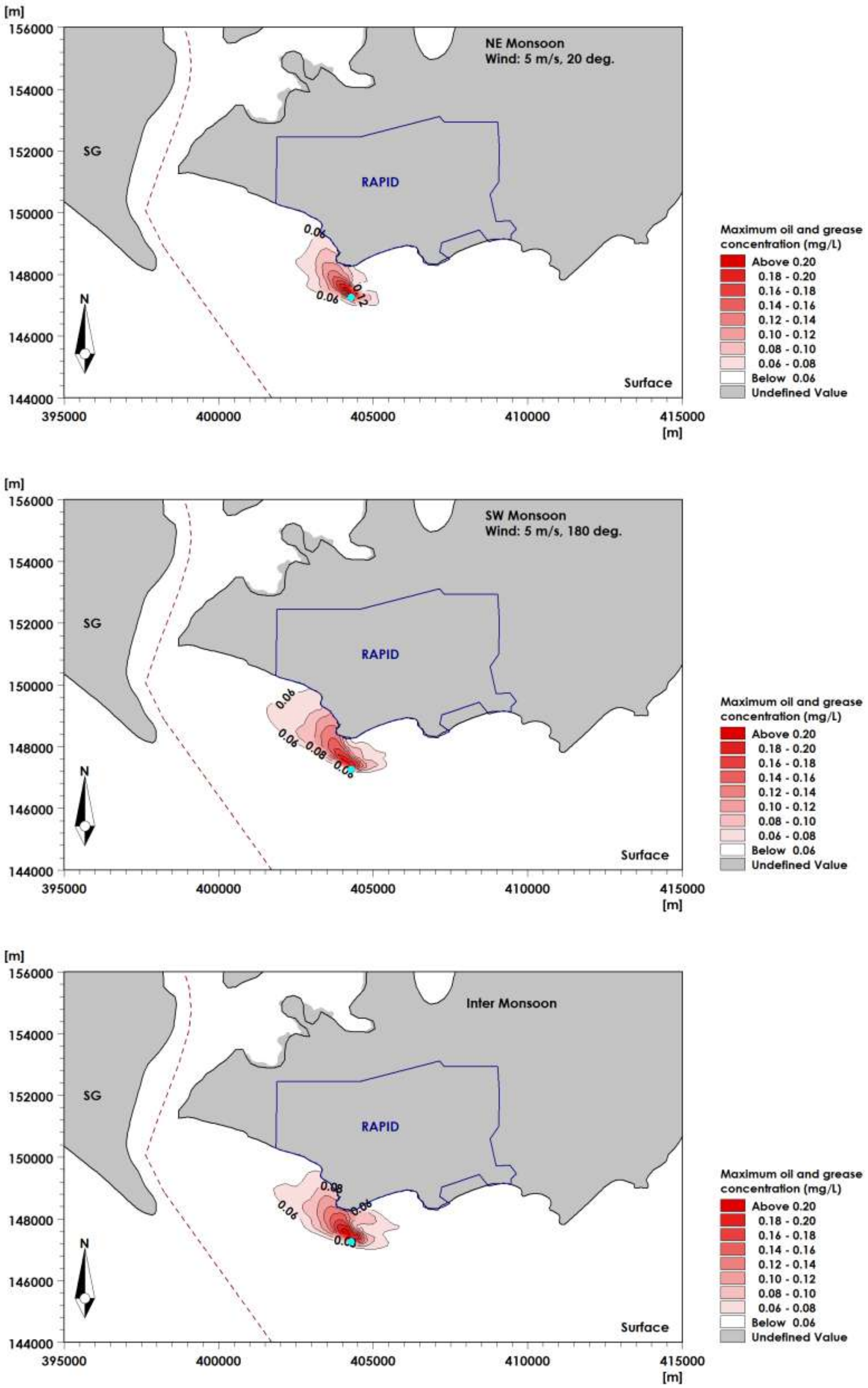

Figure 4.5: Predicted differences in maximum oil and grease during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

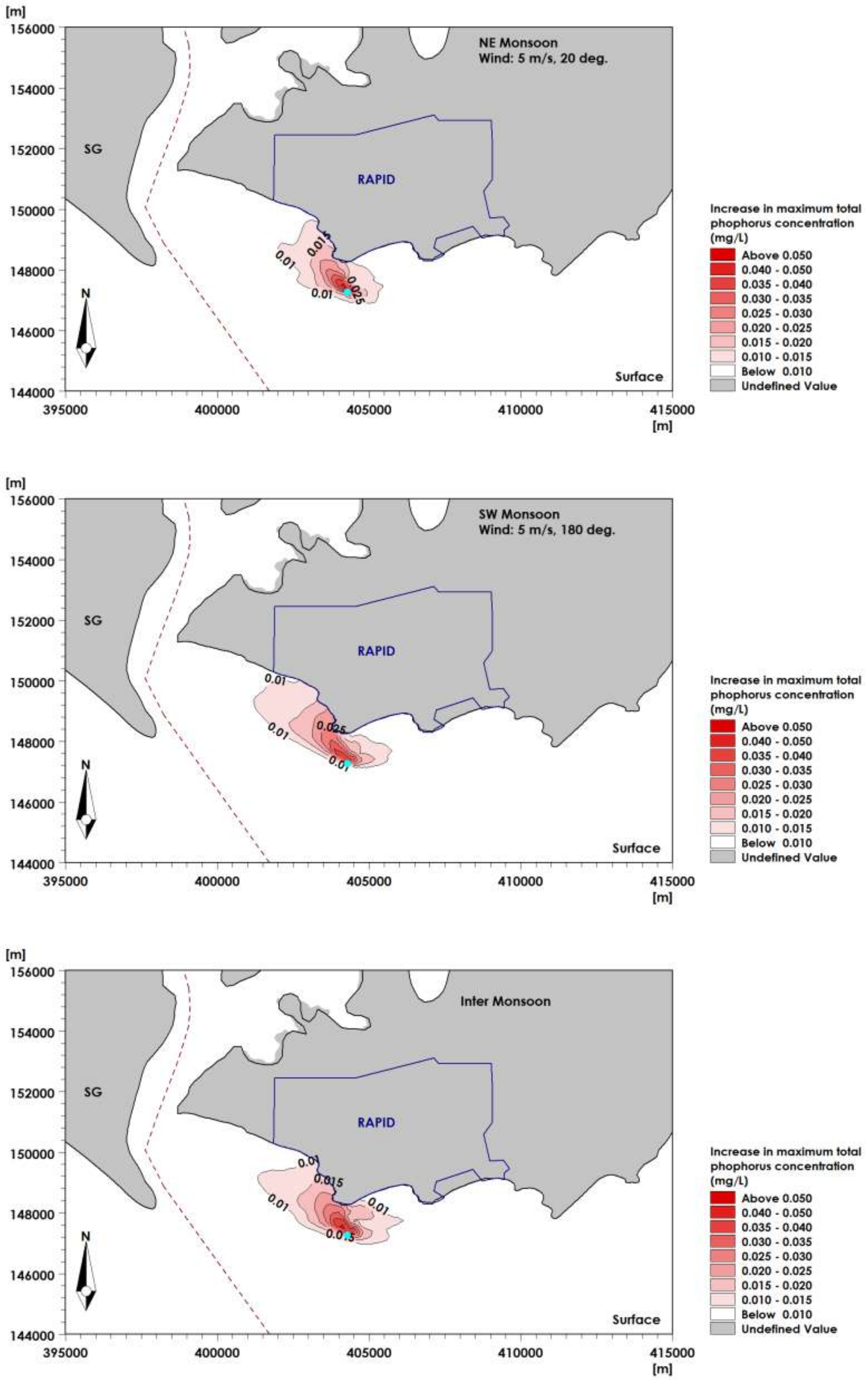

Figure 4.6: Predicted differences in maximum total phosphorus during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

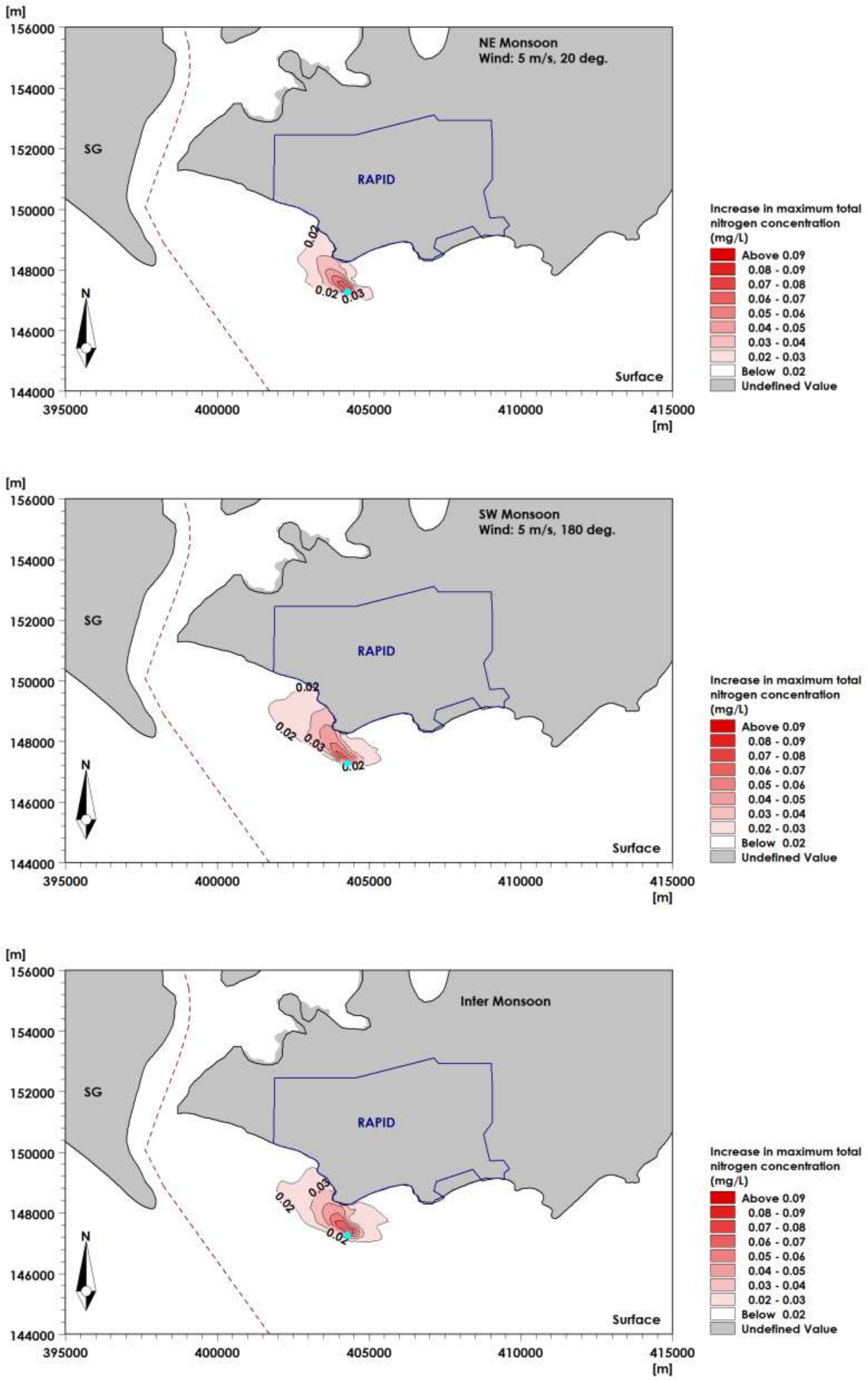

Figure 4.7: Predicted differences in maximum total nitrogen during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

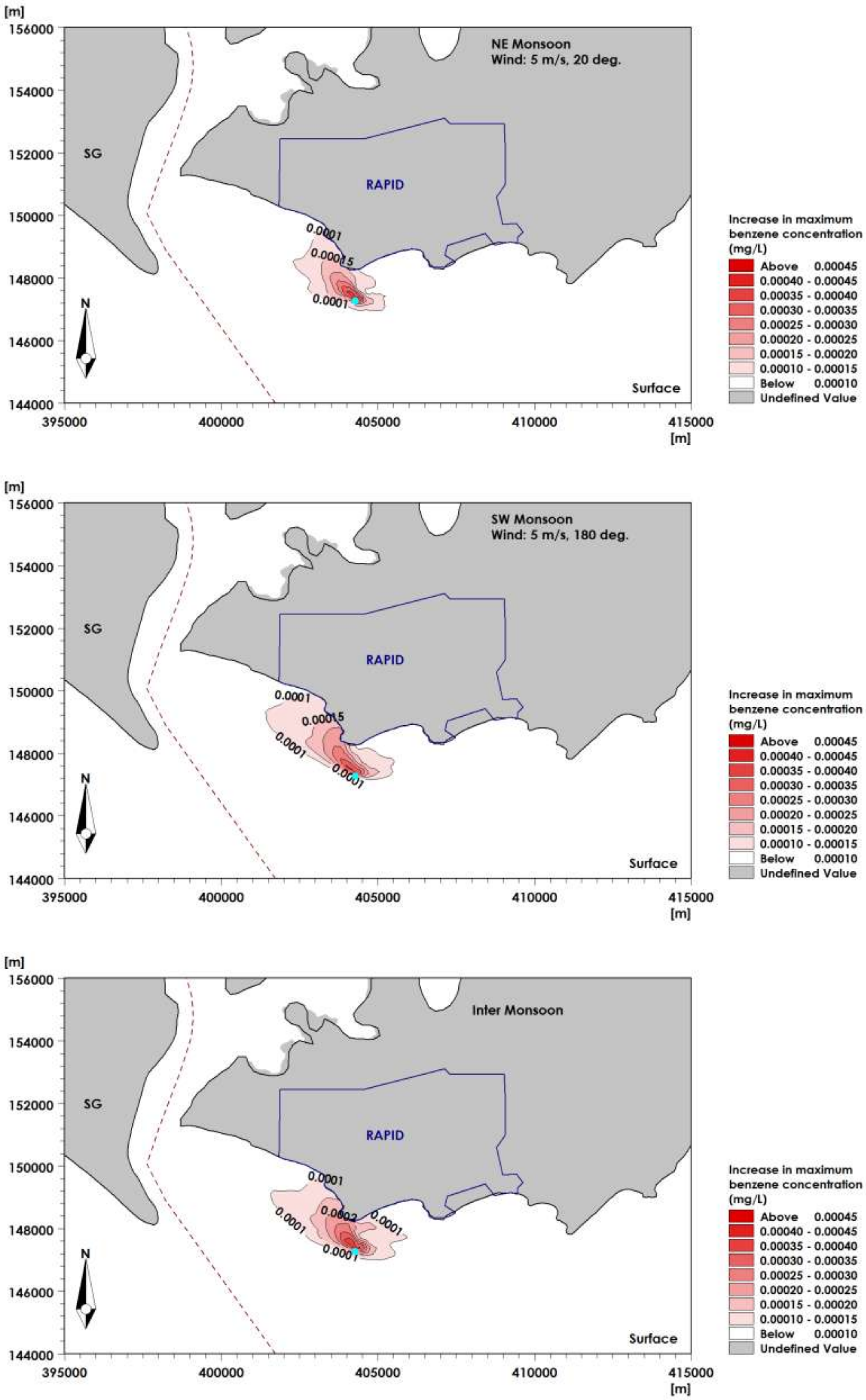

Figure 4.8: Predicted differences in maximum benzene during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom).

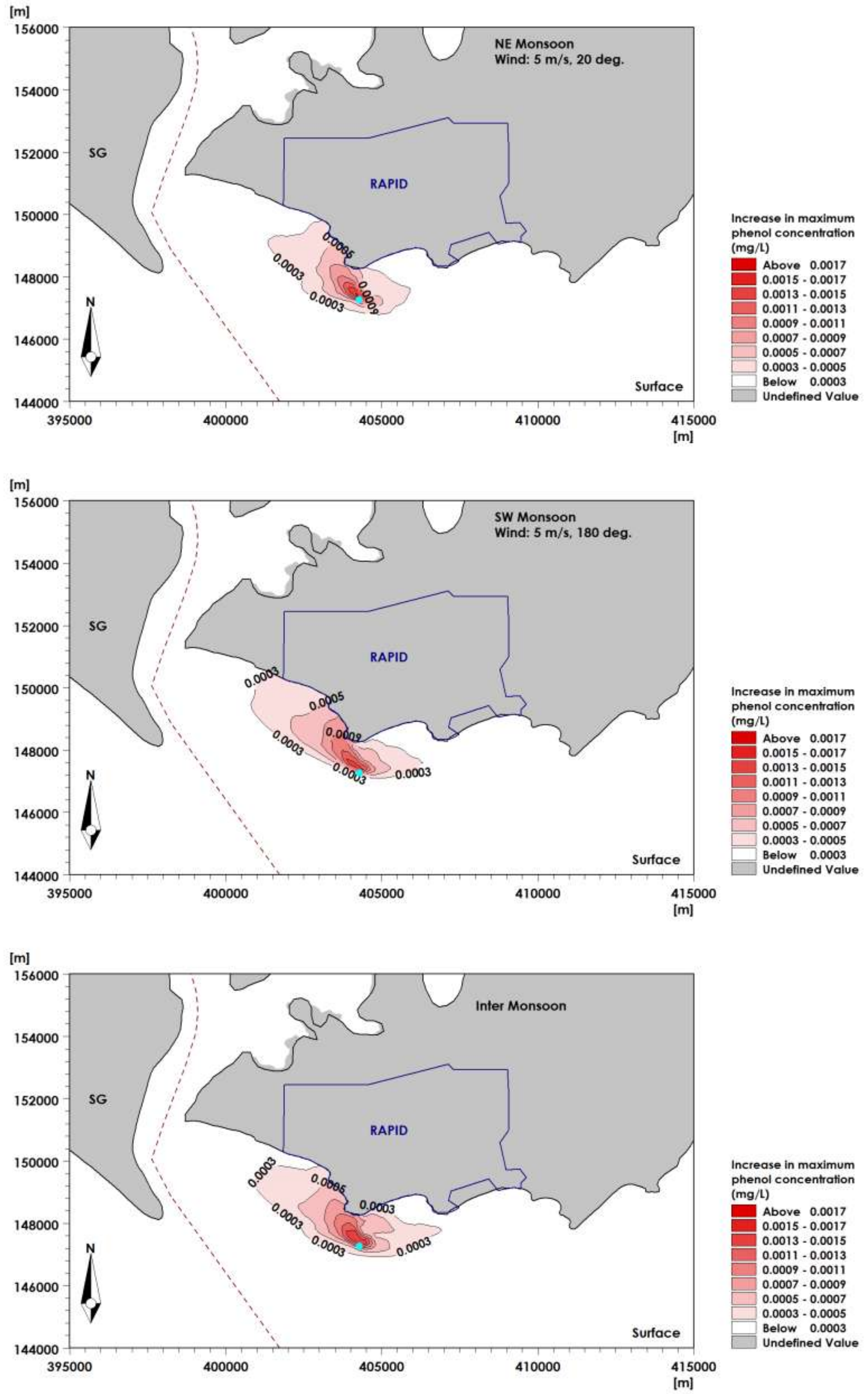

Figure 4.9: Predicted differences in maximum phenol during NE monsoon (top), SW monsoon (SW) and inter monsoon

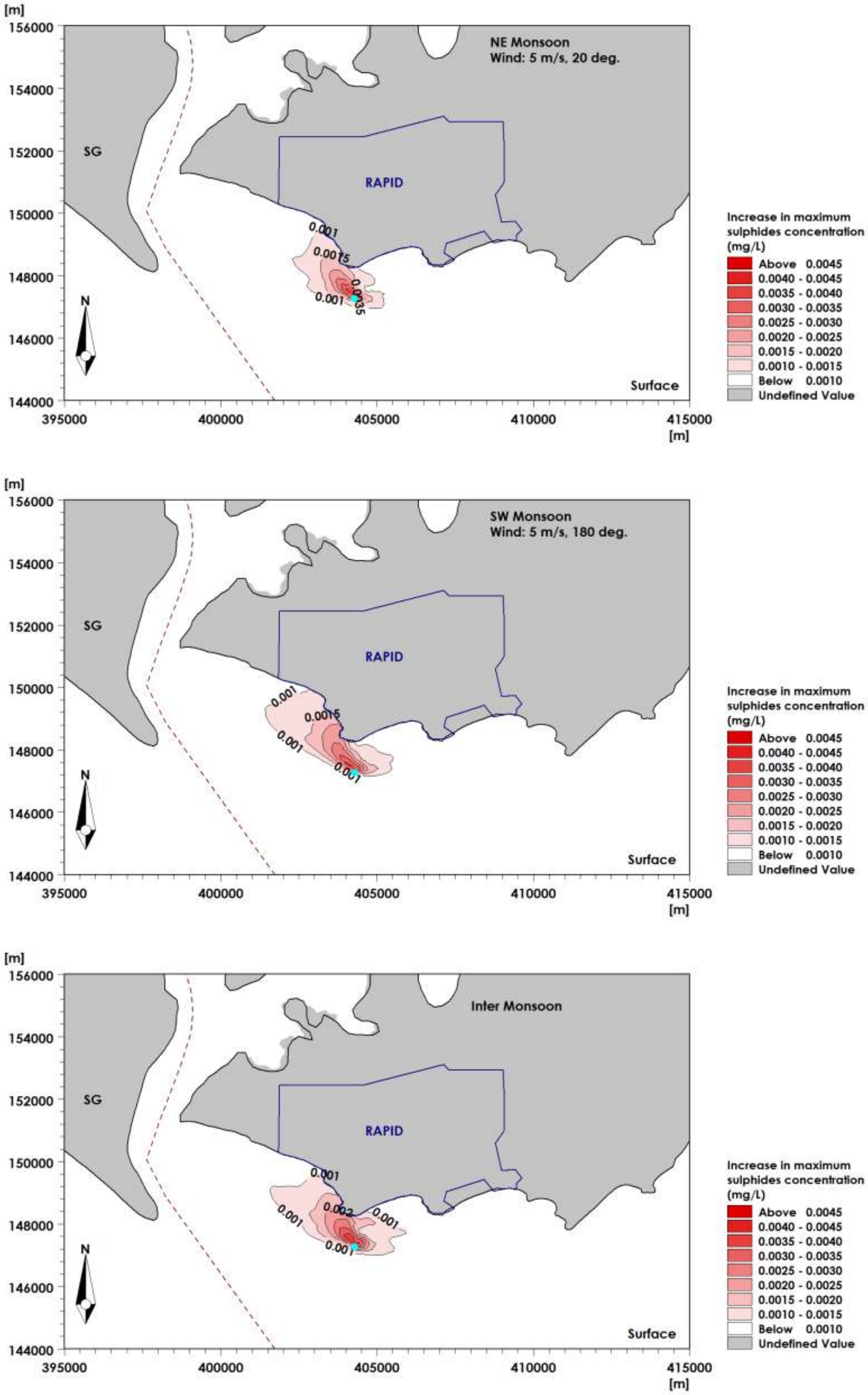

Figure 4.10: Predicted differences in maximum sulphides during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom).

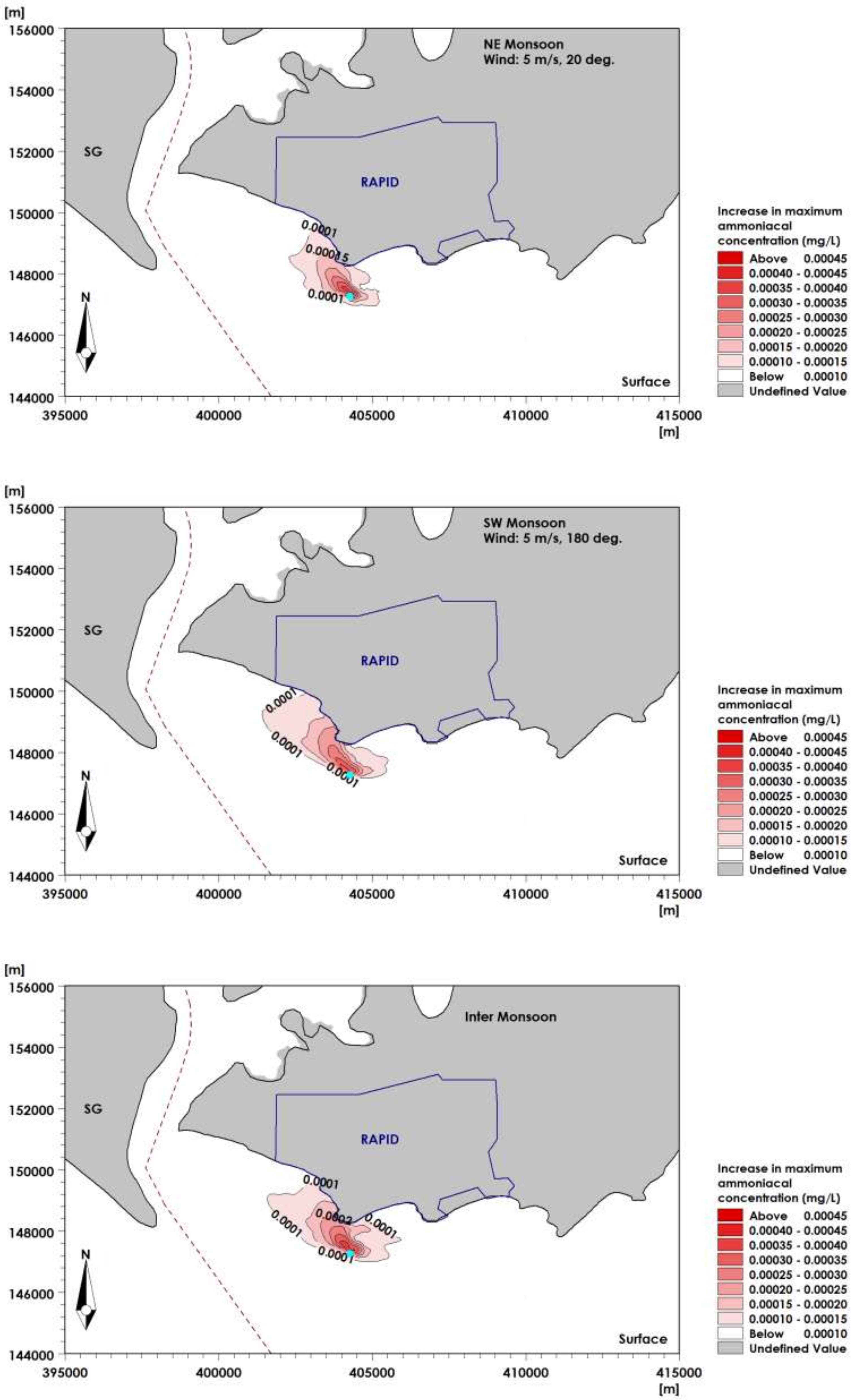

Figure 4.11: Predicted differences in maximum ammoniacal nitrogen during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom).

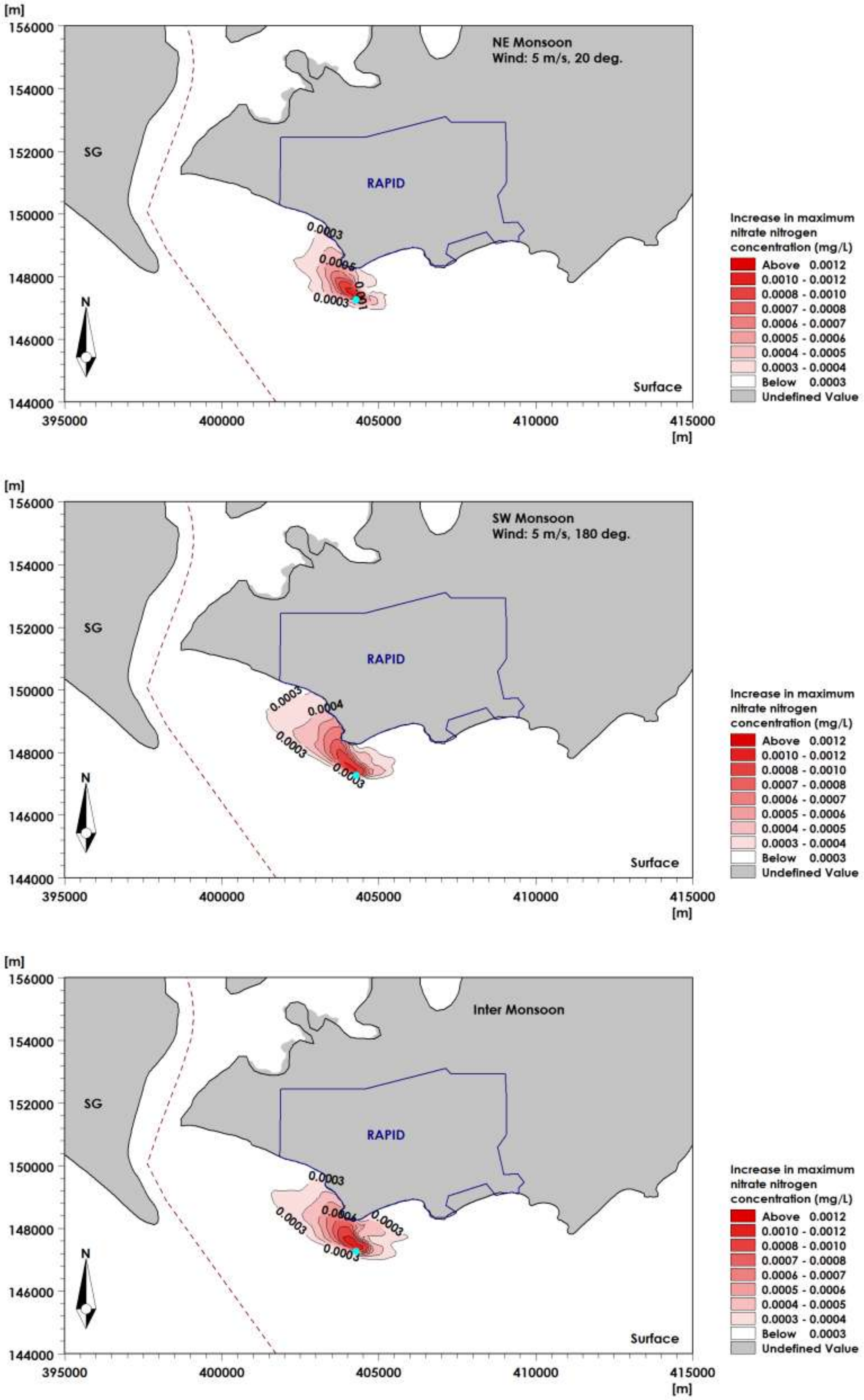

Figure 4.12: Predicted differences in maximum nitrate nitrogen during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom).

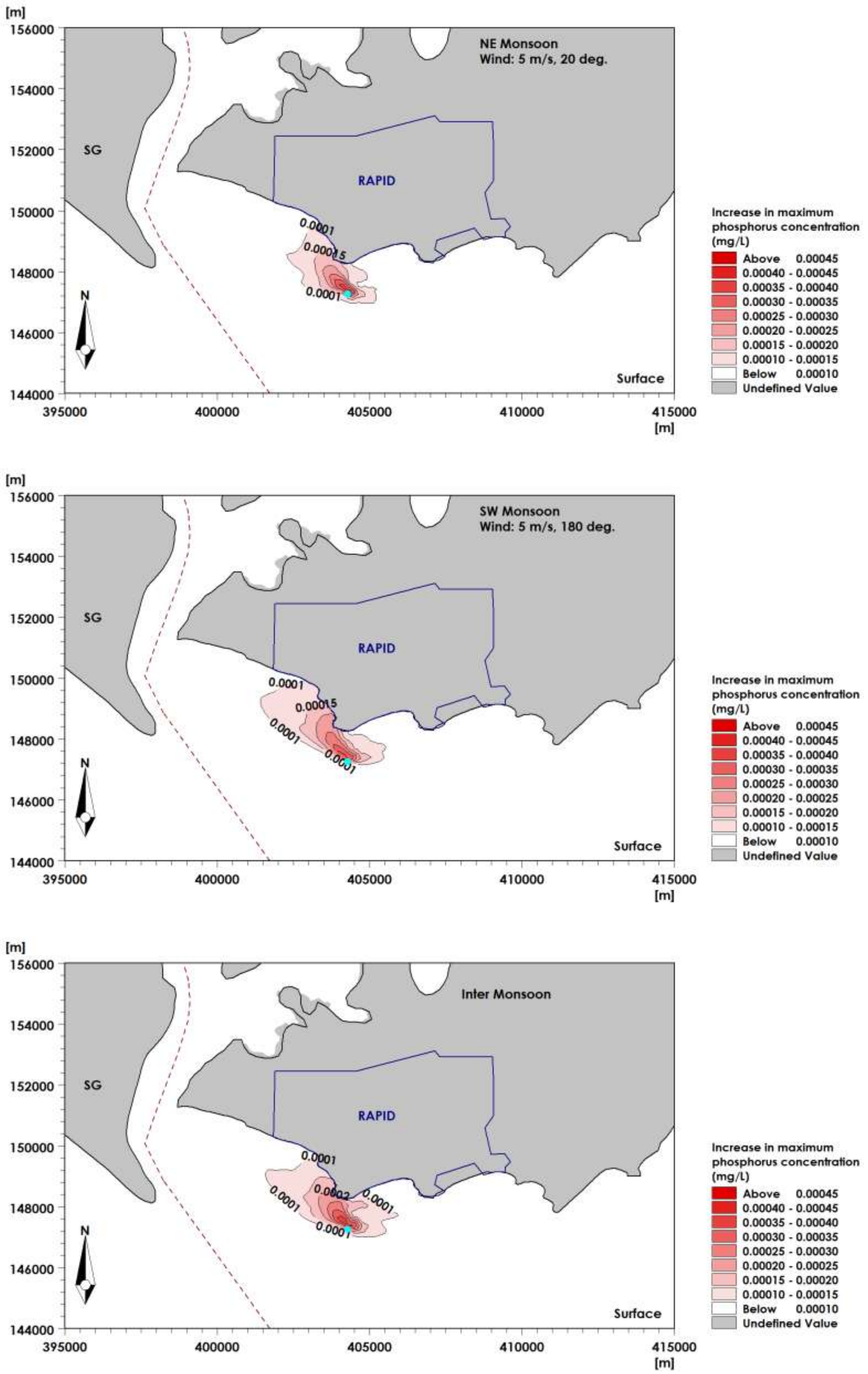

Figure 4.13: Predicted differences in maximum phosphorus during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom).

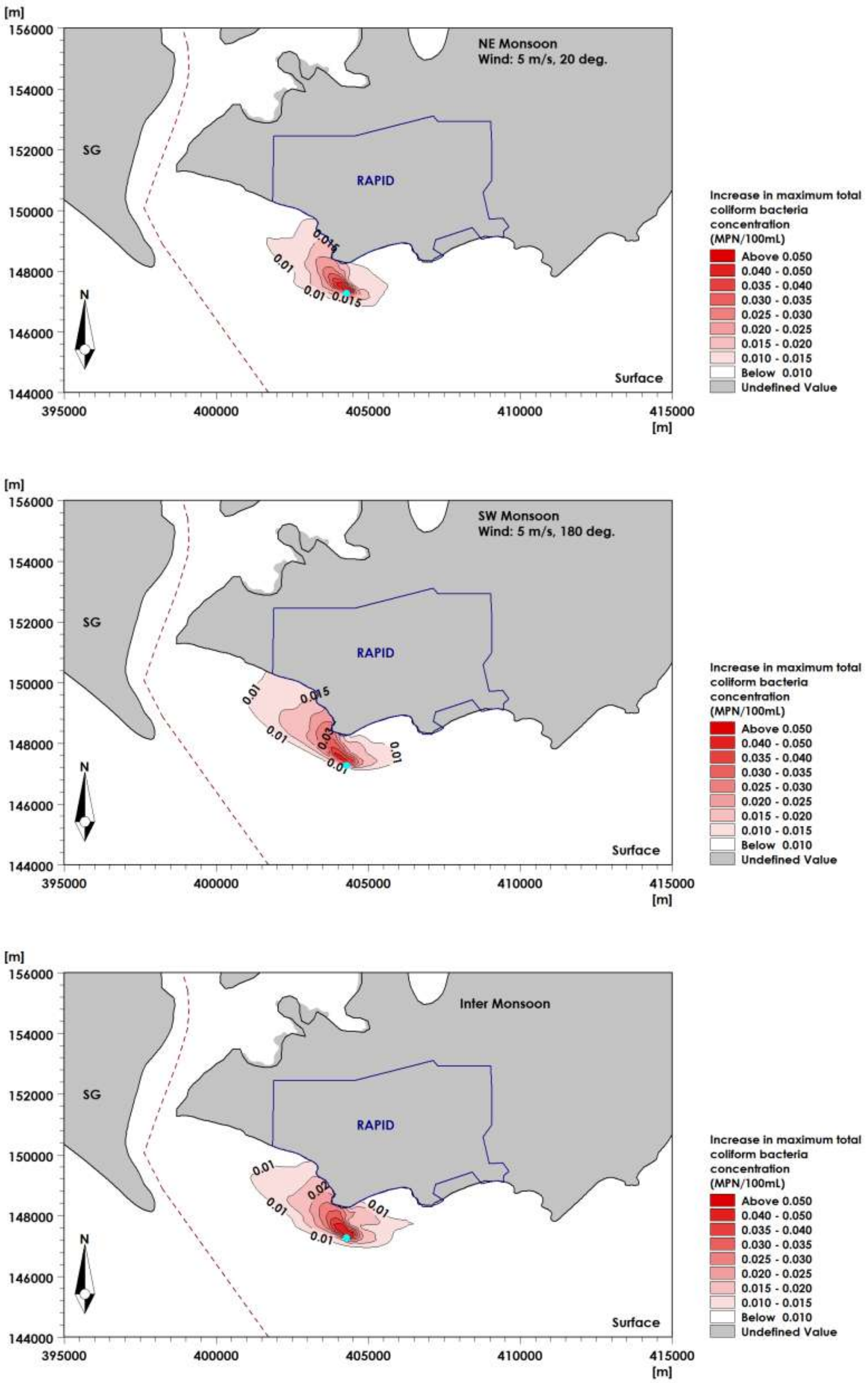

Figure 4.14: Predicted differences in maximum total coliform bacteria during NE monsoon (top), SW monsoon (middle) and inter monsoon (bottom)

4.3 Water Quality

Potential changes in water quality conditions were evaluated with the outfall in operation and compared to the background conditions taken from field measurement in **Table 3.4**. Measurement from sampling station CS1, CS2 and CS5 are located close to the outfall and used in the assessment.

Excess concentration from the effluent dispersal has been added up to the background concentration (in 2012 and 2016) and compared with Class 3 of Malaysia Marine Water Quality Standards of 29th November 2010 (MMWQS). Maximum water quality parameter concentrations at the project site after the release of effluent is shown in **Table 4.2** and **Table 4.3**.

As it can be observed, excess concentration between baseline condition and outfall in place are relatively small. The compliances with the Class 3 of MMWQS remain unchanged. Therefore, impacts on the water quality induced by the proposed ETP release are relatively small and localised.

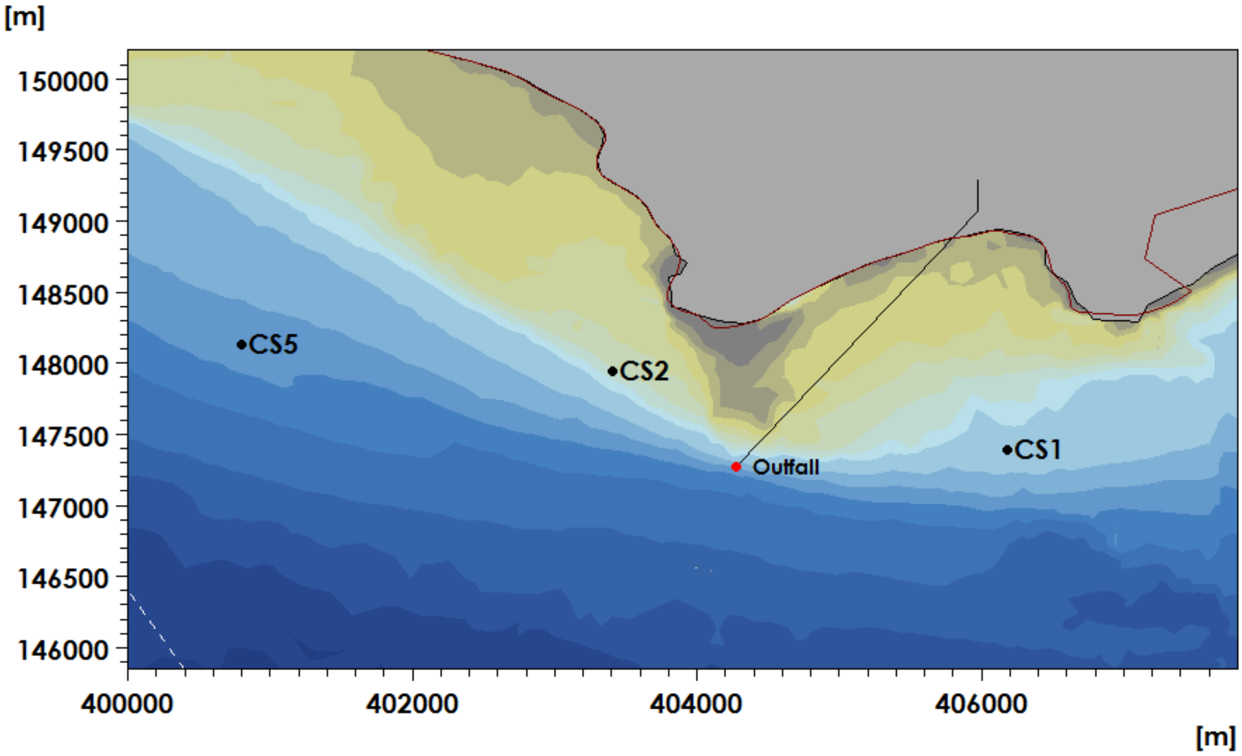

Figure 4.15: Location of the sampling stations.

Table 4.2: Comparison of effluent parameter concentration at location CS1, CS2 and CS5 with Class 3 MMWQS limit using measurement in 2012.

Parameters	Release concentration from outfall	Location	Ambient concentration (from measurement in 2012)	Maximum concentration from the model	Limit MMWQS for Class 3
Nitrate as NO3 [mg/l]	44	CS1	1.7	2.0	1
		CS2	1.6	2.5	
		CS5	1.6	1.8	
Phosphate as P [mg/l]	2	CS1	0.1	0.1	0.67
		CS2	0.1	0.1	
		CS5	0.1	0.1	
Total Suspended Solid (TSS) [mg/l]	30	CS1	13	13.3	100
		CS2	15	15.6	
		CS5	12	12.1	
Oil and Grease	10	CS1	0.04	0.1	5
		CS2	0.04	0.2	
		CS5	0.04	0.1	
Total Nitrogen	10	CS1	0.5	0.6	NA
		CS2	0.6	0.8	
		CS5	0.5	0.5	
Ammonia	6.1	CS1	NA	NA	0.32
		CS2	NA	NA	
		CS5	NA	NA	
Phenol	0.2	CS1	NA	NA	0.1
		CS2	NA	NA	
		CS5	NA	NA	

Table 4.3: Comparison of effluent parameter concentration at location CS1, CS2 and CS5 with Class 3 MMWQS limit using measurement in 2016.

Parameters	Release concentration from outfall	Location	Ambient concentration (from measurement in 2016)	Maximum concentration from the model	Limit MMWQS for Class 3
Nitrate as NO3 [mg/l]	44	CS1	1.9	2.2	1
		CS2	1.8	2.7	
		CS5	1.6	1.8	
Phosphate as P [mg/l]	2	CS1	0.1	0.1	0.67
		CS2	0.1	0.1	
		CS5	0.1	0.1	
Total Suspended Solid (TSS) [mg/l]	30	CS1	10	10.3	100
		CS2	11	11.6	
		CS5	17	17.1	
Oil and Grease	10	CS1	0.04	0.1	5
		CS2	0.04	0.2	
		CS5	0.04	0.1	
Total Nitrogen	10	CS1	0.5	0.6	NA
		CS2	0.5	0.7	
		CS5	0.5	0.5	
Ammonia	6.1	CS1	0.1	0.1	0.32
		CS2	0.1	0.2	
		CS5	0.1	0.1	
Phenol	0.2	CS1	0.001	0.002	0.1
		CS2	0.001	0.005	
		CS5	0.001	0.002	

5 Conclusions

An analysis of the potential impacts of the effluent dispersal has been carried out. From the analysis it can be concluded that:

- **Changes in Salinity**

  The predicted modelling results show that:

  - Reduction in salinity is below 1.35 PSU (less than 4.5% of ambient salinity) occur only around the outfall area, further 4 km away show smaller variations of less than 1%. So the changes are considered minor and localised around the outfall and within the project area.

- **Dispersion of Effluent**

  From the presented results, the following can be generally observed:

  - The predicted maximum concentration of pollutant is less than 3% for all climatic conditions.
  - During the NE monsoon, the dispersed pollutant concentration tend to move away from the coastline at the east side of the outfall.
  - The maximum concentration reduce quickly at area 5 km away from the outfall with an overall reduction of 97 percent. This shows that the water exchange at the outfall is expected to be good. Any potential impacts to the ambient water quality are predicted to be localised and minor.

- **Water Quality**

  - As it can be observed, excess concentration between baseline condition and outfall in place are relatively small. The compliances with the Class 3 of MMWQS remain unchanged. Therefore, impacts on the water quality induced by the proposed ETP release are relatively small and localised.