Wagerup Alumina Refinery Expansion – Health Risk Assessment 2020

Prepared for:

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Prepared by:	Lisa Smith
Reviewed by:	Simon Welchman
Approved by:	
	Simon Welchman
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Glossary

Term	Definition
µg/m^3	Micrograms per cubic metre
µm	Microns
Mtpa	Megatonnes per annum
h	Hours
kg/h	Kilograms per hour
kg/d	Kilograms per day

Nomenclature	Definition
PM_{10}	Particulate matter with a diameter less than 10 micrometres
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
PAH	Polycyclic aromatic hydrocarbons
SO_2	Sulfur dioxide
VOC	Volatile organic compounds
BaP	Benzo[a]pyrene

Abbreviations	Definition
ATSDR	Agency for Toxic Substances & Disease Registry
IARC	International Agency for Research on Cancer
CSM	Conceptual Site Model
ICR	Incremental carcinogenic risk
HRA	Health Risk Assessment
ERMP	Environmental Review and Management Program
DEWCP	Department of Environmental Water and Catchment Protection
HARP	Hot Spots Analysis and Reporting Program
NEPC	National Environment Protection Council
Air NEPM	National Environment Protection (Ambient Air Quality) Measure
OEHHA	California Office of Environmental Health Hazard Assessment's
REL	Reference exposure limit
RIVM	Dutch National Institute of Public Health and the Environment
WHO	World Health Organisation

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EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by Alcoa of Australia Ltd (Alcoa) to conduct a health risk assessment (Wagerup 2020 HRA) of the air emissions associated with the planned expansion of the Wagerup Refinery. The Wagerup 2020 HRA is a Tier 1 assessment as defined for the enHealth Guidelines (enHealth, 2012). A Tier 1 HRA is based on the most conservative assumptions regarding toxicity and exposure and as a result represents a worst case assessment of the health risk posed by emissions from the Wagerup Refinery. According to enHealth Guidelines (enHealth, 2012) risk assessment progresses from Tier 1 to Tier 2 when the conservative risk estimates at Tier 1 may be unacceptable, and further assessment is needed.

The two operating scenarios considered by the Wagerup 2020 HRA are defined as follows:

- **Base Case**: Representative emission rates from the existing Wagerup Refinery configuration operating at a maximum alumina production rate of 2.85 Mtpa.

- **Expansion Case**: Representative emission rates from the expanded Wagerup Refinery operating at a maximum alumina production rate of 3.3 Mtpa.

<u>**Health Risk Assessment Methodology**</u>

Consistent with previous HRAs, the approach taken for the Wagerup 2020 HRA followed the enHealth Guidelines (2012) for health risk assessments with the principle focus being on assessment of human health risks for neighbours of the refinery via the air inhalation exposure pathway.

The HRA consists of four broad stages:

- **Toxicity assessment/dose-response assessment** – identification of substances of potential concern together with relevant toxicity data. The toxicity data or dose-response data provides a measure of the relationship between the magnitude of the exposure to the adverse health effects.

- **Exposure assessment** – identification of exposed populations and exposure pathways in terms of the amount, frequency and duration of the exposure to harmful substances present in the environment.

- **Risk characterisation** – characterisation of the potential for adverse health effects, this is determined through combining the outcomes of the hazard assessment with the exposure assessment

- **Uncertainty assessment** - identification of potential sources of uncertainty and qualitative discussion of the magnitude of uncertainty and expected effects on risk estimates.

Toxicity Assessment

Twenty-seven target substances have been assessed as part of the Wagerup 2020 HRA. The selection of substance was based on the outcomes of the Review of Health Endpoints (Katestone, 2019).

Exposure Assessment

Fifteen discrete receptors were defined for the Wagerup 2020 HRA. Ground-level concentrations (GLCs) for the 27 target substances were determined based on:

- Dispersion modelling conducted by Environmental Technologies and Analytics (ETA, 2020).

- Peak and average emissions of the two operational scenarios; Base Case and expanded case for the Wagerup Refinery.

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Risk Characterisation

For each of the receptors three health risk scores were determined:

- Acute risk – HI_{ACUTE}

- Chronic risk – $HI_{CHRONIC}$

- Carcinogenic risk – ICR_{TOTAL}.

Uncertainty assessment

All health risk estimates made by the Wagerup 2020 HRA are based on inherently conservative assumptions. Due to the resultant compounding of conservatism across the HRA stages, the quantitative risk indicators should be considered as over-estimates of potential health risks associated with emissions from Wagerup Refinery. When the information, data and calculations are evaluated against the indicators provided by the Western Australian HRA Scoping Guideline, the outcome of the Wagerup HRA was found to have a high level of confidence.

Health Risk Assessment Results

Acute Risk

HI_{ACUTE} for all receptors are all less than 1 indicating that the acute health risk associated with atmospheric emissions from the Wagerup Refinery for both the Base Case and the Expansion Case is low.

Chronic Risk

$HI_{CHRONIC}$ for all receptors are all less than 1 indicating that the chronic health risk associated with atmospheric emissions from the Wagerup Refinery for both the Base Case and the Expansion Case is low.

Carcinogenic Risk

ICR_{TOTAL} for all receptors is less than 1×10^{-5} indicating that the carcinogenic health risk associated with atmospheric emissions from the Wagerup Refinery associated with both the Base Case and the Expansion Case is low.

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1. INTRODUCTION

Alcoa of Australia Limited (Alcoa) operates the Wagerup Alumina Refinery (Wagerup Refinery) located 130 kilometres (km) south of Perth in Western Australia. The Wagerup Refinery is positioned in the western foothills of the Darling escarpment. The local communities in the proximity of the Wagerup Refinery include Yarloop, Hamel and Waroona. The Wagerup Refinery produces alumina using the Bayer process from bauxite mined at the Willowdale mine site. The remaining material (residue) from the alumina refining process is contained in Residue Storage Areas (RSAs) at the Wagerup Refinery site. Alumina product is transported by rail from the Wagerup Refinery to Alcoa's Bunbury shipping terminal and then exported to overseas markets or to Alcoa's aluminium smelter in Victoria.

The Wagerup Refinery is currently licensed under Part V of the EP Act (L6217/1983/15) for a maximum alumina production capacity of 2.85 million tonnes per annum (Mtpa). Expansion of the Wagerup Refinery from 2.41Mtpa to 4.7Mtpa was granted Ministerial Approval (Ministerial Statement 728) in 2006. The planned expansion has not yet occurred as it is not currently practical to expand the refinery through the construction of a single-stage Third Production Unit. Alcoa is seeking changes to the Ministerial Conditions to permit production of the refinery to be increased in increments, with an initial increase in production to 3.3Mtpa. This has prompted a review of the environmental assessment of the project to ensure its currency.

This report details the approach used to conduct the HRA and presents the estimate of health risks arising from the atmospheric emissions emitted by the Wagerup Refinery at key sensitive receptor locations.

1.1 Background

Alcoa has undertaken HRA studies at several of its alumina refineries over the past decade.

Prior to 2020 the last HRA for Wagerup Refinery was conducted in 2005 (Environ, 2005). The air quality issues and associated health risks of the expansion proposal were evaluated based on emissions monitoring, air quality modelling and HRA. Public submissions responding to the environmental assessment of the project were focussed largely on the potential impact of proposed operations on air quality for surrounding communities. Studies identified as relevant to the Wagerup 2020 HRA are:

- Wagerup Emissions Inventory (2020)

- Wagerup Interim Emissions Inventory (2018)

- Wagerup Emissions Inventory (2014)

- Wagerup Emissions Inventory (2003)

- Health Risk Assessment of the Wagerup Refinery Expansion (Wagerup 2005 HRA) (2005)

- Wagerup Refinery Unit Three ERMP Response to Public Submissions (2005)

The Wagerup 2020 HRA is an update of the Wagerup 2005 HRA (using recent emissions estimates determined by Alcoa) and the outcomes of the following recent studies:

- Health Risk Assessment Phase 1 – Review of Health Endpoints (Katestone, 2019) (Health Endpoints Report)

- Air quality modelling reports:

  o Modelling Phase 2 Report (Environmental Technologies and Analytics (ETA), 2019)

  o Modelling Phase 3 Report (ETA, 2020).

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1.2   Operating parameters

The two operating scenarios considered by the Wagerup 2020 HRA are defined as follows:

- **Base Case**: Representative emission rates from the existing Wagerup Refinery configuration operating at a maximum alumina production rate of 2.85 Mtpa

- **Expansion Case**: Representative emission rates from the expanded Wagerup Refinery operating at a maximum alumina production rate of 3.3 Mtpa. This accounts for improvements in emission abatement incorporated into the design of the proposed refinery expansion.

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2. HEALTH RISK ASSESSMENT METHODOLOGY

A human environmental HRA is the process used to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals or other harmful substances in the environment. Risk assessment is intended to provide information to all parties concerned so that the best possible decisions are made (NSW, 2017).

The Wagerup 2020 HRA is a 'screening' HRA also referred to as a Tier 1 risk assessment (enHealth, 2012). The methods used in this type of HRA are inherently conservative and highly protective of human health. A Tier 1 HRA is based on the most conservative assumptions about exposure and as a result represents a worst case assessment of the health risk posed by emissions from the Wagerup Refinery. According to enHealth Guidelines (enHealth, 2012) risk assessment progresses from Tier 1 to Tier 2 when the conservative risk estimates at Tier 1 may be unacceptable, and further assessment is needed.

The HRA consists of four broad stages:

- **Toxicity assessment/dose-response assessment** – identification of substances of potential concern together with relevant toxicity data. The toxicity data or dose-response data provides a measure of the relationship between the magnitude of the exposure to the adverse health effects.

- **Exposure assessment** – identification of exposed populations and exposure pathways in terms of the amount, frequency and duration of the exposure to harmful substances present in the environment.

- **Risk characterisation** – characterisation of the potential for adverse health effects, this is determined through combining the outcomes of the hazard assessment with the exposure assessment

- **Uncertainty assessment** - identification of potential sources of uncertainty and qualitative discussion of the magnitude of uncertainty and expected effects on risk estimates.

Consistent with previous HRAs, the approach taken for the Wagerup 2020 HRA will follow the enHealth Guidelines (enHealth, 2012) for health risk assessments with the principle focus being on assessment of human health risks for neighbours of the Wagerup Refinery via the air inhalation exposure pathway.

2.1   Toxicity Assessment

The Wagerup Alumina Refinery - Review of Health Endpoints (Katestone 2019) (Review of Health Endpoints) provides a comprehensive review of both pollutants of potential concern together with a review of the health endpoints of substances emitted by the Wagerup Refinery.

The Review of Health Endpoints determined a prioritised listing of substances for each of the HRA categories of:

- Acute non-carcinogenic risk (acute risk)

- Chronic non-carcinogenic risk (chronic risk)

- Carcinogenic risk.

The prioritised list of substances was developed using a risk based methodology similar to a HRA. Current health end points were combined with substance emissions rates to estimate the relative risk associated with each substance. The relative risk associated with each substance provided an indication of the extent to which each substance would contribute to the health risk associated with substance emissions from Wagerup Refinery.

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Twenty-seven target substances have been assessed as part of the Wagerup 2020 HRA. The Review of Health Endpoints estimates that the relative risk for these target substances account for:

- 92.6% of acute health risk
- 87.1% of chronic health risk
- 99.4% of carcinogenic risk

The proportion risk covered by the target substances is significant and expected to be adequate in the estimation of health risk associated with emissions from the Wagerup Refinery, particularly considering the conservative nature of the Wagerup 2020 HRA.

A list of the substances considered by the Wagerup 2020 HRA together with average and peak emission rates for both the Base Case and the Expansion Case are summarised in Table 1.

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Table 1   Target substances with average and peak emissions rates by scenario

No	Substance	Base Case emissions 2.85 Mtpa(g/s)		Expansion Case emissions 3.3 Mtpa (g/s)	
		Average	Peak	Average	Peak
1	Nitrogen dioxide*	32.97	72.24	35.29	87.87
2	Carbon monoxide	20.88	117.24	24.33	163.96
3	Sulfur dioxide	0.94	9.43	0.98	10.95
4	Particulate matter <10um	18.95	24.15	19.22	27.18
5	Ammonia	4.41	12.59	2.55	13.43
6	Arsenic	1.16E-02	1.24E-02	1.24E-02	1.32E-02
7	Beryllium	6.17E-04	7.20E-04	6.19E-04	7.66E-04
8	Boron	2.29E-02	2.89E-02	2.29E-02	3.04E-02
9	Cadmium	4.90E-04	6.38E-04	4.90E-04	6.86E-04
10	Chromium (VI)	1.06E-03	1.09E-03	1.15E-03	1.17E-03
11	Lead	4.53E-02	4.57E-02	4.84E-02	4.92E-02
12	Manganese	2.16E-02	2.61E-02	2.29E-02	2.81E-02
13	Nickel	9.12E-03	1.73E-02	8.94E-03	1.78E-02
14	Selenium	9.95E-03	1.36E-02	1.03E-02	1.40E-02
15	Mercury	9.44E-03	2.17E-02	1.02E-02	3.02E-02
16	Acetaldehyde	0.80	2.33	0.75	2.76
17	Acetone	1.44	8.78	1.18	9.76
18	Polycyclic Aromatic Hydrocarbons	8.05E-06	3.35E-05	8.00E-06	3.65E-05
19	Benzene	0.05	0.14	0.05	0.16
20	Methyl ethyl ketone	0.18	1.32	0.17	1.40
21	Ethylbenzene	1.12E-03	2.85E-03	9.00E-04	3.92E-03
22	Formaldehyde	0.82	2.55	0.87	3.32
23	Styrene	3.11E-03	1.20E-02	3.11E-03	1.34E-02
24	Toluene	0.03	0.09	0.03	0.10
25	1,2,4 Trimethylbenzene	2.77E-03	1.64E-02	2.35E-03	1.82E-02
26	1,3,5 Trimethylbenzene	1.18E-03	3.99E-03	5.01E-04	3.99E-03
27	Xylenes	5.33E-03	1.44E-02	5.51E-03	1.79E-02

Notes: *Emitted as oxides of nitrogen

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2.1.1 Health end points

The potential health impacts of the Wagerup Refinery on surrounding sensitive receptors is primarily related to atmospheric emissions. As a result, the inhalation pathway is the most significant exposure route for the Wagerup Refinery and the corresponding risk scores will account for the vast majority of risk at each sensitive receptor. The health endpoints associated with the target substances are summarised in Table 4:

- Acute risk: Reference Exposure Limit (REL) and associated averaging period
- Chronic risk: Reference Exposure Limit (REL)
- Carcinogenic risk: Incremental Cancer Risk (ICR).

2.1.1.1 Acute risk

RELs for acute non-carcinogenic health effects are expressed as concentrations in air that are not expected to cause any adverse effects as a result of continuous exposure over a defined averaging period (typically 24 hours or less). These guidelines are appropriate for comparison with 1-hour up to 24-hour average exposure estimates. Although derived from different sources, the guidelines selected for this assessment are all intended to be protective of continually exposed (i.e. residential) receptors, including potentially sensitive subpopulations.

2.1.1.2 Chronic risk

RELs for chronic non-carcinogenic health effects are expressed as concentrations in air that are not expected to cause any adverse health effects as a result of continuous long-term exposure (a year or more). These guidelines are appropriate for comparison with annual average exposure estimates.

2.1.1.3 Carcinogenic risk

Cancers are generally defined as diseases of mutation affecting cell growth and differentiation. Although many chemicals are known to cause cancer at high doses in studies with experimental animals, relatively few chemicals have been shown to be carcinogenic in humans at doses likely to be encountered in the ambient environment. In general cancers are relatively slow to develop, and usually require prolonged exposure to carcinogenic chemicals. As a result, potential carcinogenic risks are calculated for long-term exposures.

The International Agency for Research on Cancer (IARC) classifies substances according to their potential for human carcinogenicity as indicated in Table 2.

Carcinogenic substances can be classified as genotoxic or non-genotoxic. Exposure to any amount of a genotoxic substance is assumed to incur some level of risk compared to a non-genotoxic carcinogen where effects have only been found to occur where exposure to the substance occurs in excess on a certain threshold. Potential health risks are calculated differently for genotoxic and non-genotoxic substances to account for this difference. The carcinogenic substances considered by the Wagerup HRA have been confirmed to be genotoxic with the exception of ethylbenzene, acetaldehyde and styrene where the genotoxicity or otherwise is unclear. As a conservative assumption all carcinogenic substances have been considered as genotoxic, equivalent to a non-threshold approach.

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Table 2   **IARC Classification Criteria**

Group	Description
1	Carcinogenic to humans (sufficient evidence of carcinogenicity to humans)
2A	Probably carcinogenic to humans (sufficient evidence of carcinogenicity in animals, limited evidence of carcinogenicity in humans)
2B	Possibly carcinogenic to humans (less than sufficient evidence of carcinogenicity in animals, limited evidence of carcinogenicity in humans)
3	Not classifiable as to carcinogenicity in humans (inadequate or limited evidence of carcinogenicity in animals, inadequate evidence of carcinogenicity in humans)
4	Probably not carcinogenic to humans (evidence suggesting lack of carcinogenicity in animals and humans)

2.1.1.3.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Some individual PAHs have been classified as carcinogenic by the IARC while others have not, however the carcinogenicity of the majority of this large class of substances cannot be classified due to lack of sufficient evidence. The relative carcinogenic potency of specific PAHs has been published by the Nisbet et al (1993) relative to benzo[a]pyrene (BaP), a widely reported PAH known for its carcinogenic potency. An equivalent ICR has been estimated for each PAH based on the BaP ICR of 6.0 x 10^{-4} $(\mu g/m^3)^{-1}$ (IRIS, 2019), see Table 3.

Table 3   **Relative potency for screening substances classified as PAHs relative to BaP**

Individual PAH Compound	CAS No	Toxic Equivalency Factor (TEf)	ICR (ug/m^3)$^{-1}$
Benzo(a)pyrene	50-32-8	1	6.00E-04
Naphthalene	91-20-3	0.001	6.00E-07
2-methylnaphthalene	91-57-6	0.001	6.00E-07
Phenanthrene	85-01-8	0.001	6.00E-07
Acenaphthene	83-32-9	0.001	6.00E-07
Fluoranthene	206-44-0	0.001	6.00E-07

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Table 4   Summary of health endpoints for target substances

No.	Substance	Acute risk			Chronic risk		Carcinogenic risk		
		REL(µg/m³)	Averaging Period (h)	Source	REL(µg/m³)	Source	ICR (µg/m³)⁻¹	IARC	Source
1	Nitrogen dioxide	164*	1	NEPC 2019	31*	NEPC 2019			
2	Carbon monoxide	11250	8	NEPC 2015					
3	Sulfur dioxide	57.2*	24	NEPC 2019	57	NEPC 2015			
4	Particulate matter <10 µm	50	24	NEPC 2015	25	NEPC 2015			
5	Ammonia	1290	24	ATSDR 2019	76	ATSDR 2019			
6	Arsenic & compounds	0.2	1	OEHHA 2019	0.015	OEHHA 2019	1.50E-03	1	WHO 2000
7	Beryllium & compounds				0.007	OEHHA 2019	2.40E-03	1	IRIS 2019
8	Boron & compounds	300	24	ATSDR 2019					
9	Cadmium & compounds	0.03	24	ATSDR 2019	0.005	WHO 2000	1.80E-03	1	IRIS 2019
10	Chromium (VI)				0.005	ATSDR 2019	1.20E-02	1	IRIS 2019
11	Lead & compounds						1.20E-05	1	OEHHA 2019
12	Manganese & compounds				0.05	IRIS 2019			
13	Nickel & compounds	0.2	1	OEHHA 2019	0.014	OEHHA 2019	2.60E-04	1	OEHHA 2019
14	Selenium & compounds		-		20	OEHHA 2019			
15	Mercury & compounds	0.6	1	OEHHA 2019	0.03	OEHHA 2019			
16	Acetaldehyde	470	1	OEHHA 2019	9	IRIS 2019	9.00E-07	1	WHO 2000
17	Acetone	67414	24	ATSDR					
18	Benzo(a)pyrene				0.0003	NEPC 2004	6.00E-04	1	NEPC 2004
19	Benzene	27	1	OEHHA 2019	10	ATSDR 2019	6.00E-06	1	WHO 2000
20	Methyl ethyl ketone	13000	1	OEHHA 2019	5000	IRIS 2019			
21	Ethylbenzene	23699	24	ATSDR 2019	284	ATSDR 2019	2.50E-06	1	OEHHA 2019
22	Formaldehyde	53.6	24	NEPC 2004	9	OEHHA 2019	6.00E-06	1	OEHHA 2019
23	Styrene	260	1 week	WHO 2000	900	OEHHA 2019	5.70E-07	2A	Michigan Govt
24	Toluene	4113	24	NEPC 2004	411	NEPC 2004			
25	1,2,4-Trimethylbenzene				60	IRIS 2019			
26	1,3,5-Trimethylbenzene				60	IRIS 2019			
27	Xylenes	1185	24	NEPC 2004	948	NEPC 2004			

Table notes: *Provisional 2025 goal for acute and chronic REL values have been adopted by the Wagerup 2020 HRA

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2.2   Exposure Assessment

The local communities in the proximity of the Wagerup Refinery include Yarloop, Hamel and Waroona. Yarloop is located approximately 3 km south of the Refinery, and Hamel and Waroona are located north of the Refinery approximately 5 km and 8 km away respectively. Fifteen discrete receptors were defined for the Wagerup 2020 HRA. The discrete sensitive receptor locations used in the assessment are listed in Table 5, and are shown in Figure 1 These discrete receptors are consistent with the previous dispersion modelling assessments, noting that receptor 12 is not included as it ceased being a residence in the mid-2000s (Air Assessments, 2015).

Table 5   Discrete sensitive receptor locations

ID [1]	Descriptor	Type | Current Status [2]	Easting(m)	Northing (m)
1	Boundary Rd	Individual residence | Alcoa owned	398,230	6,354,982
2		Individual residence | Alcoa owned	399,532	6,355,154
3	Yarloop	Individual residence | Area B	396,969	6,353,097
4		Individual residence | Alcoa owned	397,277	6,354,975
5		Individual residence | Alcoa owned	395,860	6,352,651
6		Individual residence | Alcoa owned	399,789	6,354,388
7	Bremner Rd	Individual residence | Alcoa owned	390,914	6,358,881
8	Somers/McClure Rds	Individual residence | Alcoa owned	392,499	6,362,279
9		Individual residence | Area B	396,238	6,362,172
10	Hamel	Individual residence | Area B	398,599	6,362,148
11		Individual residence | Area A	398,346	6,360,479
13	Waroona	Residential population	400,659	6,364,363
14	Escarpment	Individual residence | Area A	400,866	6,360,978
15		Individual residence | Alcoa owned	400,865	6,356,583
16		Individual residence | Area A	397,504	6,359,433
Notes:				
1. Receptor 12 is not included as it ceased being a residence in the mid-2000s.				
2. Area A (immediately surrounding the Refinery). Area B (residential townships of Hamel and Yarloop).				

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Figure 1   Discrete sensitive receptor locations

2.3   Estimation of Ground Level Concentrations (GLCs)

Definition of health endpoints for emitted substances forms the first part of an air emissions pathway HRA; the second phase is the evaluation of quantitative health risk at the accepted community receptor locations exposed to emissions from the refinery and associated operations, by performing exposure assessments and calculating incremental risk levels. This is achieved by inputting GLCs of substance emitted from the refinery over short, medium and longer period timescales as appropriate to the health endpoint being assessed to the estimation of cumulative risk levels. It is this second phase of a quantitative health risk assessment (QHRA) that forms the subject of the scope of work for the Wagerup 2020 HRA.

GLCs for target substances at each receptor location have been estimated based on the results of dispersion modelling conducted by Environmental Technologies and Analytics (ETA, 2020). ETA modelled the individual refinery point sources, fugitive particulate sources and fugitive vapour sources. The ETA assessment considered emissions from selected compounds (NOx, acetone, PM_{10}, acetaldehyde and ammonia), chosen to represent the different categories of substances. In addition to this Alcoa keeps a detailed annual emissions inventory for the Wagerup Refinery that is updated on a regular basis. The most recent update to the inventory was completed in February 2020 (Alcoa, 2020). Further postprocessing of the CALPUFF output files together with the most recent emissions inventory was conducted by Katestone to determine the GLCs of the full suite of target substances at each of the receptors. GLC contour maps for representative target substances are provided in Appendix A.

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A summary of predicted concentrations for each receptor is provided in Appendix B. The summary includes: 99.9th percentile, 1-hour average concentrations, 99.5th percentile 24-hour average concentrations and annual average concentrations for each pollutant. The 99.9th and 99.5th percentiles were used as these statistics are typically used to represent worst-case conditions, which by definition occur infrequently (Donoghue and Coffey, 2014 and CSIRO, 2005).

2.4 Risk Characterisation

2.4.1 Potential Exposure Pathways

The way a substance enters an organism after contact, by ingestion, inhalation or dermal absorption is referred to as the exposure pathway. In most circumstances the inhalation exposure pathway is the most significant exposure route for atmospheric air pollutants.

Previous HRA studies conducted by Alcoa (Environ 2014, Environ 2007 and Environ 2005) have determined that the inhalation pathway will account for the vast majority of risk associated with emissions from the Wagerup Refinery. Conceptual Site Models (CSMs) are used to delineate exposure sources and potential pathways leading to human exposures. The CSMs developed for previous studies considered direct exposure through inhalation and indirect exposure through soil ingestion, dermal exposure, vegetable ingestion and water ingestion. The Hot Spots Analysis and Reporting Program (HARP) methodology developed by the Californian Office of Environmental Health Hazard Assessment (OEHHA) was used to provide a quantitative evaluation of the CSM for previous Wagerup and Pinjarra HRAs. The HARP assessments found that pathways other than inhalation had the potential to be significant only for the metals arsenic and cadmium. Cadmium made only a very minor contribution to the chronic health risk justifying the exclusion of alternative pathways for cadmium. Arsenic exposure via inhalation was a significant contributor to the predicted carcinogenic risk. The HARP program indicated that the inhalation exposure pathway was likely to account for approximately 75% of the carcinogenic exposure to arsenic. The remaining 25% of the exposure was predicted to occur as a result of soil ingestion (14%), vegetable ingestion (8%), dermal absorption (2%), and drinking water ingestion (1%). See Section 3.4.2 for further discussion.

Consistent with previous HRA studies the exposure assessment for the Wagerup HRA has been confined to the inhalation pathway. Based on the HARP assessments for previous HRA studies of the Wagerup and Pinjarra alumina refineries, consideration of the inhalation pathway in the first instance has been determined to be adequate for the purposes of a Tier 1 risk assessment.

The inhalation risk associated with air emissions emitted by the refinery will be estimated for each sensitive receptor in terms of:

- Non-carcinogenic risk
    - Acute risk
    - Chronic risk
- Carcinogenic risk.

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2.4.1.1 Non-Carcinogenic Risk

The general approach for estimating the non-carcinogenic risk at each sensitive receptor will be to:

- Determine hazard quotient (HQ) for each substance where a GLC has been indicated

- HQs for each substance (i) can be summed to produce a total Hazard Index as follows:

$$Hazard\ Index\ (HI) = \sum Hazard\ Quotients\ (HQs)$$

A Hazard Index will be determined for each receptor according to the type of risk:

- HI$_{ACUTE}$

- HI$_{CHRONIC}$

HI$_{ACUTE}$

$$HI_{ACUTE} = \sum_{i=1}^{n} HQ_{ACUTE,i} = \sum_{i=1}^{n} \frac{GLC_{ACUTE,i}}{REL_{ACUTE,i}}$$

HI$_{CHRONIC}$

$$HI_{CHRONIC} = \sum_{i=1}^{n} HQ_{CHRONIC,i} = \sum_{i=1}^{n} \frac{GLC_{ANNUAL,i}}{REL_{CHRONIC,i}}$$

Where:

i   = target substance with either acute risk or chronic risk health endpoint

n   = number of relevant target substances covered by the HRA

GLC$_{ACUTE}$ = Ground Level Concentration for the relevant averaging period (1hr, 8hr or 24hr)

REL$_{ACUTE}$ = Reference Exposure Limit for substances with acute risk health end points

GLC$_{CHRONIC}$ = Annual average Ground Level Concentration

REL$_{CHRONIC}$ = Reference Exposure Limit for substances with chronic risk health end points

The enHealth Guidelines (enHealth, 2012) for 'screening' HRAs provide the following advice for the interpretation of HIs:

- Values less than one represent no cause for concern

- Values greater than one but less than 10 generally do not represent cause for concern because of the inherent conservatism embedded in the exposure and toxicity assessments

- Values greater than ten may present some concern with respect to possible health effect and trigger the need for further, more refined investigations.

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2.4.1.2 Carcinogenic Risk

The cumulative carcinogenic risk (ICR_{TOTAL}) across all relevant target substances provides an indication of the incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to potential carcinogens. An ICR_{TOTAL} for each receptor will be determined:

$$ICR_{TOTAL} = \sum_{i-1}^{n} GLC_{ANNUAL,i} \times ICR_i$$

Where:

i   = target substance with a carcinogenic risk health endpoint

n   = number of relevant target substances covered by the HRA

GLC$_{ANNUAL}$ = Annual average Ground Level Concentration

ICR$_{TOTAL}$ = Cumulative Incremental Carcinogenic Risk (ICR) for substances with carcinogenic risk health endpoints

The ICR that is considered acceptable varies amongst jurisdictions, typically ranging from one in a million ($1x10^{-6}$) to one in ten thousand ($1x10^{-4}$). EnHealth (2012) suggest that where the carcinogenic risk is the outcome of multiple chemical exposures a combined risk of one in one hundred thousand ($1x10^{-5}$) may be considered acceptable. For individual carcinogens, a target risk level of one in a million (1×10^{-6}) is the one most commonly used. The origin of the 10^{-6} level has been attributed to US regulators designating this level as a negligible or essentially non-existent risk, a convenient quantitative expression of *de minimus non curat lex* (the law does not deal with trifles). A carcinogenic risk target of one in one hundred thousand ($1x10^{-5}$) has therefore been adopted for this assessment as an indicator of acceptable cumulative carcinogenic risk at receptors with one in a million ($1x10^{-6}$) indicating the acceptable risk associated with individual carcinogens at receptors.

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3. HEALTH RISK ASSESSMENT RESULTS

At each of the receptors the application of the methodology described in Section 2 has determined a set of three health risk scores:

- Acute risk – HI_{ACUTE}
- Chronic risk – $HI_{CHRONIC}$
- Carcinogenic risk – ICR_{TOTAL}.

A summary of the receptor health risk scores according to risk category is provided in the following sections. Further details for each receptor including GLCs and HQs are provided in Appendix A.

3.1   Acute risk

The acute risk associated with atmospheric emissions of target substances has been assessed for each receptor as well as across the modelling domain. Acute risk scores (HI_{ACUTE}) have been calculated for each receptor according to the emission scenario:

- Base Case (alumina production rate of 2.85 Mtpa)
- Expansion Case (alumina production rate of 3.3 Mtpa).

The GLCs used to determine acute risk are:

- 99.9th percentile for 1-hour and 8-hour averaging periods
- 99.5th percentile for 24-hour averaging period.

The 99.9th percentile 1-hour average concentration is derived from the 9th highest 1-hour average predicted GLC. The 99.9th percentile 8-hour average concentration is derived from the 2nd highest 8-hour average predicted GLC. The 99.5th percentile 24-hour average concentration is derived from the 2nd highest 24-hour average predicted GLC.

Appendix A provides further details for each receptor including HQs for target substances for both the Base Case and the Expansion Case together with the relative contribution of each substance to the overall acute risk (HI_{ACUTE}) associated with the Expansion Case.

HI_{ACUTE} for each receptor, including the relative change associated with the Wagerup Refinery Expansion Case, are summarised in Table 6. The HI_{ACUTE} across the modelling domain for the Base Case and the Expansion Case is also illustrated in Figure 2 and Figure 3, respectively. The maximum HI_{ACUTE} for both the Base Case and the Expansion Case occurs at Receptor 7, 0.794 and 0.837 respectively. All HI_{ACUTE} are less than 1 indicating that the acute health risk associated with atmospheric emissions associated with both the Base Case and the Expansion Case is low. The HI_{ACUTE} for Receptor 7 is strongly influenced by emissions of particulate matter <10um (PM_{10}) and emissions of metals namely arsenic and nickel. Increases in HI_{ACUTE} from the Base Case to the Expansion Case for all receptors are largely attributable to increases in emissions of PM_{10} and associated emissions of metals and the corresponding increases in GLCs of these substances. Increased emissions of oxides of nitrogen have also contributed to the increase in HI_{ACUTE}, but to a lesser extent.

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Table 6   Summary of acute risk (HI$_{ACUTE}$) for each receptor

Receptor	Base Case (2.85Mtpa)	Expansion Case (3.3Mtpa)	Change from Base Case (%)
1	0.346	0.425	23%
2	0.258	0.304	18%
3	0.245	0.273	11%
4	0.342	0.393	15%
5	0.212	0.233	10%
6	0.227	0.269	19%
7	0.794	0.837	5%
8	0.212	0.256	21%
9	0.303	0.310	2%
10	0.233	0.262	12%
11	0.293	0.332	13%
13	0.119	0.139	17%
14	0.203	0.236	16%
15	0.317	0.352	11%
16	0.453	0.505	11%
Notes: Receptor 12 is not included as it ceased being a residence in the mid-2000s.			

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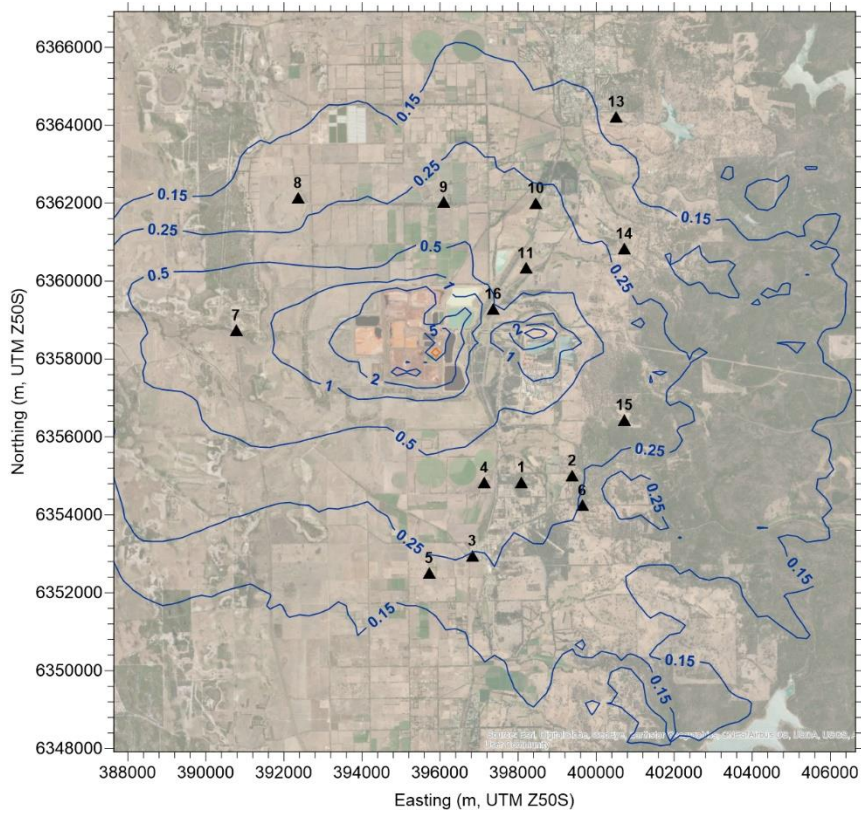
Figure 2   **Acute risk (HI$_{ACUTE}$) contour map – Base Case**
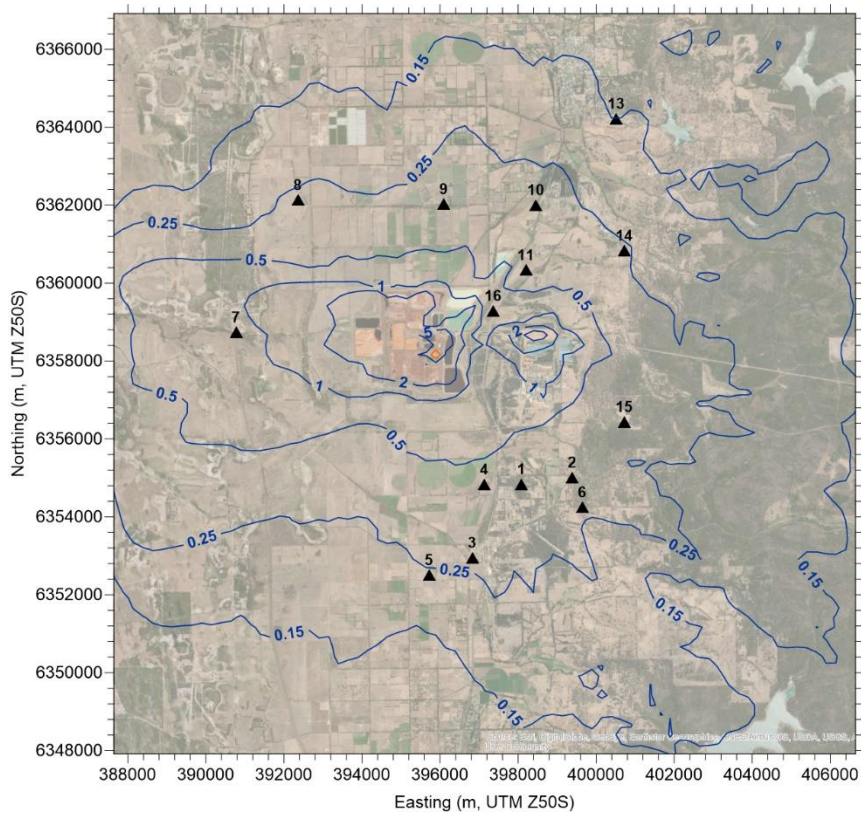
Figure 3   **Acute risk (HI$_{ACUTE}$) contour map – Expansion Case**

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3.2   Chronic Risk

The chronic risk associated with atmospheric emissions of target substances has been assessed for each receptor as well as across the modelling domain. Chronic risk scores ($HI_{CHRONIC}$) have been calculated for each receptor according to the emission scenario:

- Base Case (alumina production rate of 2.85 Mtpa)

- Expansion Case (alumina production rate of 3.3 Mtpa).

Appendix A provides further details for each receptor including:

- GLCs for target substances

- GLC contour maps for key substances

- HQs for target substances.

$HI_{CHRONIC}$ for each receptor, including the relative change associated with the Wagerup Refinery Expansion Case, are summarised in Table 7. $HI_{CHRONIC}$ across the modelling domain for the Base Case and the Expansion Case are illustrated in Figure 4 and Figure 5, respectively. The maximum $HI_{CHRONIC}$ for both the Base Case and the Expansion Case occurs at Receptor 16, 0.314 and 0.283, respectively. All $HI_{CHRONIC}$ are less than 1 indicating that the chronic health risk associated with atmospheric emissions associated with both the Base Case and the Expansion Case is low. $HI_{CHRONIC}$ for all receptors is strongly influenced by emissions of particulate matter <10um (PM_{10}) and emissions of metals, namely arsenic, nickel, manganese and chromium (VI). In most cases $HI_{CHRONIC}$ has decreased from the Base Case to the Expansion Case. This decrease is largely attributable to a decrease in GLCs of ammonia, nickel, mercury and acetaldehyde. Emissions of ammonia, nickel and mercury have decreased from the Base Case to the Expansion Case. Mercury emissions have increased however changes to annual emission rates for individual stack sources i.e. reduction in emissions from some stack sources and increases in emission from others, have culminated in reduced GLC of mercury for all receptors.

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Table 7   Summary of chronic risk (HI$_{CHRONIC}$) for each receptor

Receptor	Base Case (2.85Mtpa)	Expansion Case (3.3Mtpa)	Change from Base Case (%)
1	0.081	0.072	-13%
2	0.054	0.049	-11%
3	0.054	0.048	-13%
4	0.089	0.078	-14%
5	0.055	0.048	-15%
6	0.042	0.038	-11%
7	0.183	0.204	10%
8	0.155	0.185	16%
9	0.128	0.120	-7%
10	0.078	0.069	-12%
11	0.152	0.135	-13%
13	0.024	0.021	-10%
14	0.039	0.036	-10%
15	0.043	0.040	-6%
16	0.314	0.283	-11%

Notes: Receptor 12 is not included as it ceased being a residence in the mid-2000s.
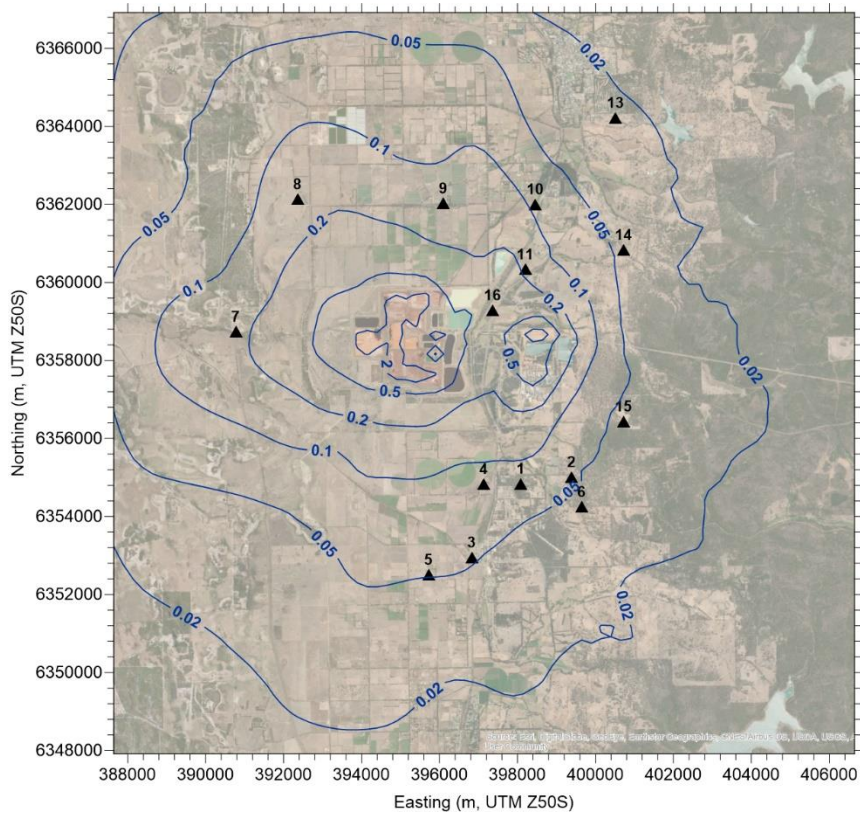
Figure 4   Chronic risk (HI$_{CHRONIC}$) contour map – Base Case

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Figure 5   Chronic risk ($HI_{CHRONIC}$) contour map – Expansion Case

3.3 Carcinogenic risk

The carcinogenic risk associated with atmospheric emissions of target substances has been assessed for each receptor as well as across the modelling domain. Carcinogenic risk scores (ICR_{TOTAL}) have been calculated for each receptor according to the emission scenario:

- Base Case (alumina production rate of 2.85 Mtpa)

- Expansion Case (alumina production rate of 3.3 Mtpa).

Appendix A provides further details for each receptor including:

- GLCs for target substances

- GLC contour maps for key substances

- ICRs for target substances.

ICR_{TOTAL} for each receptor, including the relative change associated with the Wagerup Refinery Expansion Case, are summarised in Table 8. The expression of ICR_{TOTAL} presented in Table 8 can be explained by way of example, considering Receptor 7 and ICR_{TOTAL} of 2.65×10^{-6} (0.00000265) is equivalent to a risk of 1 in 2,650,000.

ICR_{TOTAL} across the modelling domain for the Base Case and the Expansion Case are illustrated in Figure 6 and Figure 7, respectively. The maximum ICR_{TOTAL} for both the Base Case and the Expansion Case occurs at Receptor 7, 2.28×10^{-6} and 2.65×10^{-6}, respectively. All ICR_{TOTAL} are less than 1×10^{-5} indicating that the carcinogenic health risk associated with atmospheric emissions associated with both the Base Case and the Expansion Case is low. Increases in ICR_{TOTAL} from the Base Case to the Expansion Case are largely attributable to increases in emissions of arsenic and chromium and the corresponding increases in GLCs of these substances.

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Table 8   **Summary of carcinogenic risk (ICR$_{TOTAL}$) for each receptor**

Receptor	Base Case (2.85Mtpa)	Expansion Case (3.3Mtpa)	Change from Base Case (%)
1	5.53E-07	5.55E-07	0%
2	3.46E-07	3.46E-07	0%
3	4.29E-07	4.36E-07	2%
4	6.51E-07	6.43E-07	-1%
5	4.13E-07	4.25E-07	3%
6	2.89E-07	2.89E-07	0%
7	2.28E-06	2.65E-06	16%
8	1.60E-06	2.11E-06	32%
9	8.93E-07	9.53E-07	7%
10	4.96E-07	4.98E-07	0%
11	8.21E-07	8.07E-07	-2%
13	1.63E-07	1.66E-07	2%
14	2.26E-07	2.26E-07	0%
15	2.99E-07	3.00E-07	0%
16	1.62E-06	1.59E-06	-2%

Notes: Receptor 12 is not included as it ceased being a residence in the mid-2000s.

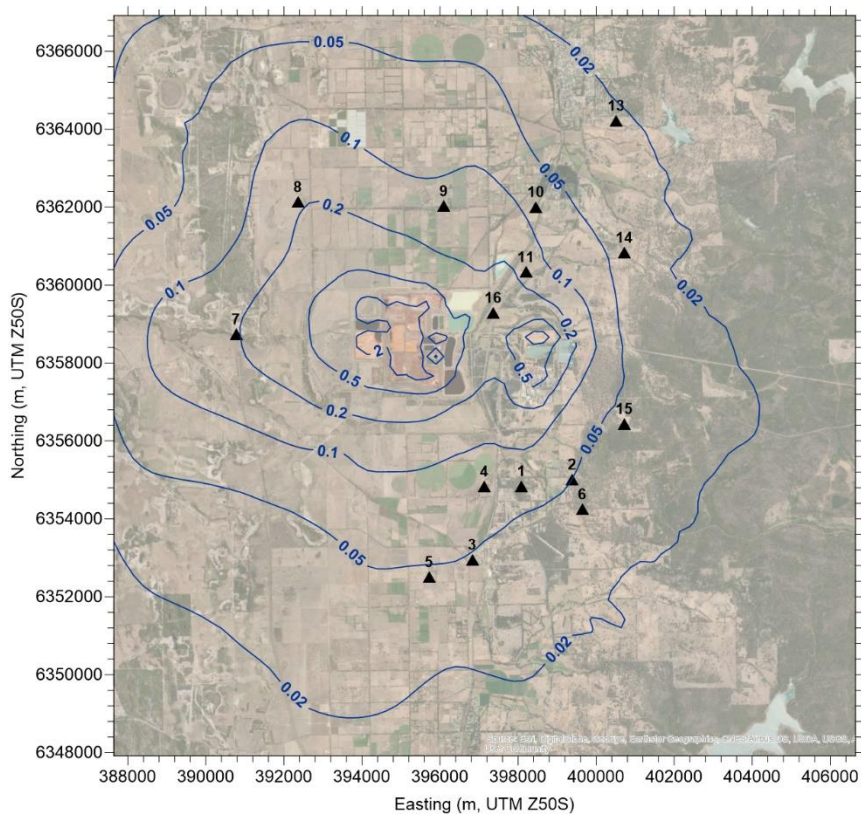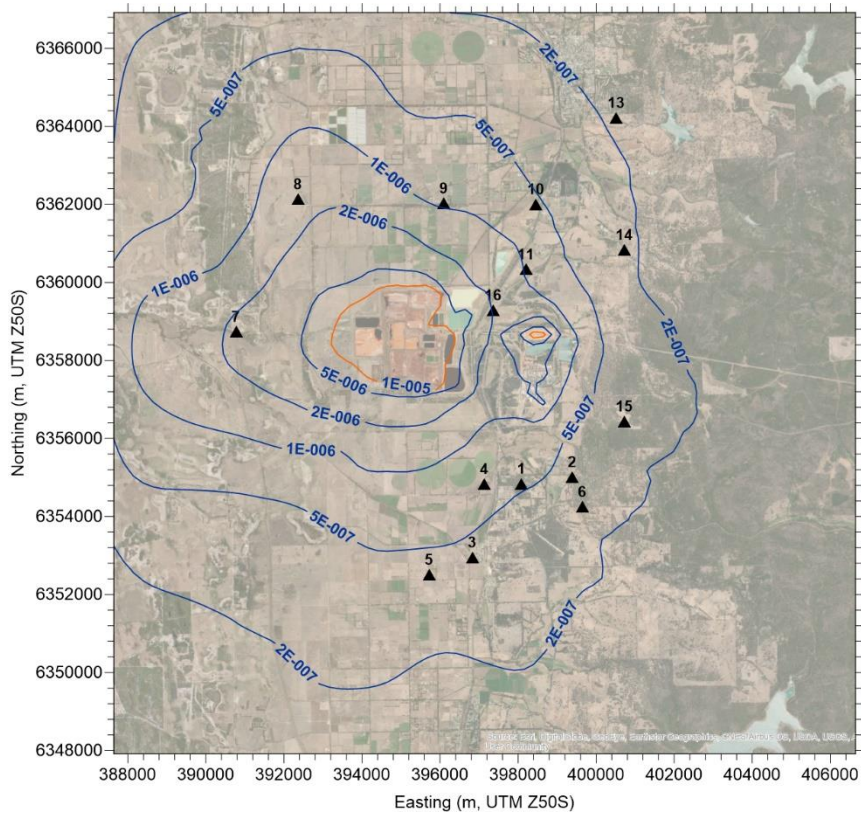**Figure 6**   **Carcinogenic risk (ICR$_{TOTAL}$) contour map – Base Case**

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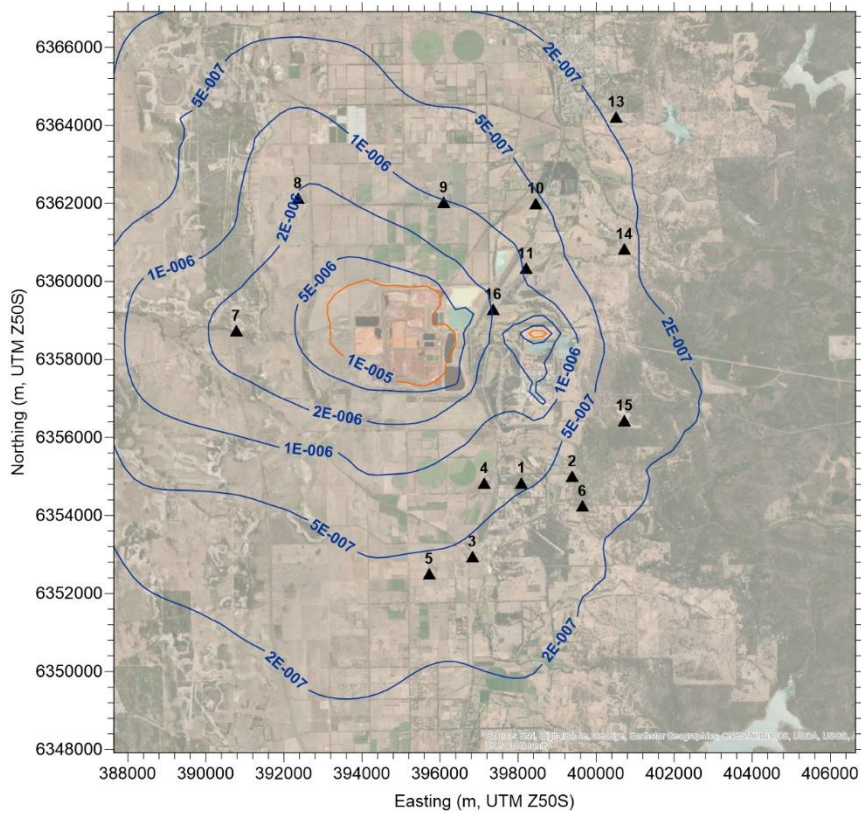
Figure 7   Carcinogenic risk (ICR$_{TOTAL}$) contour map – Expansion Case

An additional measure for the assessment of carcinogenic risk is to compare the magnitude of carcinogenic risk associated with individual substances to the guideline of 1×10^{-6}. Only receptors with an ICR$_{TOTAL}$ greater than 1×10^{-6} have the potential to have substance ICRs that exceed the guideline. The ICRs are greater than 1×10^{-6} at receptors 7, 8 and 16 for both the Base Case and Expansion Case scenarios. Substance ICRs at receptors 7, 8 and 16 are summarised in Table 9. Substance ICRs are greater than or equal to 1×10^{-6} for:

- Arsenic: Receptor 7 (Base Case & Expansion Case) and Receptor 8 (Expansion Case)

- Chromium (VI): Receptor 7 (Expansion Case)

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Table 9   Summary of substance carcinogenic risk (ICR$_i$) for receptors 7, 8 and 16

Substance	Base Case (2.85 Mtpa)- Receptor			Expansion Case (3.3Mtpa) - Receptor		
	7	8	16	7	8	16
Arsenic & compounds	1.10E-06	7.43E-07	6.27E-07	1.29E-06	1.00E-06	6.44E-07
Beryllium & compounds	6.93E-08	4.88E-08	9.80E-08	7.95E-08	6.26E-08	9.38E-08
Cadmium & compounds	3.56E-08	2.70E-08	6.73E-08	4.04E-08	3.34E-08	6.23E-08
Chromium (VI)	8.65E-07	5.78E-07	3.36E-07	1.02E-06	7.85E-07	3.42E-07
Lead & compounds	3.32E-08	2.24E-08	3.30E-08	3.87E-08	3.01E-08	3.61E-08
Nickel & compounds	9.56E-08	6.73E-08	1.40E-07	1.09E-07	8.62E-08	1.38E-07
Acetaldehyde	1.80E-08	3.57E-08	1.85E-07	1.52E-08	3.12E-08	1.37E-07
Polycyclic Aromatic Hydrocarbons	1.16E-10	2.17E-10	7.18E-10	1.18E-10	2.32E-10	6.99E-10
Benzene	5.86E-09	1.02E-08	2.25E-08	5.87E-09	1.08E-08	2.01E-08
Ethylbenzene	5.59E-11	9.28E-11	6.91E-10	2.15E-11	2.59E-11	1.51E-10
Formaldehyde	5.08E-08	6.35E-08	1.12E-07	5.18E-08	6.58E-08	1.11E-07
Styrene	1.51E-11	1.21E-11	5.18E-11	1.43E-11	1.04E-11	3.74E-11
ICR$_{TOTAL}$	**2.28E-06**	**1.60E-06**	**1.62E-06**	**2.65E-06**	**2.11E-06**	**1.59E-06**

The Wagerup 2020 HRA is a Tier 1 HRA that provides a conservative assessment of the health risk associated with emissions from the Wagerup Refinery. Where the risk associated with either a receptor or a substance is higher than the guideline values applied this provides an indication that further, more refined investigation is required. The Wagerup 2020 HRA has adopted a carcinogenic risk target of one in one hundred thousand (1×10^{-5}) as an indicator of acceptable cumulative carcinogenic risk, ICR$_{TOTAL}$. The ICR$_{TOTAL}$ for all receptors is less than 1×10^{-5} indicating that the carcinogenic health risk associated with atmospheric emissions associated with both the Base Case and the Expansion Case is low. Further to this a carcinogenic risk target of one in a million (1×10^{-6}) has been adopted as an indicator of acceptable risk associated with individual carcinogens at receptors (ICR$_i$). The results of the assessment of carcinogenic risk for individual carcinogens at Receptors 7 and 8 indicate that further investigation into atmospheric emissions of arsenic and chromium (VI) from the Wagerup Refinery is required to better understand these emissions and how they are measured and managed.

3.4   Uncertainty discussion

The outcomes of all HRAs come with some level of uncertainty, following is a discussion of the uncertainties associated with each phase of the Wagerup 2020 HRA.

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3.4.1 Toxicity assessment

The health endpoints used in the Wagerup 2020 HRA are sourced from a comprehensive review of substances and their associated health endpoints (Katestone, 2019). Key references consulted for the review include:

- Air NEPM: National Environment Protection (Ambient Air Quality) Measure (NEPC, 2015)

- Air Toxics NEPM: National Environment Protection (Air Toxics) Measure, (NEPC, 2004)

- OEHHA: California Office of Environmental Health Hazard Assessment's (OEHHA) Toxicity Criteria Database

- ATSDR: U.S. Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels (MRLs) for Hazardous Substances

- IRIS: U.S. Environment Protection Agency's (USEPA) Integrated Risk Information System

- International Agency for Research on Cancer (IARC), 2019. "IARC Monographs on the Evaluation of Carcinogenic Risks to Humans; v. 1-123C."

- WHO: World Health Organisation (WHO) Air Quality Guidelines for Europe Second Edition (2000)

- RIVM: Dutch National Institute of Public Health and the Environment (RIVM) human- toxicological Maximum Permissible Risk Levels (2001).

Health protective guideline values or health endpoints for substances are inherently conservative and generally at a level where no or minimal adverse health effects have been observed. The application of health guidelines published by reputable authorities is intended to prevent the underestimation of risk and will therefore by design result in the overestimation of risk.

The RELs for nitrogen dioxide (acute risk and chronic risk) and sulfur dioxide (acute risk) are the standards for these substances that are contained in the recent draft National Environment Protection (Ambient Air Quality) Measure (Air NEPM) that has not yet come into effect. The Draft Air NEPM has proposed new standards for nitrogen dioxide and sulfur dioxide to replace the existing standards. The Draft Air NEPM also introduces additional more stringent standards with a goal that they are achieved by 2025. The RELs selected for this study are the more stringent goal related standards. Using these stricter standards as RELs provides an added level of conservatism to the estimation risk.

Table 10   Draft Air NEMP - Standards for nitrogen oxide and sulfur dioxide compared to the current Air NEPM (µg/m³ dry @ 0°C, 1 atm)

Pollutant	Averaging period	Current Air NEPM standards (µg/Nm³)	Draft Air NEPM standards (µg/Nm³)	
			New Standard	2025 goal
Nitrogen dioxide	1 hour	246	185	164
	1 year	62	39	31
Sulfur dioxide	1 hour	572	286	215
	1 day	229	57	-
	1 year	57	Removed	-

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3.4.2 Exposure assessment

GLCs provide a measure of the exposure of receptors to target substances. The peak emissions have been assumed to occur continuously for the entire 1-hour, 8-hour or 24-hour period whereas in reality the peak emission rate may only occur for half an hour up to an hour. Acute risk scores are based on GLCs associated with 1-hr (99.9th percentile), 8-hr (99.9th percentile) and 24-hour (99.5th percentile) emissions rates of target substances. The use of these percentiles mean that the emissions concentrations used in the Wagerup 2020 HRA are only predicted to occur 0.5% of the time, for the other 99.5% of the time the emissions concentrations and hence GLCs will be lower. The use of the peak emissions rates will result in a highly conservative assessment of acute risk.

In addition to this the exposure characteristics inherent in the Wagerup 2020 HRA assume that:

- Acute risk: occupants at receptor locations are considered to be outside for the duration of peak concentrations considered by the assessment

- Chronic risk: occupants at receptor locations are considered to be outside 24 hours a day, seven days per week over the entire year

- Carcinogenic risk: occupants at receptor locations are considered to be outside 24 hours a day, seven days per week over the entire year for their lifetime (approximated as a 70-year period).

These assumptions are highly conservative as occupants at receptor location would spend some time indoors and some time away from the property.

In most circumstances the inhalation pathway is expected to represent the most significant exposure route for atmospheric emission sources. The potential for atmospheric pollutants to pose a risk to multiple exposure pathways (multi-pathway) is related to the properties of the substance; in particular, the tendency of a substance to persist in the environment and bioaccumulate. In relation to the Wagerup HRA, substances that are present in the particulate phase are the most likely to present a multi-pathway risk. Depending on their size, substances in the particulate phase may deposit on surfaces, such as soil and crops, and be available for ingestion.

Substances considered by the Wagerup HRA with the greatest potential to present a multi-pathway risk include:

- Arsenic

- Cadmium

- Chromium (VI)

- Nickel

- Beryllium

- Lead.

In terms of the Wagerup HRA, the multi-pathway risk is only of significance to carcinogenic risk. Arsenic is a significant contributor to carcinogenic risk. Previous analysis (Environ 2004) has indicated that the inhalation pathway for arsenic is likely to account for approximately 75% of the risk. An increase of 25% to the carcinogenic risk for arsenic will not have a material effect on ICR_{TOTAL} at any of the receptors. All risk scores would remain within the risk thresholds applied in the Wagerup HRA in terms of both the cumulative risk and individual substance risk associated with each receptor. The consideration of multi-pathway risk for substances other that arsenic is expected to have minimal impact on ICR_{TOTAL} in comparison to arsenic.

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3.4.3 Risk characterisation

The health risk at a given receptor is based on combining the health endpoint with the GLC across target substances at each receptor for each risk type. The risks associated with multiple substances is not necessarily additive; this is the case where the health endpoint of one substance is associated with different health effects to the health end point of another substance. As a result, risk scores determined for Tier 1 HRAs are inherently conservative.

In addition to this, a non-threshold approach has been applied to the assessment of cumulative carcinogenic risk. All carcinogenic substances included in the Wagerup HRA have been considered to be genotoxic leading to a conservative estimate of cancer risk at each receptor.

Based on the above discussion the uncertainties in the Wagerup 2020 HRA result in a conservative assessment of health risk across all risk types assessed by the Wagerup 2020 HRA.

3.4.4 Risk confidence

In addition to the risk characterisation, the Health Risk Assessment (Scoping) Guidelines (WA Department of Health, 2010) (HRA Scoping Guidelines) also recommend assessment of the confidence level associated with screening level HRAs. The confidence in the data and information used in the Wagerup HRA has been evaluated against the indicators provided by the HRA Scoping Guideline provided in Table 11.

Table 11   Confidence in Predicted Risk Rating (WA Department of Health, 2010)

Confidence Level	Data available
High confidence	Several expert investigations/studies Excellent information and survey data Long term monitoring results available Modelling conducted and calibration shows good adherence to real occurrences Strong evidence of exposures resulting in adverse health impacts
Reasonable confidence	More limited information and survey data available – complies with Department of Health guidance Short term monitoring results available Modelling conducted but calibration shows occasional aberration from predicted occurrences. Available information is adequate and there is some evidence of exposures resulting in health impacts
Low confidence	No survey data No model verification possible No modelling conducted Available information is inadequate Little information on exposures and health impacts

The confidence levels associated with the Wagerup HRA are summarised in Table 12.

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Table 12   Confidence levels associated with the Wagerup HRA

Aspect	Confidence Level	Comments
Toxicity assessment	High confidence	Substance toxicities are based on RELs and ICRs published by reputable authorities that have been determined by expert investigations and standardised procedures.
Exposure assessment	High confidence	Modelling and measurement of pollutants by Alcoa shows good adherence to measured pollutant concentrations.
Risk characterisation	High confidence	Risk characterisation is a combination of the toxicity assessment with the exposure assessment and is based on excellent information and modelled emissions with a high level of confidence.

Overall, the outcomes of the Wagerup HRA have been assessed as having a high level of confidence.

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4. CONCLUSION

The Wagerup 2020 HRA provides a Tier 1 HRA for atmospheric emissions associated with two operation scenarios namely: Base Case (alumina production of 2.85 Mtpa) and Expansion Case (alumina production of 3.3 Mtpa). The target substances for the Wagerup 2020 HRA have been determined based on current emissions from the Wagerup Refinery together with acute risk, chronic risk and carcinogenic risk health endpoints for each substance.

The assessment of both acute risk and chronic risk shows that the risk to all receptors due to atmospheric emissions from the Wagerup Refinery is low. The total carcinogenic risk to all receptors is also low compared to health risk guidelines however individual cancer risk associated with arsenic and chromium (VI) requires further detailed investigation.

As with any risk evaluation, there are areas of uncertainty in this assessment. To ensure that potential risks are not underestimated, uniformly conservative assumptions have been used to characterise exposure and toxicity. Due to the resultant compounding of conservatism, the quantitative risk indicators should be considered as over-estimates of potential health risks associated with emissions from the Wagerup Refinery.

When the information, data and calculations are evaluated against the indicators provided by the Western Australian HRA Scoping Guideline, the outcomes of the Wagerup HRA have been determined to have a high level of confidence.

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APPENDIX A - GLC CONTOUR MAPS FOR KEY SUBSTANCES

In this appendix GLC contour maps based on substance risk attributes are provided for both acute and annual averaging periods. GLC contour maps corresponding to REL averaging periods are included for each substance for both the Base Case and the Expansion case. In the following sections GLC contour maps are provided for the following substances::

- Oxides of nitrogen (as NO_2)
- Particulate Matter <10µm
- Carbon monoxide
- Acetone
- Acetaldehyde
- Formaldehyde
- Benzene

- Toluene
- Ammonia
- Mercury
- Cadmium
- Arsenic
- Chromium (VI)

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A1   OXIDES OF NITROGEN (AS NO₂)
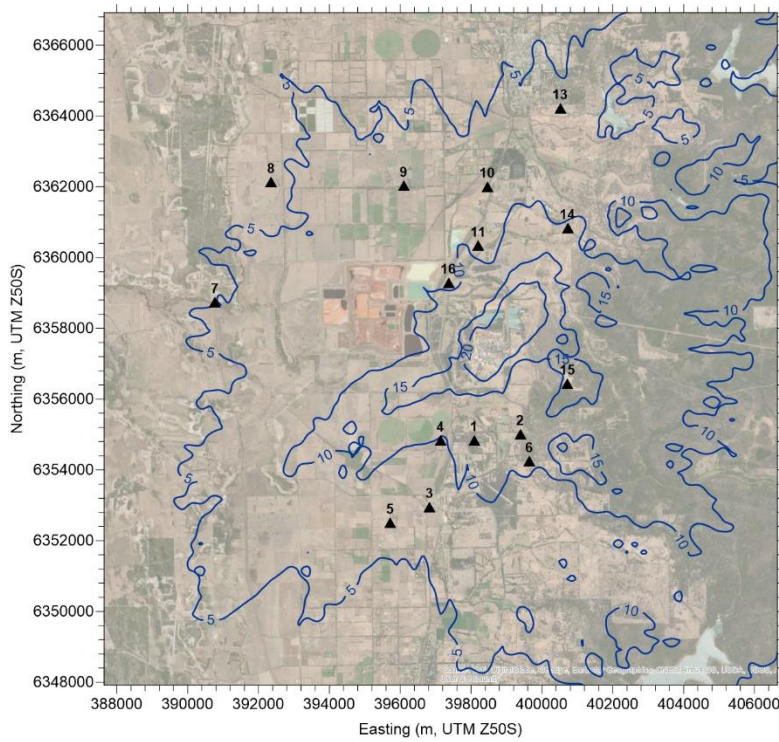
Figure A1   **Base Case: GLC (µg/m³) contour map for NO₂ (1hr, 99.9th percentile)**
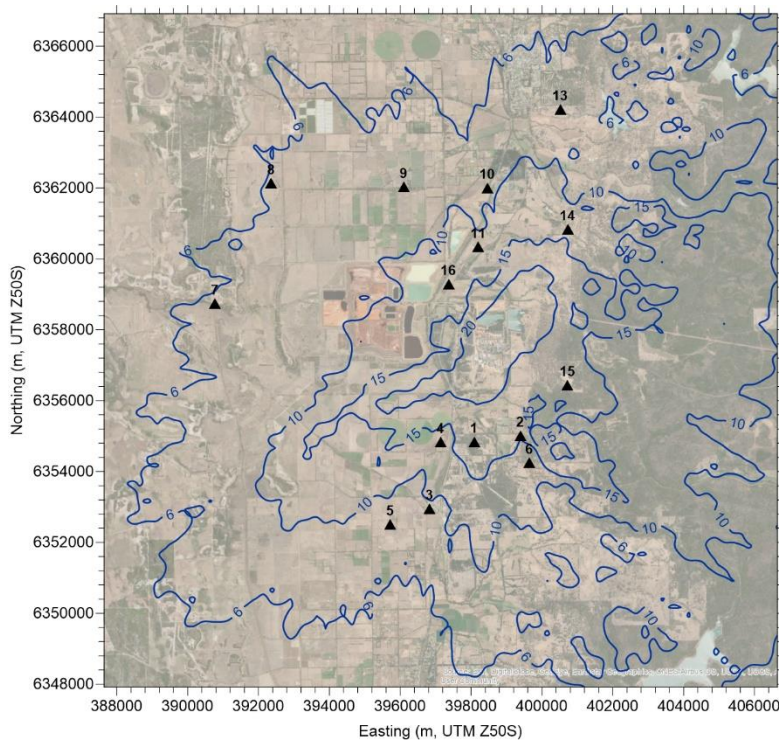
Figure A2   **Expansion Case: GLC (µg/m³) contour map for NO₂ (1hr, 99.9th percentile)**

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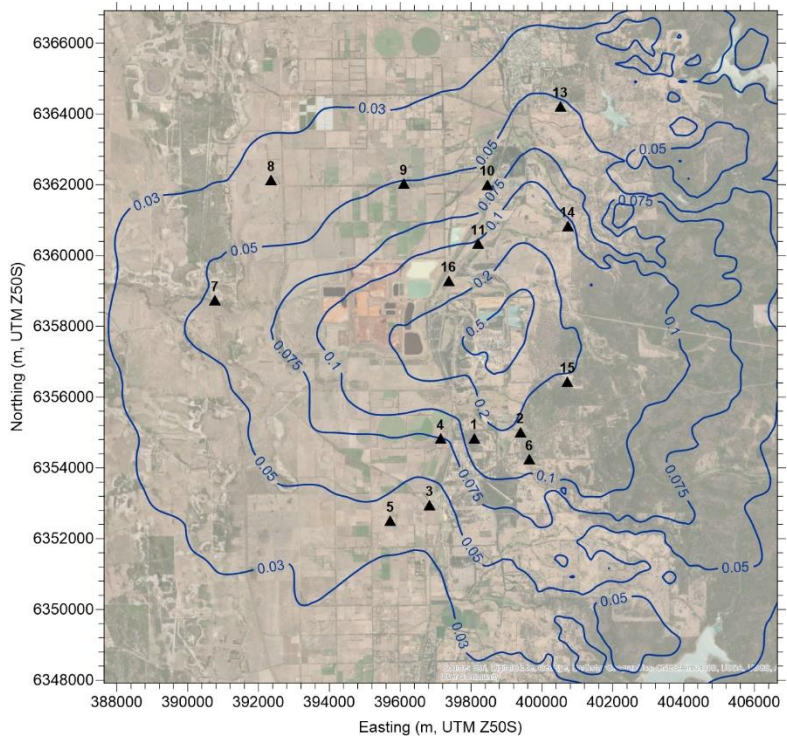
Figure A3   **Base Case: GLC (µg/m³) contour map for NO₂ (annual)**
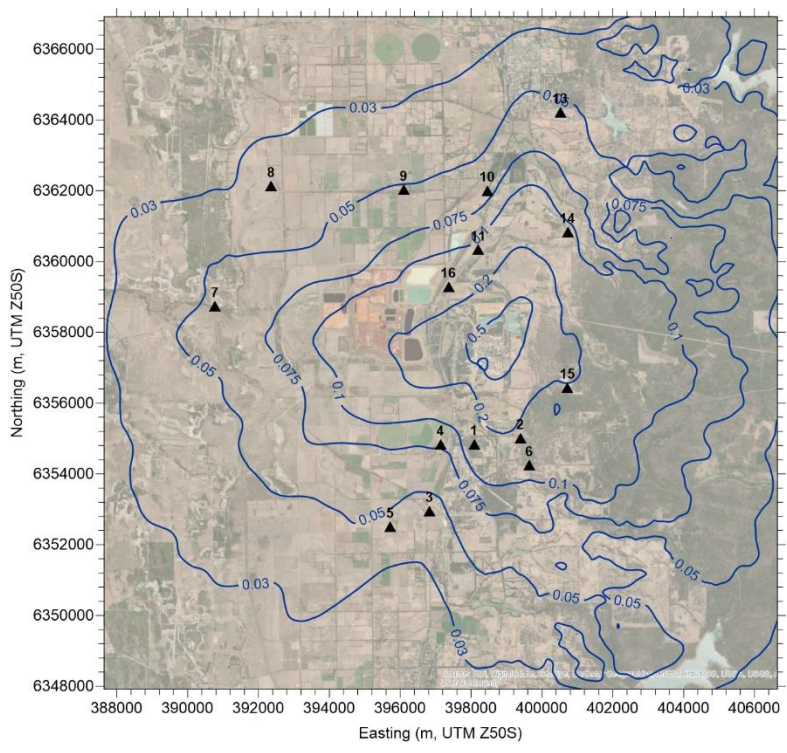
Figure A4   **Expansion Case: GLC (µg/m³) contour map for NO₂ (annual)**

A2 PARTICULATE MATTER <10µm
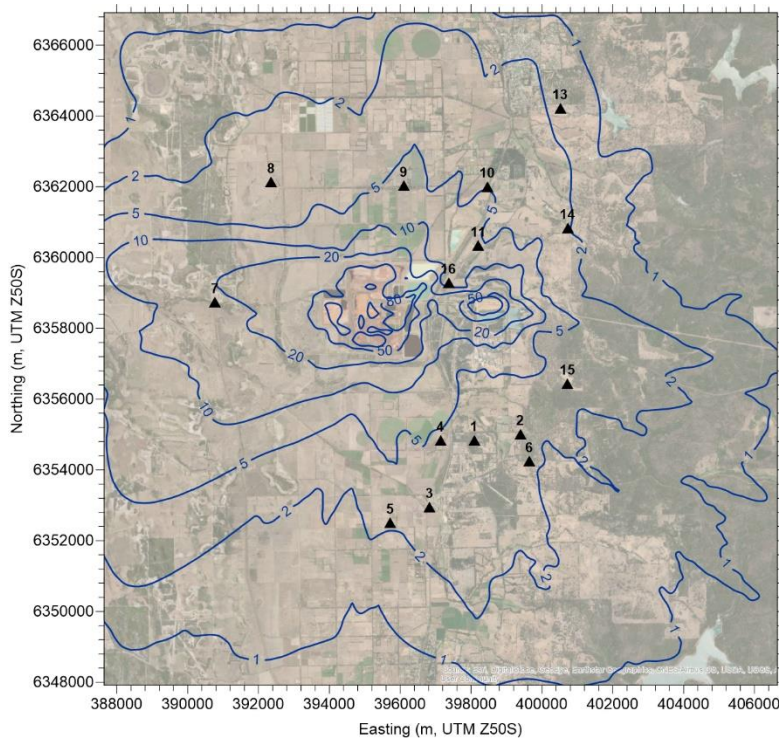
Figure A5   Base Case: GLC (µg/m³) contour map for PM$_{10}$ (24hr, 99.5th percentile)
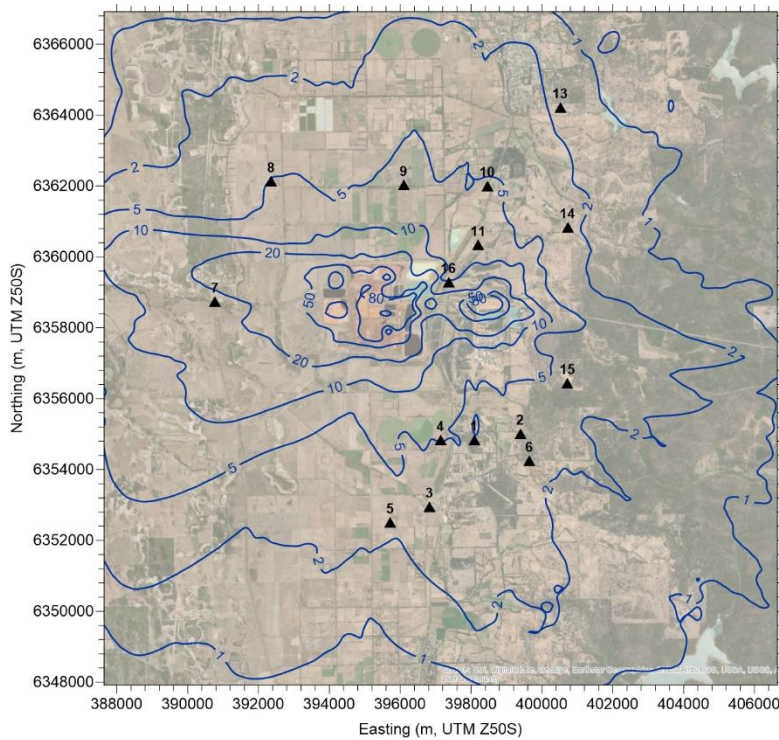
Figure A6   Expansion Case: GLC (µg/m³) contour map for PM$_{10}$ (24hr, 99.5th percentile)
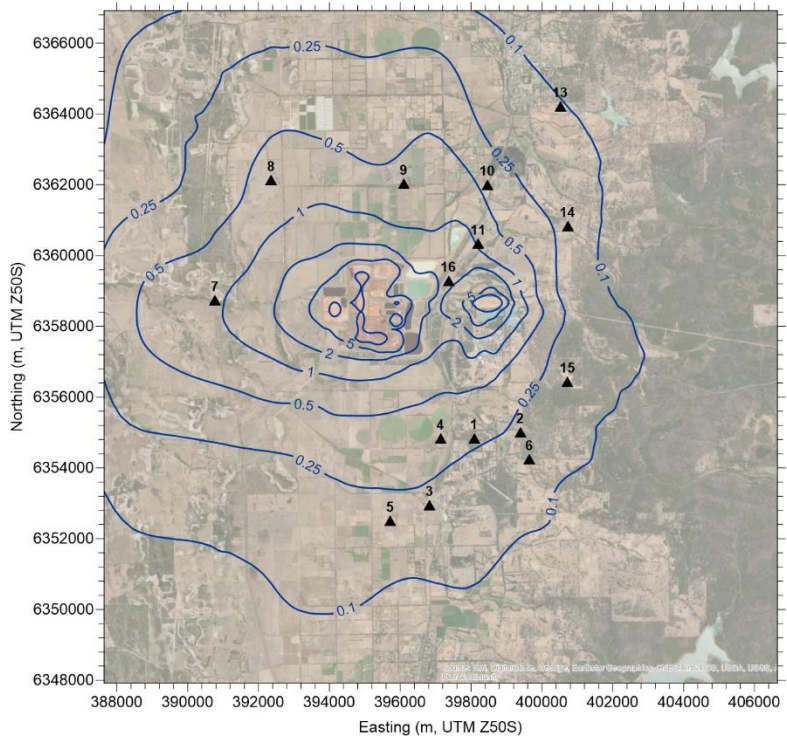
Figure A7   Base Case: GLC (µg/m^3) contour map for PM$_{10}$ (annual)
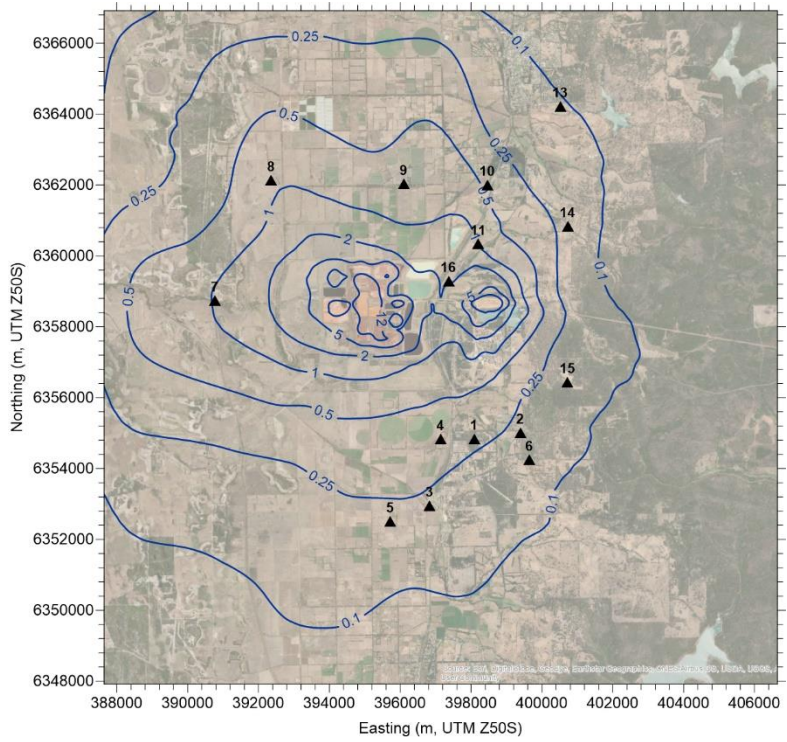
Figure A8   Expansion Case: GLC (µg/m^3) contour map for PM$_{10}$ (annual)

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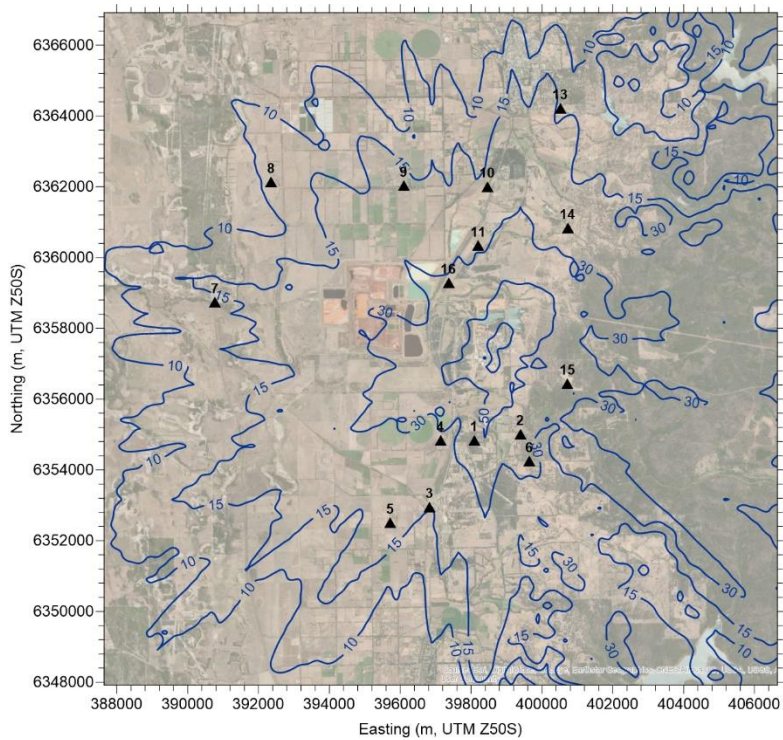
A3 CARBON MONOXIDE

Figure A9   Base Case: GLC (µg/m³) contour map for carbon monoxide (8hr, 99.9th percentile)
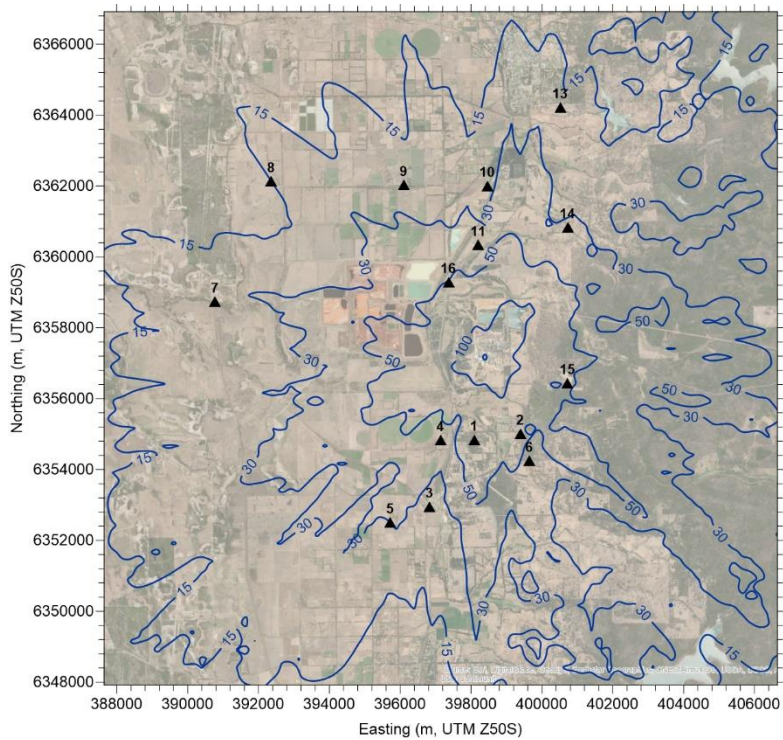
Figure A10   Expansion Case: GLC (µg/m³) contour map for carbon monoxide (8hr, 99.9th percentile)

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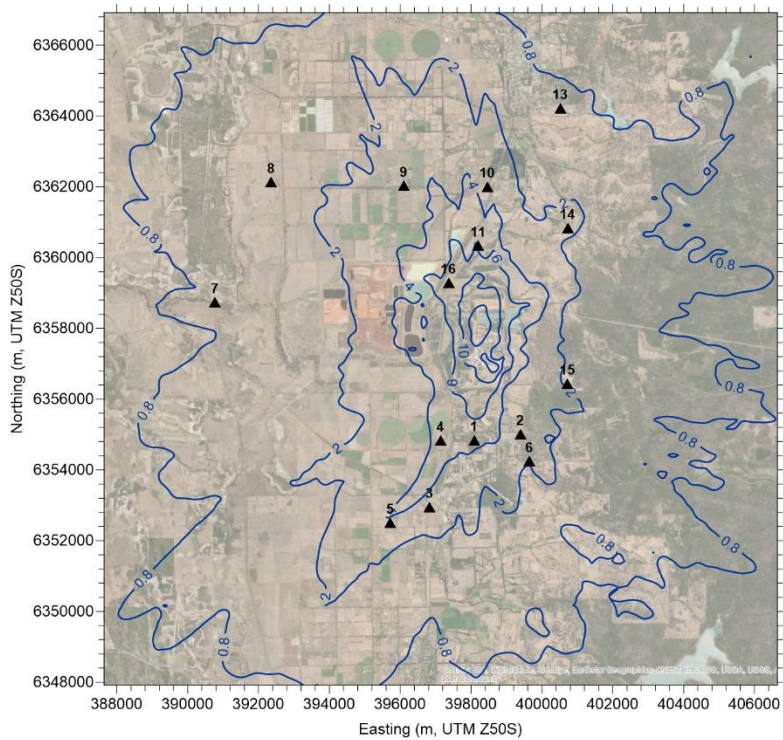
A4   ACETONE

Figure A11   Base Case: GLC (µg/m^3) contour map for acetone (24hr, 99.5th percentile)
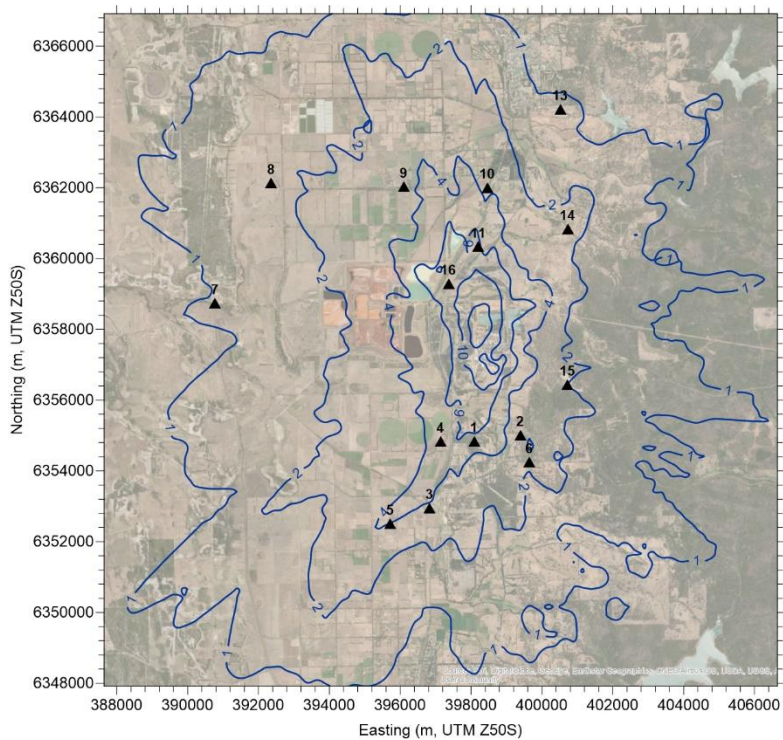
Figure A12   Expansion Case: GLC (µg/m^3) contour map for acetone (24hr, 99.5th percentile)

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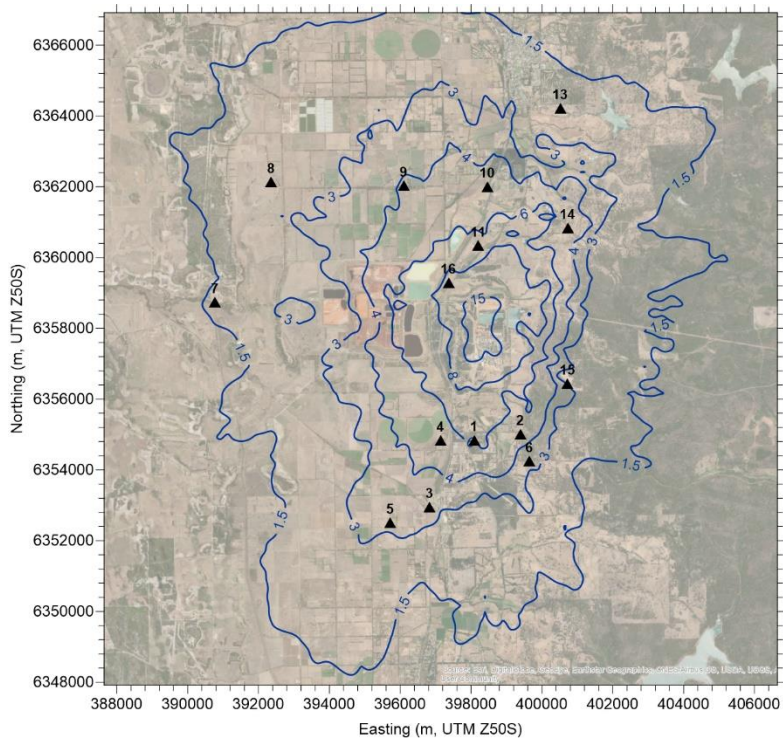
A5   ACETALDEHYDE

Figure A13   Base Case: GLC (µg/m³) contour map for acetaldehyde (1hr, 99.9th percentile)
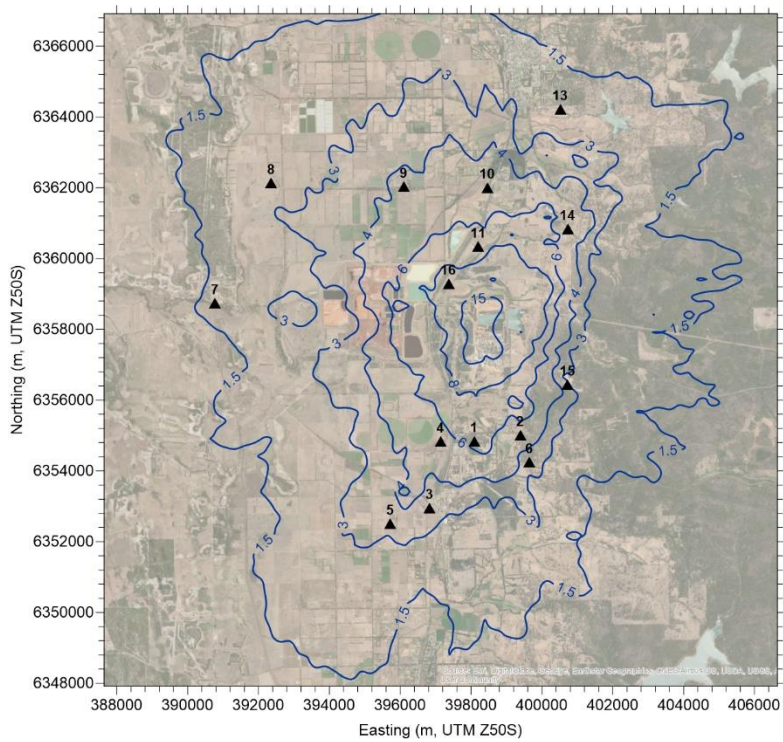
Figure A14   Expansion Case: GLC (µg/m³) contour map for acetaldehyde (1hr, 99.9th percentile)

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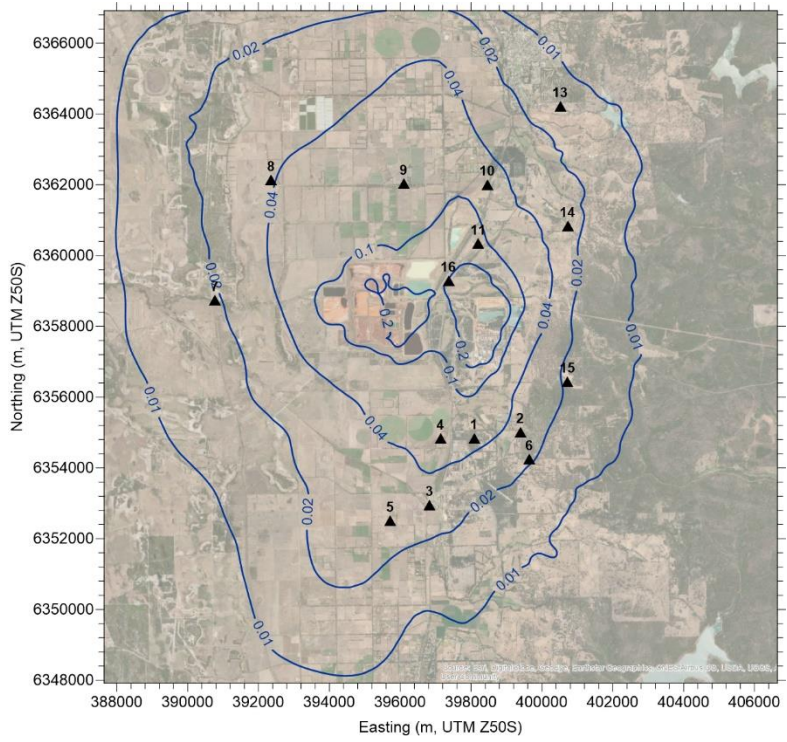
Figure A15   Base Case: GLC (µg/m³) contour map for acetaldehyde (annual)
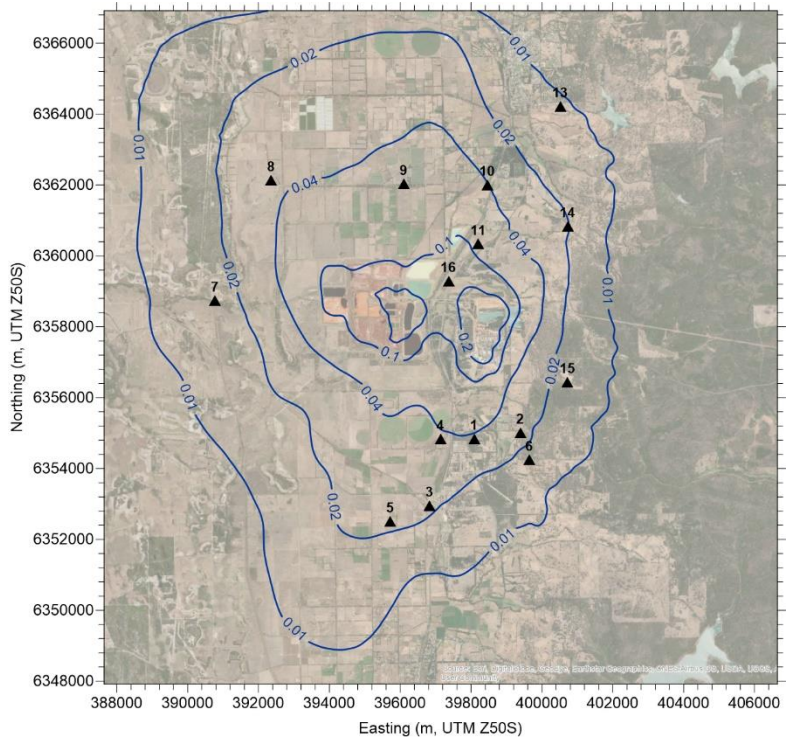
Figure A16   Expansion Case: GLC (µg/m³) contour map for acetaldehyde (annual)

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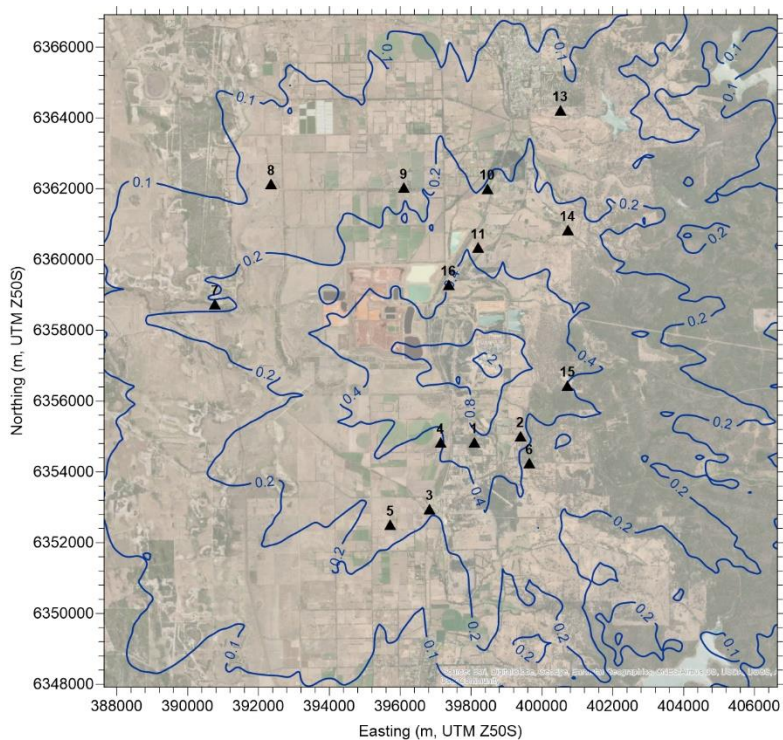
A6 FORMALDEHYDE

Figure A17   **Base Case: GLC (µg/m³) contour map for formaldehyde (24hr, 99.5th percentile)**
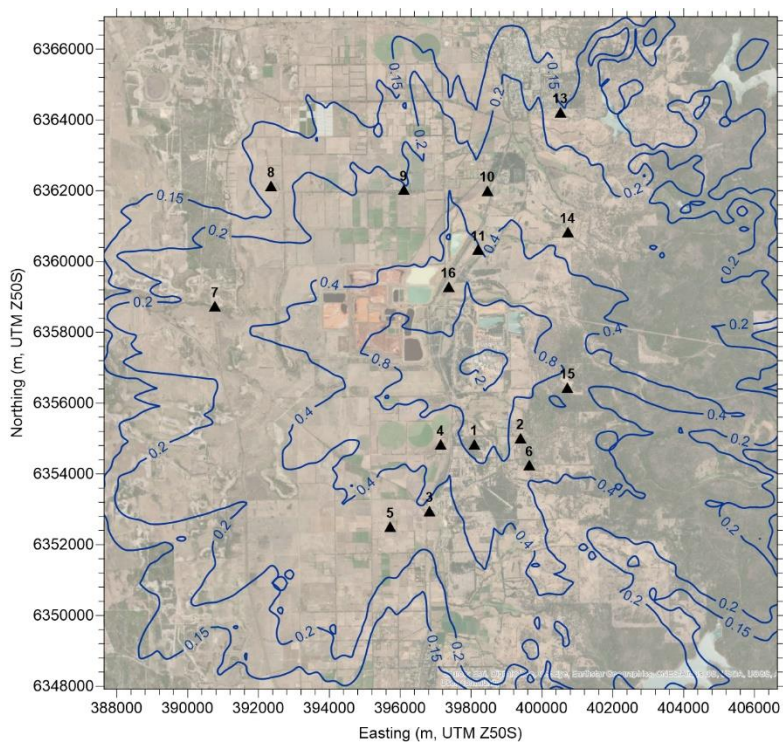
Figure A18   **Expansion Case: GLC (µg/m³) contour map for formaldehyde (24hr, 99.5th percentile)**
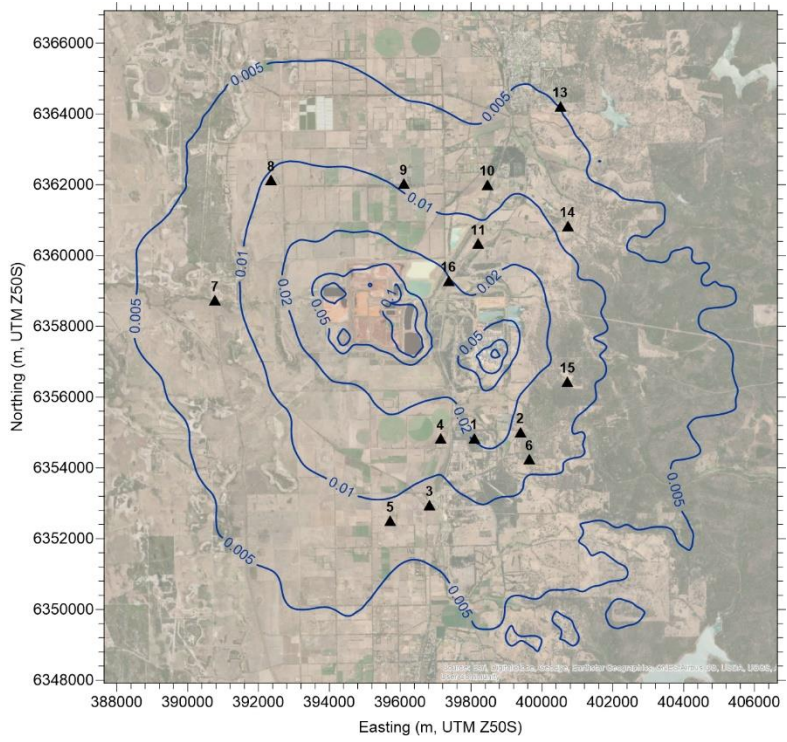
Figure A19   Base Case: GLC (µg/m³) contour map for formaldehyde (annual)
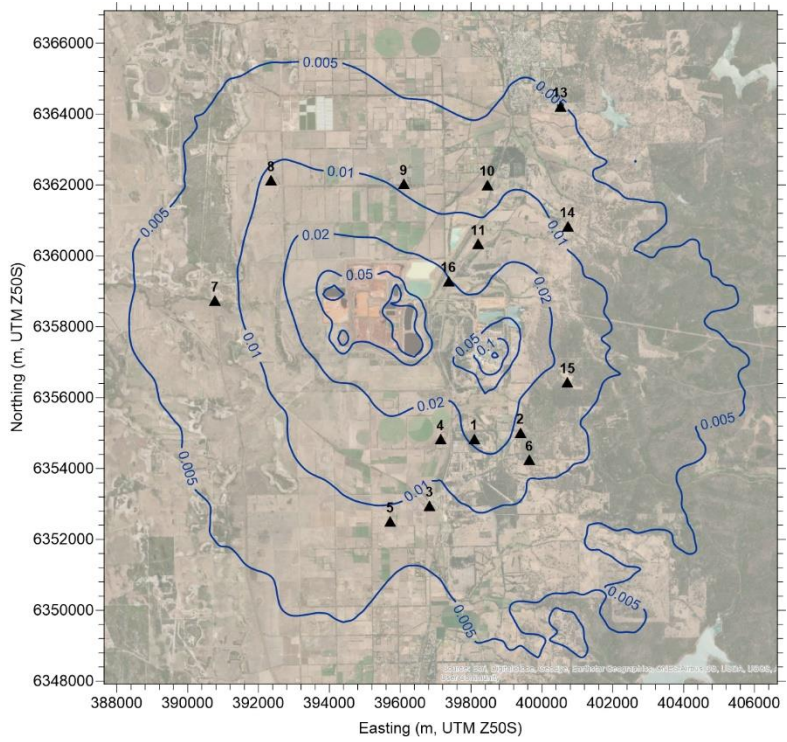
Figure A20   Expansion Case: GLC (µg/m³) contour map for formaldehyde (annual)

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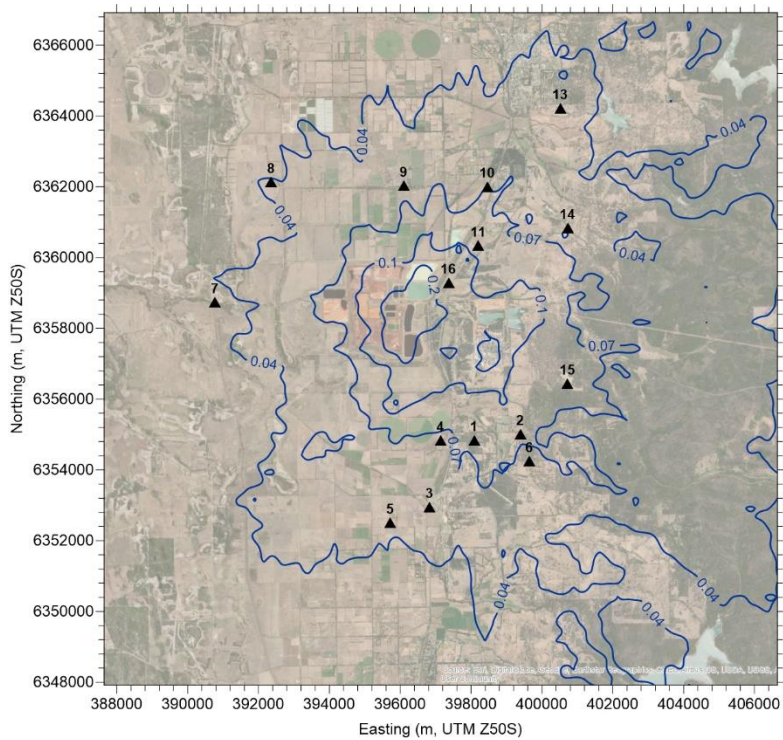
A7 BENZENE

Figure A21   Base Case: GLC (µg/m³) contour map for benzene (1hr, 99.9 percentile)
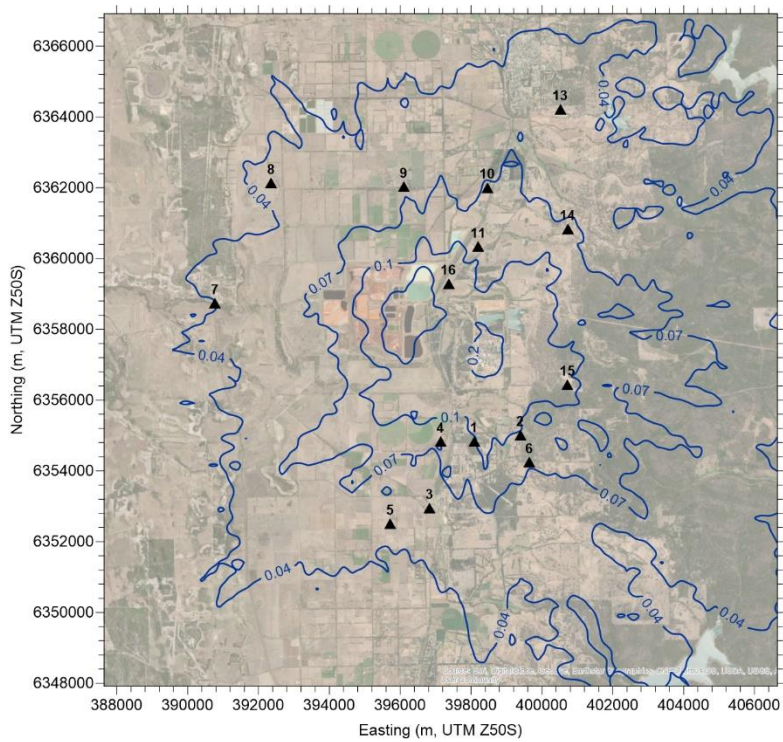
Figure A22   Expansion Case: GLC (µg/m³) contour map for benzene (1hr, 99.9[th] percentile)

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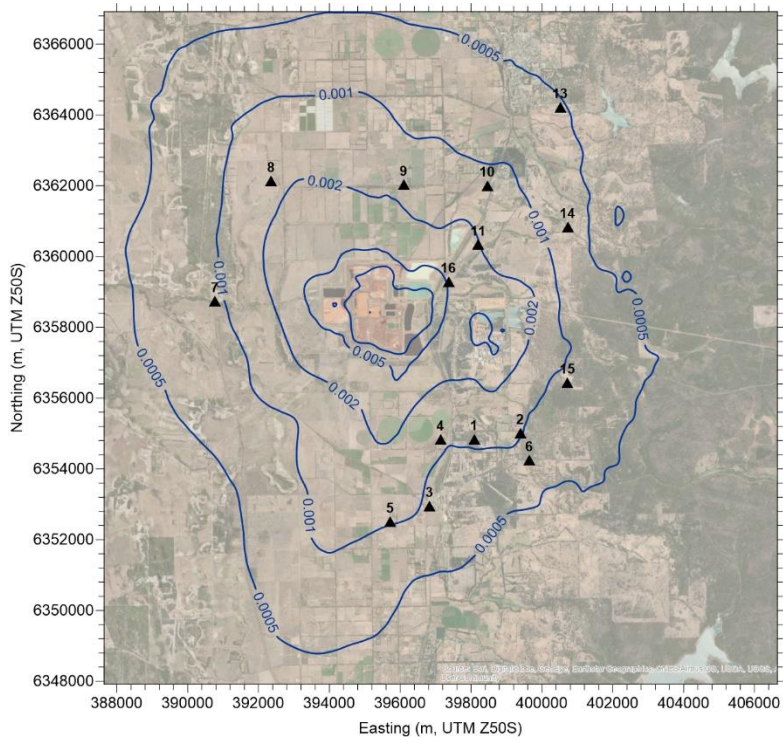
Figure A23   Base Case: GLC (µg/m³) contour map for benzene (annual)
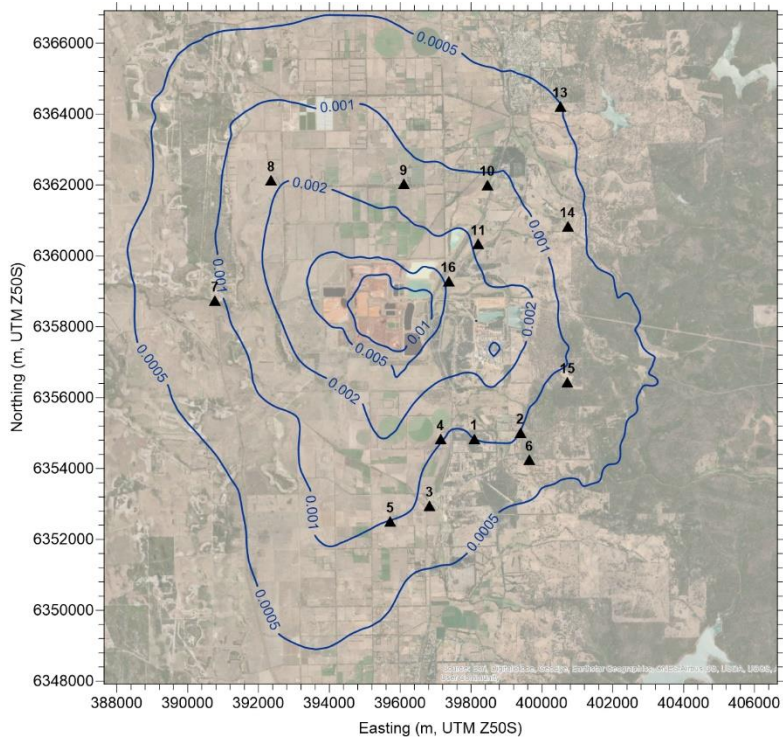
Figure A24   Expansion Case: GLC (µg/m³) contour map for benzene (annual)

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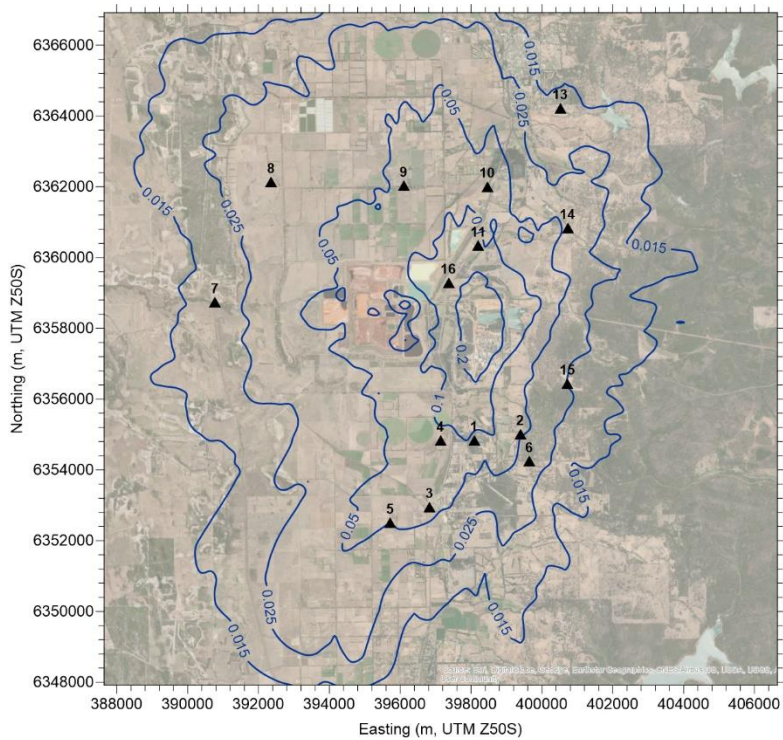
A8 TOLUENE

Figure A25   Base Case: GLC (µg/m^3) contour map for toluene (24hr, 99.5th percentile)
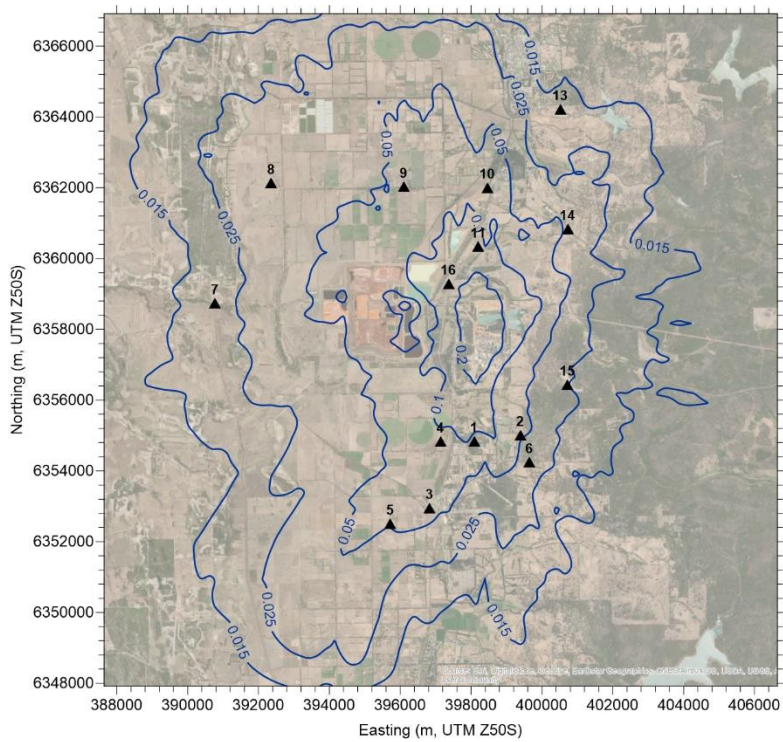
Figure A26   Expansion Case: GLC (µg/m^3) contour map for toluene (24hr, 99.5th percentile)

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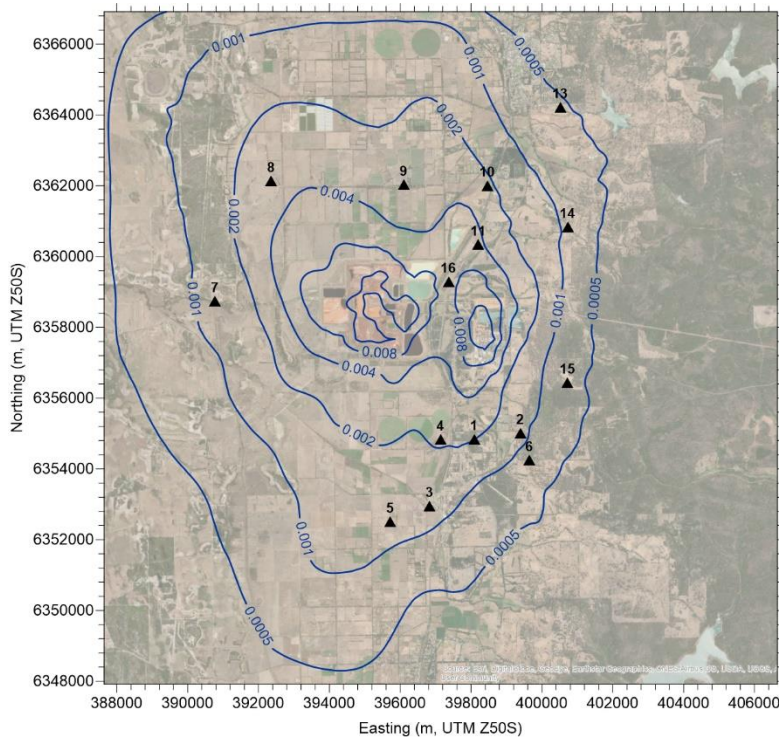
Figure A27   Base Case: GLC (µg/m³) contour map for toluene (annual)
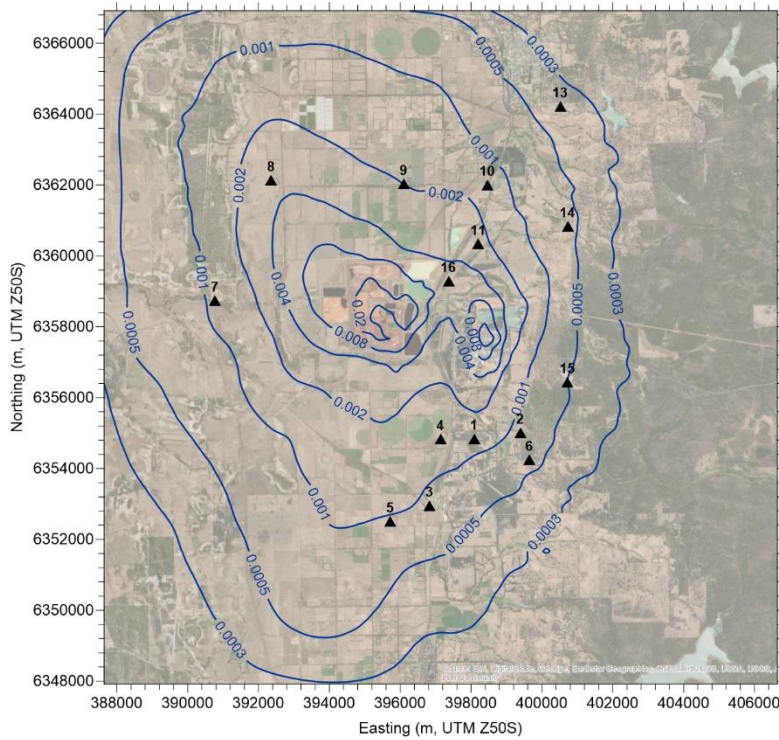
Figure A28   Expansion Case: GLC (µg/m³) contour map for toluene (annual)

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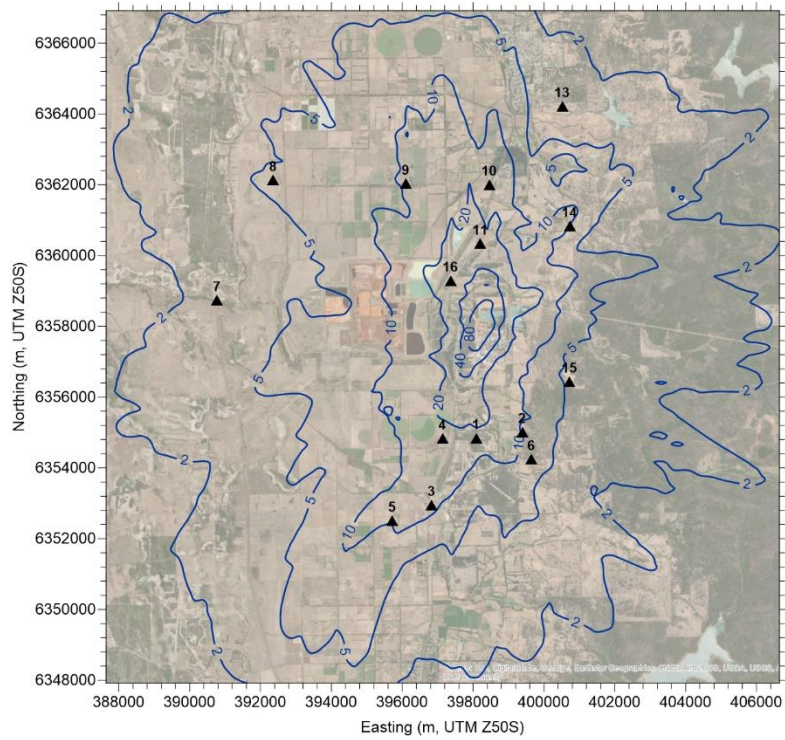
A9   AMMONIA

Figure A29   Base Case: GLC (μg/m³) contour map for ammonia (24hr, 99.5th percentile)
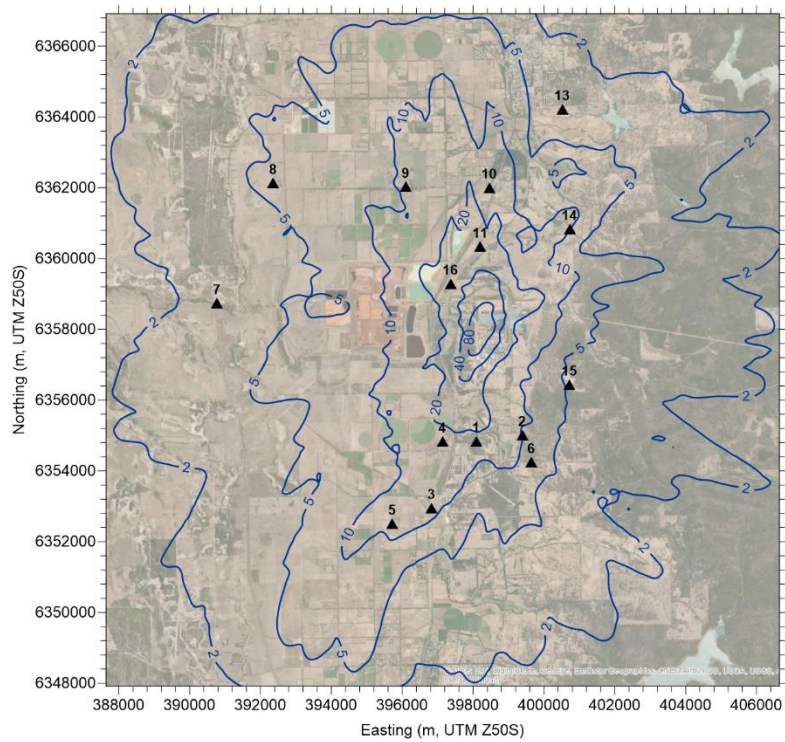
Figure A30   Expansion Case: GLC (μg/m³) contour map for ammonia (24hr, 99.5th percentile)

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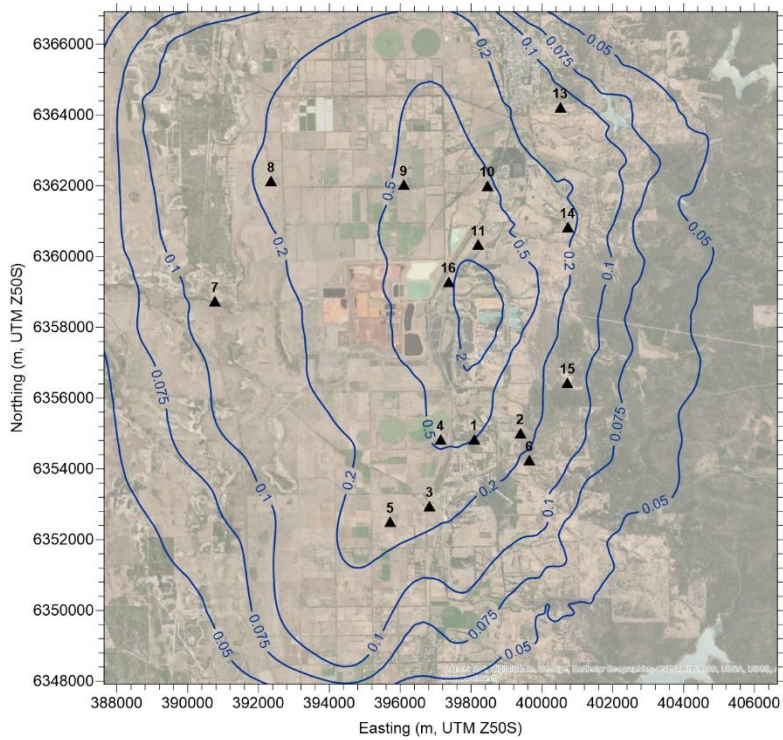
Figure A31   Base Case: GLC (µg/m³) contour map for ammonia (annual)
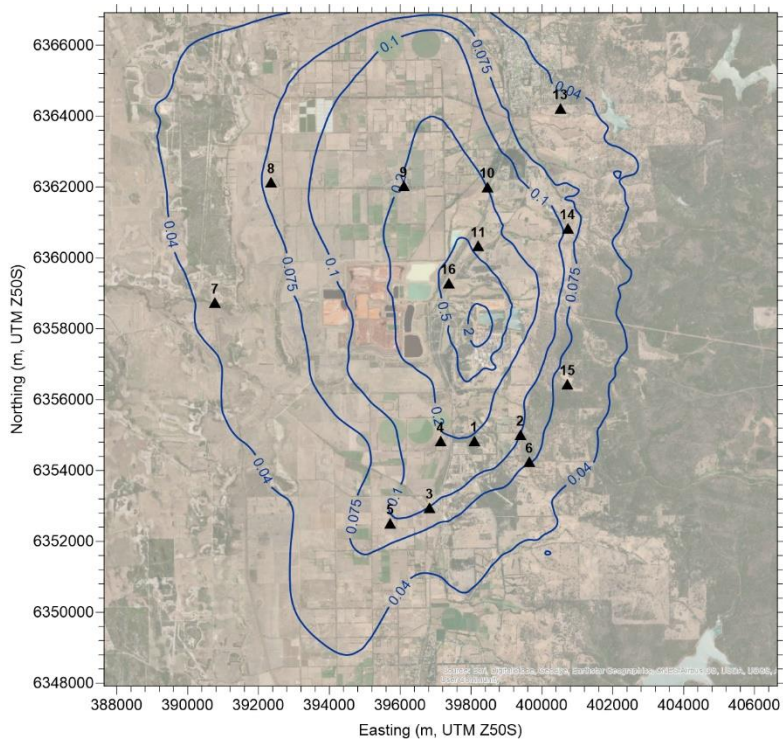
Figure A32   Expansion Case: GLC (µg/m³) contour map for ammonia (annual)

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A10 MERCURY
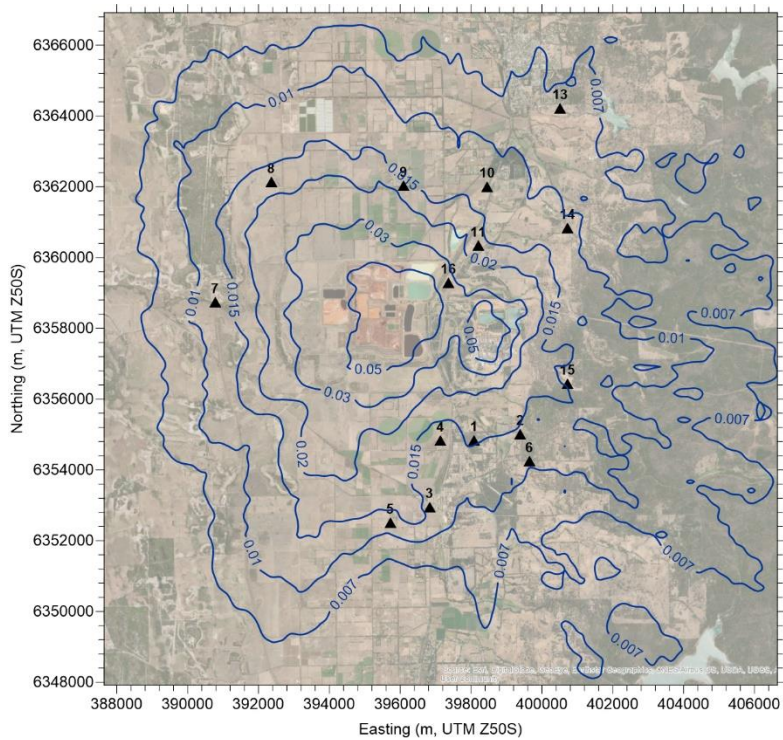
Figure A33 **Base Case: GLC (µg/m³) contour map for mercury (1hr, 99.9th percentile)**
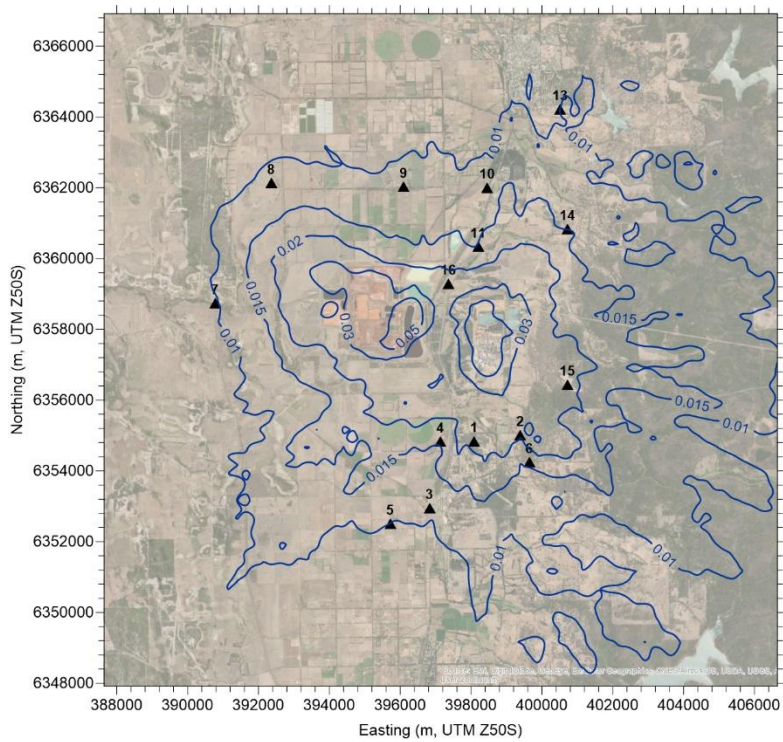
Figure A34 **Expansion Case: GLC (µg/m³) contour map for mercury (1hr, 99.9th percentile)**

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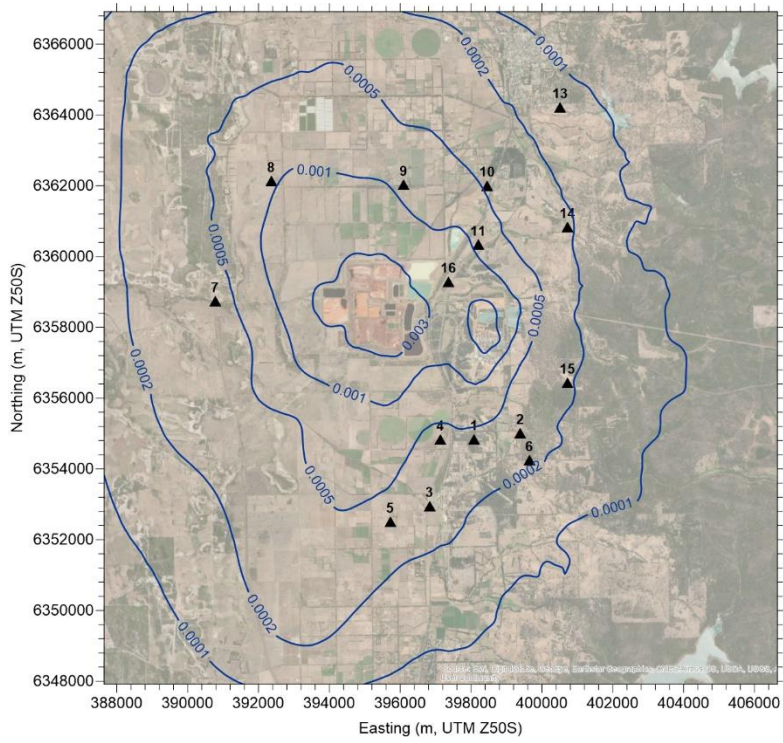
Figure A35 Base Case: GLC (µg/m³) contour map for mercury (annual)
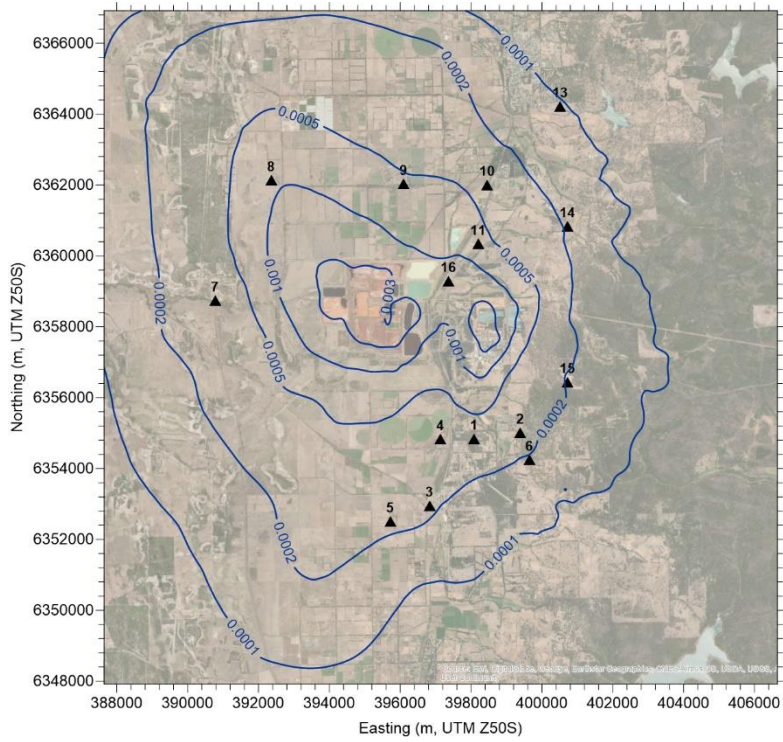
Figure A36 Expansion Case: GLC (µg/m³) contour map for mercury (annual)

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A11 CADMIUM
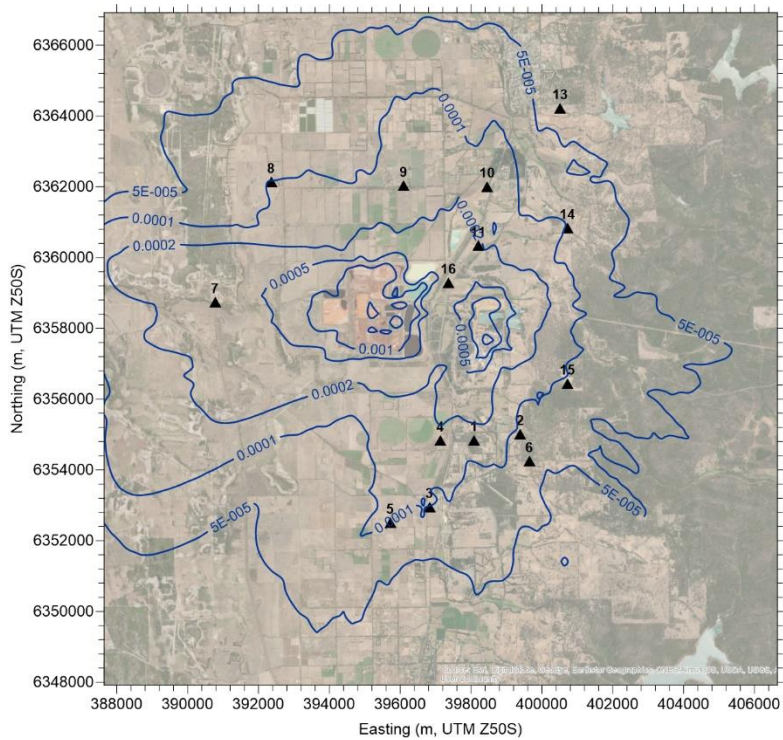
Figure A37   Base Case: GLC (µg/m³) contour map for cadmium (24hr, 99.5th percentile)
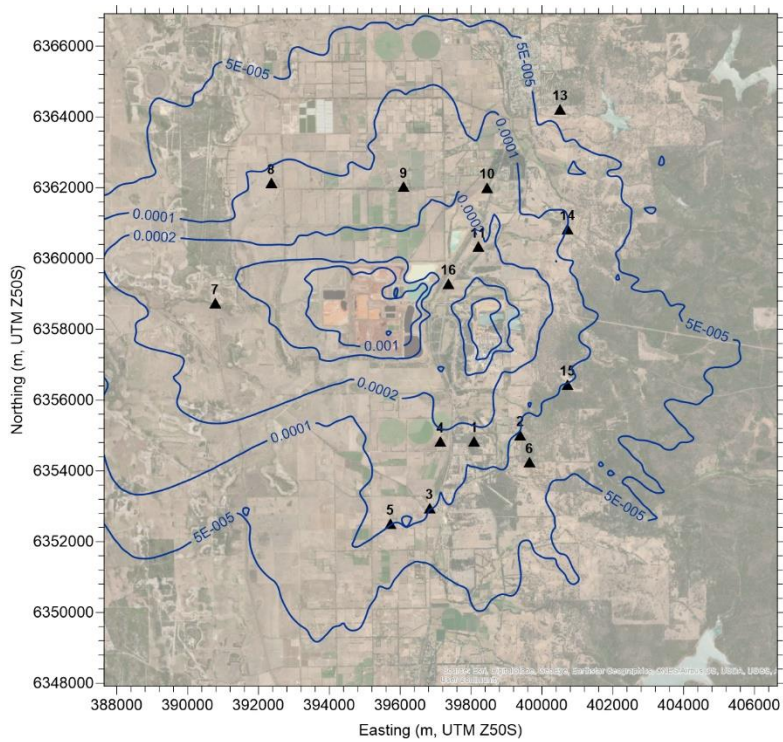
Figure A38   Expansion Case: GLC (µg/m³) contour map for cadmium (24hr, 99.5th percentile)

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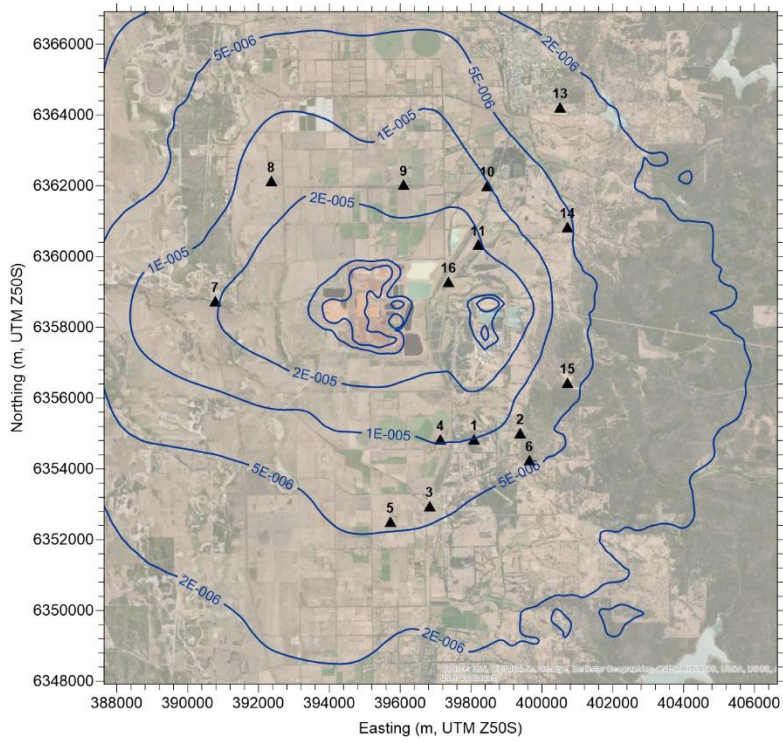
Figure A39   Base Case: GLC (µg/m^3) contour map for cadmium (annual)
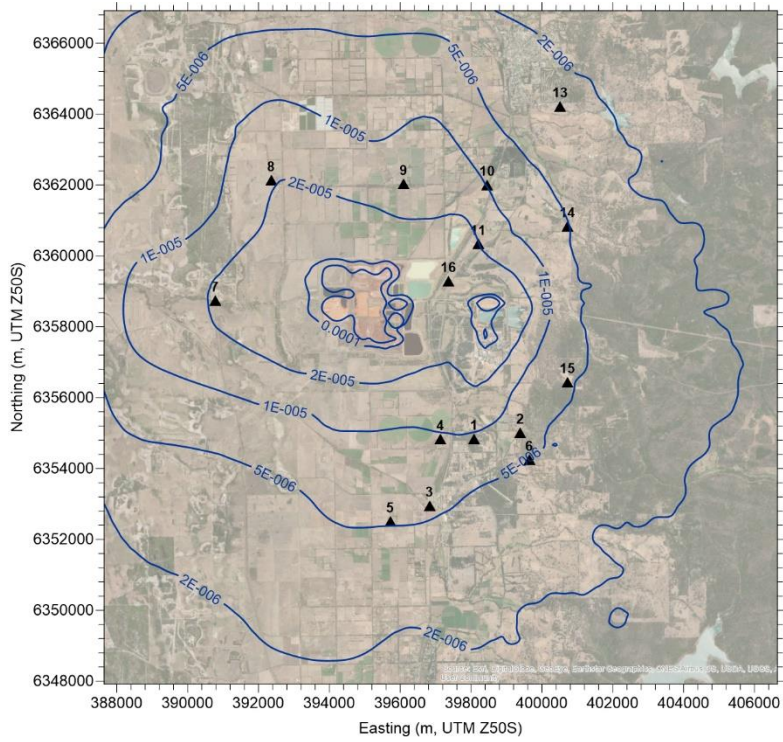
Figure A40   Expansion Case: GLC (µg/m^3) contour map for cadmium (annual)

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A12 ARSENIC
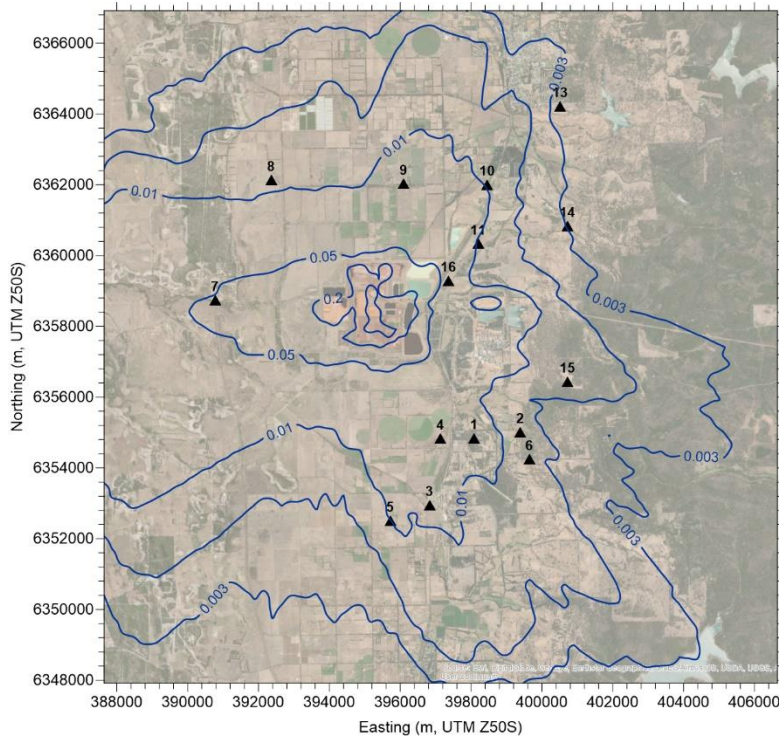
Figure A41   Base Case: GLC (µg/m³) contour map for arsenic (1hr, 99.9th percentile)
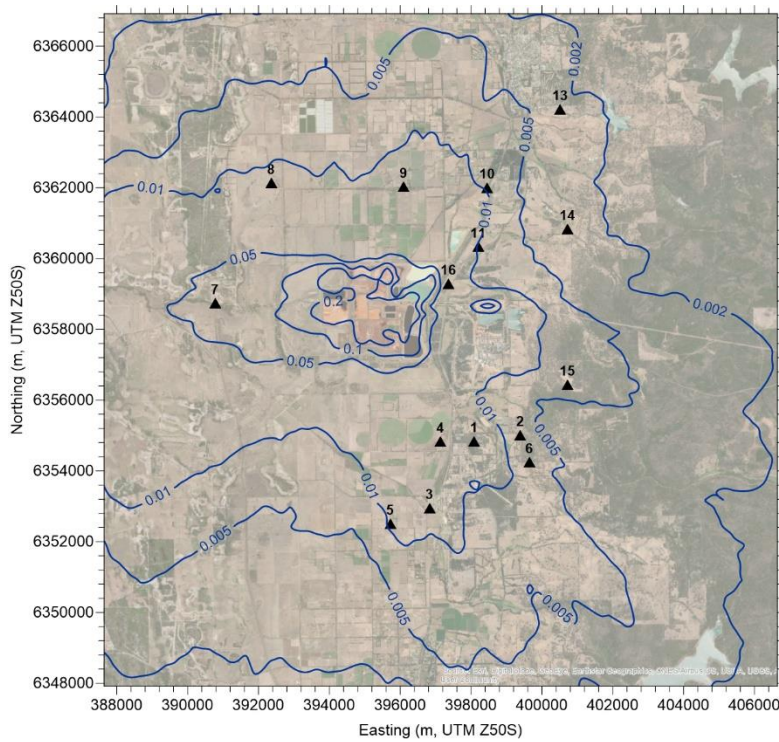
Figure A42   Expansion Case: GLC (µg/m³) contour map for arsenic (1hr, 99.9th percentile)

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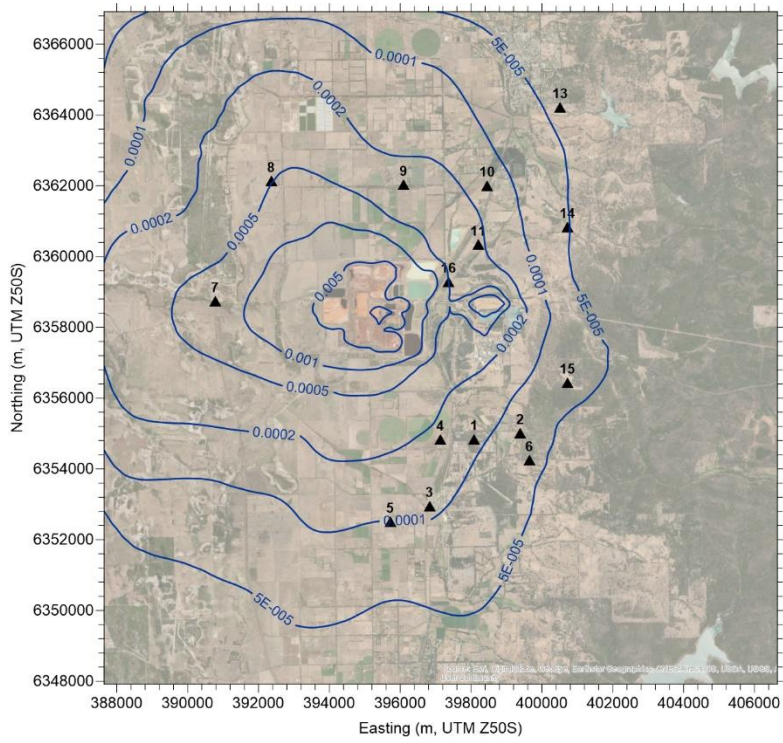
Figure A43   Base Case: GLC (µg/m^3) contour map for arsenic (annual)
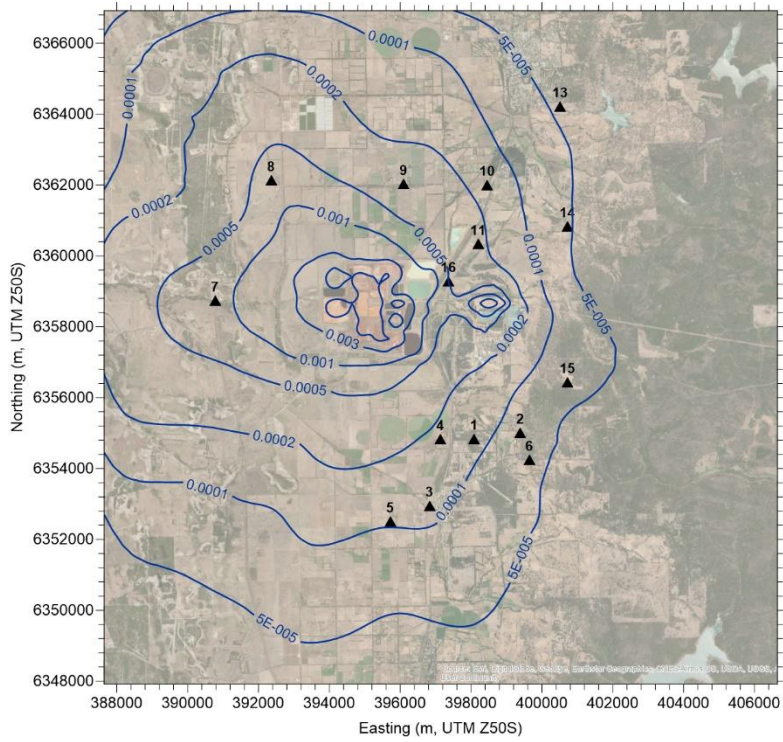
Figure A44   Expansion Case: GLC (µg/m^3) contour map for arsenic (annual)

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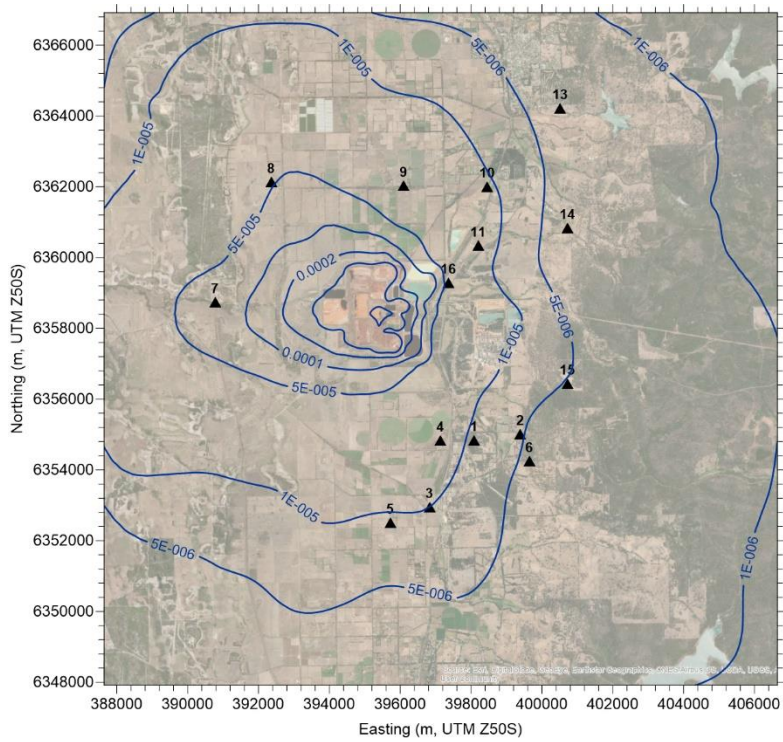
A13 CHROMIUM (VI)

Figure A45   Base Case: GLC (µg/m³) contour map for chromium (VI) (annual)
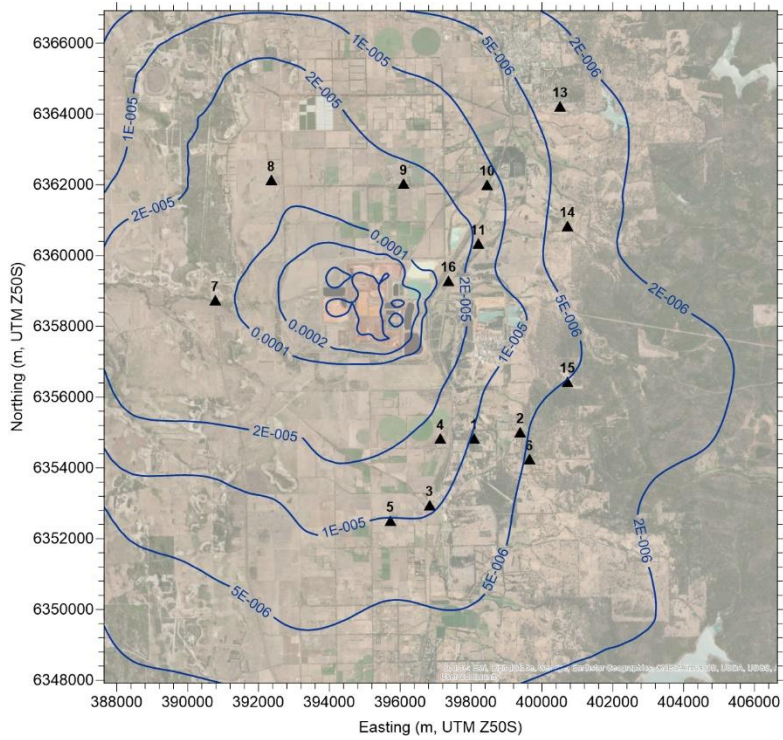
Figure A46   Expansion Case: GLC (µg/m³) contour map for chromium (VI) (annual)

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APPENDIX B – RISK ASSESSMENT RECEPTOR RESULTS

This appendix is organised by risk type:

- Acute risk

- Chronic risk

- Carcinogenic risk

It contains a summary of key data for each receptor including:

- Acute risk

    - Reference exposure limits (RELs) for each substance in µg/m^3

    - Averaging period in hours

    - Ground level concentration (GLC) for the applicable averaging period in µg/m^3

    - Hazard Quotient (HQ$_{ACUTE}$)

- Chronic risk

    - Reference exposure limits (REL) for each substance in µg/m^3

    - Annual ground level concentration (GLC) in µg/m^3

    - Hazard Quotient HQ$_{CHRONIC}$

- Carcinogenic risk

    - Incremental carcinogenic risk (ICR) for each substance in (µg/m^3)$^{-1}$

    - Annual ground level concentration (GLC) in µg/m^3

    - Cumulative incremental carcinogenic risk (ICR$_{TOTAL}$)

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B1   ACUTE RISK

Table B1   Receptor 1 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case		Expansion Case		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of Hazard Index
Nitrogen dioxide	164	1	1.31E+01	7.99E-02	1.76E+01	1.08E-01	25.3%
Carbon monoxide	11250	8	4.27E+01	3.80E-03	7.52E+01	6.69E-03	1.6%
Sulfur dioxide	57.2	24	1.24E+00	2.17E-02	1.70E+00	2.98E-02	7.0%
Particulate matter < 10 µm	50	24	3.56E+00	7.11E-02	3.99E+00	7.98E-02	18.8%
Ammonia	1290	24	1.47E+01	1.14E-02	1.50E+01	1.17E-02	2.7%
Arsenic & compounds	0.2	1	1.23E-02	6.17E-02	1.39E-02	6.95E-02	16.3%
Boron & compounds	300	24	4.16E-03	1.39E-05	4.25E-03	1.42E-05	0.0%
Cadmium & compounds	0.03	24	1.47E-04	4.90E-03	1.50E-04	5.01E-03	1.2%
Nickel & compounds	0.2	1	6.95E-03	3.47E-02	7.54E-03	3.77E-02	8.9%
Mercury & compounds	0.6	1	1.55E-02	2.58E-02	2.35E-02	3.91E-02	9.2%
Acetaldehyde	470	1	6.80 E+00	1.45E-02	7.09E+00	1.51E-02	3.5%
Acetone	67414	24	4.44E+00	6.59E-05	5.38E+00	7.98E-05	0.0%
Benzene	27	1	8.53E-02	3.16E-03	1.12E-01	4.15E-03	1.0%
Methyl ethyl ketone	13000	1	2.87E+00	2.21E-04	3.01E+00	2.32E-04	0.1%
Ethylbenzene	23699	24	2.10E-03	8.85E-08	2.06E-03	8.70E-08	0.0%
Formaldehyde	53.6	24	6.93E-01	1.29E-02	1.02E+00	1.90E-02	4.5%
Styrene	260	24	7.09E-03	2.73E-05	9.23E-03	3.55E-05	0.0%
Toluene	4113	24	8.39E-02	2.04E-05	8.48E-02	2.06E-05	0.0%
Xylenes	1185	24	9.35E-03	7.89E-06	9.49E-03	8.01E-06	0.0%
Hazard index (total)			**-**	**0.346**	**-**	**0.425**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B2   Receptor 2 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of Hazard Index
Nitrogen dioxide	164	1	1.23E+01	7.51E-02	1.52E+01	9.25E-02	30.4%
Carbon monoxide	11250	8	3.48E+01	3.09E-03	5.19E+01	4.61E-03	1.5%
Sulfur dioxide	57.2	24	1.17E+00	2.04E-02	1.37E+00	2.40E-02	7.9%
Particulate matter < 10 µm	50	24	2.46E+00	4.92E-02	2.81E+00	5.62E-02	18.5%
Ammonia	1290	24	8.10E+00	6.28E-03	8.33E+00	6.46E-03	2.1%
Arsenic & compounds	0.2	1	5.28E-03	2.64E-02	5.48E-03	2.74E-02	9.0%
Boron & compounds	300	24	3.19E-03	1.06E-05	3.28E-03	1.09E-05	0.0%
Cadmium & compounds	0.03	24	8.31E-05	2.77E-03	9.13E-05	3.04E-03	1.0%
Nickel & compounds	0.2	1	6.30E-03	3.15E-02	6.94E-03	3.47E-02	11.4%
Mercury & compounds	0.6	1	1.37E-02	2.29E-02	1.88E-02	3.13E-02	10.3%
Acetaldehyde	470	1	4.53E+00	9.64E-03	4.78E+00	1.02E-02	3.4%
Acetone	67414	24	2.75E+00	4.08E-05	3.12E+00	4.63E-05	0.0%
Benzene	27	1	7.55E-02	2.80E-03	9.10E-02	3.37E-03	1.1%
Methyl ethyl ketone	13000	1	1.75E+00	1.34E-04	1.96E+00	1.51E-04	0.0%
Ethylbenzene	23699	24	1.21E-03	5.12E-08	1.28E-03	5.40E-08	0.0%
Formaldehyde	53.6	24	4.18E-01	7.81E-03	5.30E-01	9.88E-03	3.3%
Styrene	260	24	2.40E-03	9.21E-06	3.01E-03	1.16E-05	0.0%
Toluene	4113	24	4.66E-02	1.13E-05	4.88E-02	1.19E-05	0.0%
Xylenes	1185	24	5.40E-03	4.55E-06	5.79E-03	4.88E-06	0.0%
Hazard index (total)			**-**	**0.258**	**-**	**0.304**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B3   Receptor 3 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI_{ACUTE}
Nitrogen dioxide	164	1	6.75E+00	4.12E-02	8.64E+00	5.27E-02	19.3%
Carbon monoxide	11250	8	1.53E+01	1.36E-03	2.53E+01	2.25E-03	0.8%
Sulfur dioxide	57.2	24	5.11E-01	8.94E-03	6.70E-01	1.17E-02	4.3%
Particulate matter < 10 µm	50	24	3.12E+00	6.24E-02	3.30E+00	6.60E-02	24.2%
Ammonia	1290	24	1.05E+01	8.11E-03	1.08E+01	8.38E-03	3.1%
Arsenic & compounds	0.2	1	1.21E-02	6.07E-02	1.29E-02	6.46E-02	23.7%
Boron & compounds	300	24	3.11E-03	1.04E-05	3.27E-03	1.09E-05	0.0%
Cadmium & compounds	0.03	24	8.90E-05	2.97E-03	9.29E-05	3.10E-03	1.1%
Nickel & compounds	0.2	1	5.40E-03	2.70E-02	5.74E-03	2.87E-02	10.5%
Mercury & compounds	0.6	1	1.13E-02	1.88E-02	1.18E-02	1.97E-02	7.2%
Acetaldehyde	470	1	3.49E+00	7.42E-03	3.66E+00	7.78E-03	2.9%
Acetone	67414	24	2.89E+00	4.29E-05	3.26E+00	4.83E-05	0.0%
Benzene	27	1	4.69E-02	1.74E-03	5.28E-02	1.95E-03	0.7%
Methyl ethyl ketone	13000	1	1.34E+00	1.03E-04	1.50E+00	1.15E-04	0.0%
Ethylbenzene	23699	24	1.41E-03	5.96E-08	1.41E-03	5.95E-08	0.0%
Formaldehyde	53.6	24	2.27E-01	4.24E-03	3.08E-01	5.74E-03	2.1%
Styrene	260	24	2.65E-03	1.02E-05	3.19E-03	1.23E-05	0.0%
Toluene	4113	24	5.48E-02	1.33E-05	5.60E-02	1.36E-05	0.0%
Xylenes	1185	24	6.09E-03	5.14E-06	6.20E-03	5.23E-06	0.0%
Hazard index (HI_{ACUTE}) (total)			**-**	**0.245**	**-**	**0.273**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B4   Receptor 4 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI_{ACUTE}
Nitrogen dioxide	164	1	9.85E+00	6.01E-02	1.30E+01	7.96E-02	20.2%
Carbon monoxide	11250	8	2.67E+01	2.37E-03	4.14E+01	3.68E-03	0.9%
Sulfur dioxide	57.2	24	6.99E-01	1.22E-02	9.23E-01	1.61E-02	4.1%
Particulate matter < 10 µm	50	24	4.64E+00	9.27E-02	5.03E+00	1.01E-01	25.6%
Ammonia	1290	24	1.79E+01	1.39E-02	1.87E+01	1.45E-02	3.7%
Arsenic & compounds	0.2	1	1.59E-02	7.97E-02	1.67E-02	8.34E-02	21.2%
Boron & compounds	300	24	4.57E-03	1.52E-05	4.95E-03	1.65E-05	0.0%
Cadmium & compounds	0.03	24	1.72E-04	5.73E-03	1.84E-04	6.13E-03	1.6%
Nickel & compounds	0.2	1	7.08E-03	3.54E-02	7.41E-03	3.71E-02	9.4%
Mercury & compounds	0.6	1	1.16E-02	1.94E-02	1.61E-02	2.69E-02	6.8%
Acetaldehyde	470	1	5.25E+00	1.12E-02	5.51E+00	1.17E-02	3.0%
Acetone	67414	24	4.81E+00	7.13E-05	5.28E+00	7.83E-05	0.0%
Benzene	27	1	6.30E-02	2.33E-03	7.73E-02	2.86E-03	0.7%
Methyl ethyl ketone	13000	1	2.16E+00	1.66E-04	2.34E+00	1.80E-04	0.0%
Ethylbenzene	23699	24	2.36E-03	9.94E-08	2.35E-03	9.93E-08	0.0%
Formaldehyde	53.6	24	3.82E-01	7.13E-03	5.54E-01	1.03E-02	2.6%
Styrene	260	24	4.43E-03	1.71E-05	5.19E-03	2.00E-05	0.0%
Toluene	4113	24	7.85E-02	1.91E-05	8.03E-02	1.95E-05	0.0%
Xylenes	1185	24	9.93E-03	8.38E-06	1.01E-02	8.55E-06	0.0%
Hazard index (HI_{ACUTE}) (total)			**-**	**0.342**	**-**	**0.393**	**100.0%**

* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.

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Table B5　　Receptor 5 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	6.39E+00	3.90E-02	8.16E+00	4.98E-02	21.4%
Carbon monoxide	11250	8	1.71E+01	1.52E-03	3.12E+01	2.77E-03	1.2%
Sulfur dioxide	57.2	24	4.16E-01	7.27E-03	6.28E-01	1.10E-02	4.7%
Particulate matter < 10 µm	50	24	2.30E+00	4.60E-02	2.65E+00	5.29E-02	22.7%
Ammonia	1290	24	1.01E+01	7.84E-03	1.05E+01	8.15E-03	3.5%
Arsenic & compounds	0.2	1	9.99E-03	4.99E-02	9.88E-03	4.94E-02	21.2%
Boron & compounds	300	24	2.32E-03	7.73E-06	2.49E-03	8.28E-06	0.0%
Cadmium & compounds	0.03	24	9.32E-05	3.11E-03	9.75E-05	3.25E-03	1.4%
Nickel & compounds	0.2	1	4.44E-03	2.22E-02	4.40E-03	2.20E-02	9.5%
Mercury & compounds	0.6	1	1.29E-02	2.15E-02	1.03E-02	1.72E-02	7.4%
Acetaldehyde	470	1	3.53E+00	7.52E-03	3.72E+00	7.91E-03	3.4%
Acetone	67414	24	2.83E+00	4.19E-05	3.17E+00	4.70E-05	0.0%
Benzene	27	1	4.67E-02	1.73E-03	5.11E-02	1.89E-03	0.8%
Methyl ethyl ketone	13000	1	1.43E+00	1.10E-04	1.55E+00	1.19E-04	0.1%
Ethylbenzene	23699	24	1.36E-03	5.76E-08	1.42E-03	5.98E-08	0.0%
Formaldehyde	53.6	24	2.35E-01	4.39E-03	3.44E-01	6.42E-03	2.8%
Styrene	260	24	2.83E-03	1.09E-05	3.24E-03	1.25E-05	0.0%
Toluene	4113	24	5.26E-02	1.28E-05	5.38E-02	1.31E-05	0.0%
Xylenes	1185	24	6.00E-03	5.07E-06	6.20E-03	5.23E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.212**	**-**	**0.233**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B6   Receptor 6 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	1.06E+01	6.48E-02	1.32E+01	8.05E-02	30.0%
Carbon monoxide	11250	8	3.25E+01	2.89E-03	4.28E+01	3.81E-03	1.4%
Sulfur dioxide	57.2	24	1.20E+00	2.09E-02	1.30E+00	2.27E-02	8.4%
Particulate matter < 10 µm	50	24	2.02E+00	4.05E-02	2.26E+00	4.52E-02	16.8%
Ammonia	1290	24	5.98E+00	4.63E-03	6.13E+00	4.75E-03	1.8%
Arsenic & compounds	0.2	1	5.57E-03	2.78E-02	5.87E-03	2.93E-02	10.9%
Boron & compounds	300	24	2.48E-03	8.27E-06	2.58E-03	8.61E-06	0.0%
Cadmium & compounds	0.03	24	5.95E-05	1.98E-03	6.41E-05	2.14E-03	0.8%
Nickel & compounds	0.2	1	5.78E-03	2.89E-02	5.96E-03	2.98E-02	11.1%
Mercury & compounds	0.6	1	1.12E-02	1.87E-02	1.83E-02	3.05E-02	11.3%
Acetaldehyde	470	1	3.33E+00	7.09E-03	3.56E+00	7.58E-03	2.8%
Acetone	67414	24	2.10E+00	3.12E-05	2.50E+00	3.70E-05	0.0%
Benzene	27	1	6.63E-02	2.45E-03	7.97E-02	2.95E-03	1.1%
Methyl ethyl ketone	13000	1	1.34E+00	1.03E-04	1.52E+00	1.17E-04	0.0%
Ethylbenzene	23699	24	8.88E-04	3.75E-08	9.12E-04	3.85E-08	0.0%
Formaldehyde	53.6	24	3.59E-01	6.71E-03	5.00E-01	9.32E-03	3.5%
Styrene	260	24	2.32E-03	8.93E-06	2.78E-03	1.07E-05	0.0%
Toluene	4113	24	3.07E-02	7.47E-06	3.18E-02	7.72E-06	0.0%
Xylenes	1185	24	3.54E-03	2.99E-06	3.85E-03	3.25E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.227**	**-**	**0.269**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B7   Receptor 7 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	4.82E+00	2.94E-02	6.24E+00	3.81E-02	4.5%
Carbon monoxide	11250	8	1.45E+01	1.29E-03	2.33E+01	2.07E-03	0.2%
Sulfur dioxide	57.2	24	4.47E-01	7.82E-03	5.76E-01	1.01E-02	1.2%
Particulate matter < 10 µm	50	24	1.68E+01	3.37E-01	1.62E+01	3.23E-01	38.6%
Ammonia	1290	24	2.56E+00	1.98E-03	2.61E+00	2.02E-03	0.2%
Arsenic & compounds	0.2	1	5.08E-02	2.54E-01	5.71E-02	2.86E-01	34.1%
Boron & compounds	300	24	1.75E-02	5.85E-05	1.68E-02	5.59E-05	0.0%
Cadmium & compounds	0.03	24	3.37E-04	1.12E-02	3.22E-04	1.07E-02	1.3%
Nickel & compounds	0.2	1	2.44E-02	1.22E-01	2.76E-02	1.38E-01	16.5%
Mercury & compounds	0.6	1	1.28E-02	2.14E-02	1.02E-02	1.70E-02	2.0%
Acetaldehyde	470	1	1.70E+00	3.62E-03	1.80E+00	3.84E-03	0.5%
Acetone	67414	24	9.06E-01	1.34E-05	1.01E+00	1.51E-05	0.0%
Benzene	27	1	3.47E-02	1.29E-03	4.23E-02	1.57E-03	0.2%
Methyl ethyl ketone	13000	1	6.32E-01	4.86E-05	7.21E-01	5.55E-05	0.0%
Ethylbenzene	23699	24	3.52E-04	1.48E-08	3.78E-04	1.60E-08	0.0%
Formaldehyde	53.6	24	1.89E-01	3.52E-03	2.63E-01	4.91E-03	0.6%
Styrene	260	24	1.12E-03	4.31E-06	1.28E-03	4.91E-06	0.0%
Toluene	4113	24	1.88E-02	4.56E-06	1.98E-02	4.82E-06	0.0%
Xylenes	1185	24	1.66E-03	1.40E-06	1.82E-03	1.53E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.794**	**-**	**0.837**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B8   Receptor 8 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	4.87E+00	2.97E-02	6.14E+00	3.74E-02	14.6%
Carbon monoxide	11250	8	1.12E+01	9.92E-04	1.63E+01	1.45E-03	0.6%
Sulfur dioxide	57.2	24	3.44E-01	6.02E-03	4.15E-01	7.26E-03	2.8%
Particulate matter < 10 µm	50	24	3.34E+00	6.67E-02	4.65E+00	9.31E-02	36.3%
Ammonia	1290	24	5.30E+00	4.11E-03	5.53E+00	4.29E-03	1.7%
Arsenic & compounds	0.2	1	8.53E-03	4.26E-02	1.10E-02	5.50E-02	21.4%
Boron & compounds	300	24	3.40E-03	1.13E-05	4.67E-03	1.56E-05	0.0%
Cadmium & compounds	0.03	24	8.99E-05	3.00E-03	1.09E-04	3.64E-03	1.4%
Nickel & compounds	0.2	1	4.26E-03	2.13E-02	4.95E-03	2.47E-02	9.7%
Mercury & compounds	0.6	1	1.70E-02	2.84E-02	1.16E-02	1.93E-02	7.5%
Acetaldehyde	470	1	2.28E+00	4.84E-03	2.44E+00	5.18E-03	2.0%
Acetone	67414	24	1.52E+00	2.25E-05	1.69E+00	2.51E-05	0.0%
Benzene	27	1	3.83E-02	1.42E-03	4.21E-02	1.56E-03	0.6%
Methyl ethyl ketone	13000	1	8.06E-01	6.20E-05	9.41E-01	7.24E-05	0.0%
Ethylbenzene	23699	24	6.84E-04	2.89E-08	6.83E-04	2.88E-08	0.0%
Formaldehyde	53.6	24	1.28E-01	2.38E-03	1.76E-01	3.28E-03	1.3%
Styrene	260	24	6.39E-04	2.46E-06	7.85E-04	3.02E-06	0.0%
Toluene	4113	24	3.42E-02	8.32E-06	3.45E-02	8.39E-06	0.0%
Xylenes	1185	24	3.69E-03	3.11E-06	3.78E-03	3.19E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.212**	**-**	**0.256**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B9   Receptor 9 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI_{ACUTE}
Nitrogen dioxide	164	1	6.58E+00	4.01E-02	7.75E+00	4.72E-02	15.2%
Carbon monoxide	11250	8	1.68E+01	1.49E-03	2.24E+01	1.99E-03	0.6%
Sulfur dioxide	57.2	24	4.72E-01	8.25E-03	5.41E-01	9.46E-03	3.1%
Particulate matter < 10 µm	50	24	4.81E+00	9.62E-02	5.03E+00	1.01E-01	32.5%
Ammonia	1290	24	1.02E+01	7.92E-03	1.07E+01	8.33E-03	2.7%
Arsenic & compounds	0.2	1	1.47E-02	7.35E-02	1.42E-02	7.10E-02	22.9%
Boron & compounds	300	24	4.79E-03	1.60E-05	4.94E-03	1.65E-05	0.0%
Cadmium & compounds	0.03	24	1.44E-04	4.81E-03	1.56E-04	5.18E-03	1.7%
Nickel & compounds	0.2	1	6.68E-03	3.34E-02	6.45E-03	3.22E-02	10.4%
Mercury & compounds	0.6	1	1.41E-02	2.35E-02	1.12E-02	1.86E-02	6.0%
Acetaldehyde	470	1	4.04E+00	8.60E-03	4.31E+00	9.16E-03	3.0%
Acetone	67414	24	2.87E+00	4.25E-05	3.26E+00	4.83E-05	0.0%
Benzene	27	1	5.96E-02	2.21E-03	6.08E-02	2.25E-03	0.7%
Methyl ethyl ketone	13000	1	1.28E+00	9.85E-05	1.45E+00	1.12E-04	0.0%
Ethylbenzene	23699	24	1.34E-03	5.66E-08	1.38E-03	5.81E-08	0.0%
Formaldehyde	53.6	24	1.42E-01	2.65E-03	1.94E-01	3.62E-03	1.2%
Styrene	260	24	1.04E-03	3.99E-06	1.24E-03	4.78E-06	0.0%
Toluene	4113	24	6.26E-02	1.52E-05	6.37E-02	1.55E-05	0.0%
Xylenes	1185	24	6.86E-03	5.79E-06	7.11E-03	6.00E-06	0.0%
Hazard index (HI_{ACUTE}) (total)			**-**	**0.303**	**-**	**0.310**	**100.0%**

* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.

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Table B10   Receptor 10 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	6.96E+00	4.25E-02	8.86E+00	5.41E-02	20.7%
Carbon monoxide	11250	8	1.97E+01	1.75E-03	2.58E+01	2.30E-03	0.9%
Sulfur dioxide	57.2	24	5.75E-01	1.01E-02	6.88E-01	1.20E-02	4.6%
Particulate matter < 10 µm	50	24	3.24E+00	6.48E-02	3.86E+00	7.73E-02	29.5%
Ammonia	1290	24	1.29E+01	9.98E-03	1.33E+01	1.03E-02	3.9%
Arsenic & compounds	0.2	1	8.50E-03	4.25E-02	8.45E-03	4.23E-02	16.1%
Boron & compounds	300	24	3.28E-03	1.09E-05	3.50E-03	1.17E-05	0.0%
Cadmium & compounds	0.03	24	1.31E-04	4.37E-03	1.38E-04	4.61E-03	1.8%
Nickel & compounds	0.2	1	4.46E-03	2.23E-02	4.72E-03	2.36E-02	9.0%
Mercury & compounds	0.6	1	1.16E-02	1.94E-02	1.09E-02	1.82E-02	6.9%
Acetaldehyde	470	1	4.3093	9.17E-03	4.58E+00	9.74E-03	3.7%
Acetone	67414	24	2.95E+00	4.37E-05	3.29E+00	4.88E-05	0.0%
Benzene	27	1	6.80E-02	2.52E-03	6.93E-02	2.57E-03	1.0%
Methyl ethyl ketone	13000	1	1.29E+00	9.93E-05	1.44E+00	1.11E-04	0.0%
Ethylbenzene	23699	24	1.71E-03	7.23E-08	1.73E-03	7.29E-08	0.0%
Formaldehyde	53.6	24	1.79E-01	3.34E-03	2.45E-01	4.56E-03	1.7%
Styrene	260	24	1.15E-03	4.43E-06	1.43E-03	5.51E-06	0.0%
Toluene	4113	24	5.92E-02	1.44E-05	6.03E-02	1.47E-05	0.0%
Xylenes	1185	24	7.48E-03	6.31E-06	7.71E-03	6.50E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.233**	**-**	**0.262**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B11   Receptor 11 - Acute risk profile

Substance	REL (μg/m^3)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (μg/m^3)	Hazard quotient	GLC* (μg/m^3)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	8.34E+00	5.09E-02	1.07E+01	6.53E-02	19.6%
Carbon monoxide	11250	8	2.65E+01	2.35E-03	3.57E+01	3.17E-03	1.0%
Sulfur dioxide	57.2	24	8.09E-01	1.41E-02	9.72E-01	1.70E-02	5.1%
Particulate matter < 10 μm	50	24	4.81E+00	9.63E-02	5.59E+00	1.12E-01	33.6%
Ammonia	1290	24	1.86E+01	1.44E-02	1.93E+01	1.50E-02	4.5%
Arsenic & compounds	0.2	1	7.49E-03	3.75E-02	7.84E-03	3.92E-02	11.8%
Boron & compounds	300	24	6.19E-03	2.06E-05	6.71E-03	2.24E-05	0.0%
Cadmium & compounds	0.03	24	1.80E-04	5.99E-03	1.88E-04	6.28E-03	1.9%
Nickel & compounds	0.2	1	5.01E-03	2.51E-02	5.20E-03	2.60E-02	7.8%
Mercury & compounds	0.6	1	1.50E-02	2.50E-02	1.51E-02	2.51E-02	7.6%
Acetaldehyde	470	1	6.21E+00	1.32E-02	6.55E+00	1.39E-02	4.2%
Acetone	67414	24	4.80E+00	7.13E-05	5.27E+00	7.82E-05	0.0%
Benzene	27	1	8.16E-02	3.02E-03	8.48E-02	3.14E-03	0.9%
Methyl ethyl ketone	13000	1	1.91E+00	1.47E-04	2.11E+00	1.62E-04	0.0%
Ethylbenzene	23699	24	2.49E-03	1.05E-07	2.58E-03	1.09E-07	0.0%
Formaldehyde	53.6	24	2.45E-01	4.58E-03	3.39E-01	6.32E-03	1.9%
Styrene	260	24	1.98E-03	7.62E-06	2.45E-03	9.41E-06	0.0%
Toluene	4113	24	9.17E-02	2.23E-05	9.31E-02	2.26E-05	0.0%
Xylenes	1185	24	1.11E-02	9.39E-06	1.16E-02	9.77E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.293**	**-**	**0.332**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B12   Receptor 13 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	5.88E+00	3.58E-02	7.84E+00	4.78E-02	34.4%
Carbon monoxide	11250	8	1.28E+01	1.13E-03	1.70E+01	1.51E-03	1.1%
Sulfur dioxide	57.2	24	3.96E-01	6.92E-03	4.78E-01	8.36E-03	6.0%
Particulate matter < 10 µm	50	24	1.19E+00	2.37E-02	1.30E+00	2.60E-02	18.7%
Ammonia	1290	24	3.08E+00	2.39E-03	3.24E+00	2.51E-03	1.8%
Arsenic & compounds	0.2	1	2.15E-03	1.08E-02	2.16E-03	1.08E-02	7.8%
Boron & compounds	300	24	1.66E-03	5.52E-06	1.70E-03	5.66E-06	0.0%
Cadmium & compounds	0.03	24	3.55E-05	1.18E-03	3.82E-05	1.27E-03	0.9%
Nickel & compounds	0.2	1	2.75E-03	1.37E-02	2.78E-03	1.39E-02	10.0%
Mercury & compounds	0.6	1	8.27E-03	1.38E-02	9.95E-03	1.66E-02	11.9%
Acetaldehyde	470	1	2.4069	5.12E-03	2.52E+00	5.37E-03	3.9%
Acetone	67414	24	8.43E-01	1.25E-05	9.51E-01	1.41E-05	0.0%
Benzene	27	1	5.11E-02	1.89E-03	5.36E-02	1.98E-03	1.4%
Methyl ethyl ketone	13000	1	7.28E-01	5.60E-05	7.69E-01	5.92E-05	0.0%
Ethylbenzene	23699	24	4.51E-04	1.90E-08	5.02E-04	2.12E-08	0.0%
Formaldehyde	53.6	24	1.10E-01	2.05E-03	1.46E-01	2.72E-03	2.0%
Styrene	260	24	6.12E-04	2.36E-06	6.91E-04	2.66E-06	0.0%
Toluene	4113	24	1.57E-02	3.83E-06	1.61E-02	3.92E-06	0.0%
Xylenes	1185	24	2.12E-03	1.79E-06	2.22E-03	1.87E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.119**	**-**	**0.139**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B13   Receptor 14 - Acute risk profile

Substance	REL ($\mu g/m^3$)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* ($\mu g/m^3$)	Hazard quotient	GLC* ($\mu g/m^3$)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	1.08E+01	6.60E-02	1.31E+01	8.00E-02	33.9%
Carbon monoxide	11250	8	2.34E+01	2.08E-03	3.18E+01	2.83E-03	1.2%
Sulfur dioxide	57.2	24	8.36E-01	1.46E-02	9.84E-01	1.72E-02	7.3%
Particulate matter < 10 μm	50	24	1.90E+00	3.79E-02	2.20E+00	4.40E-02	18.6%
Ammonia	1290	24	8.44E+00	6.54E-03	8.83E+00	6.85E-03	2.9%
Arsenic & compounds	0.2	1	2.68E-03	1.34E-02	2.90E-03	1.45E-02	6.1%
Boron & compounds	300	24	1.93E-03	6.42E-06	2.05E-03	6.84E-06	0.0%
Cadmium & compounds	0.03	24	7.41E-05	2.47E-03	7.89E-05	2.63E-03	1.1%
Nickel & compounds	0.2	1	5.31E-03	2.65E-02	5.38E-03	2.69E-02	11.4%
Mercury & compounds	0.6	1	1.01E-02	1.68E-02	1.28E-02	2.14E-02	9.0%
Acetaldehyde	470	1	4.8343	1.03E-02	5.39E+00	1.15E-02	4.9%
Acetone	67414	24	2.09E+00	3.10E-05	2.28E+00	3.38E-05	0.0%
Benzene	27	1	6.22E-02	2.30E-03	7.04E-02	2.61E-03	1.1%
Methyl ethyl ketone	13000	1	1.38E+00	1.06E-04	1.45E+00	1.12E-04	0.0%
Ethylbenzene	23699	24	1.21E-03	5.10E-08	1.31E-03	5.51E-08	0.0%
Formaldehyde	53.6	24	2.33E-01	4.34E-03	3.14E-01	5.85E-03	2.5%
Styrene	260	24	1.18E-03	4.53E-06	1.35E-03	5.21E-06	0.0%
Toluene	4113	24	4.17E-02	1.01E-05	4.33E-02	1.05E-05	0.0%
Xylenes	1185	24	5.52E-03	4.66E-06	5.88E-03	4.96E-06	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.203**	**-**	**0.236**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B14   Receptor 15 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI_ACUTE
Nitrogen dioxide	164	1	1.79E+01	1.09E-01	1.88E+01	1.15E-01	32.5%
Carbon monoxide	11250	8	3.69E+01	3.28E-03	5.13E+01	4.56E-03	1.3%
Sulfur dioxide	57.2	24	1.38E+00	2.41E-02	1.58E+00	2.77E-02	7.9%
Particulate matter < 10 µm	50	24	2.65E+00	5.30E-02	2.85E+00	5.70E-02	16.2%
Ammonia	1290	24	3.93E+00	3.04E-03	4.08E+00	3.16E-03	0.9%
Arsenic & compounds	0.2	1	6.98E-03	3.49E-02	7.61E-03	3.80E-02	10.8%
Boron & compounds	300	24	3.12E-03	1.04E-05	3.28E-03	1.09E-05	0.0%
Cadmium & compounds	0.03	24	7.91E-05	2.64E-03	8.58E-05	2.86E-03	0.8%
Nickel & compounds	0.2	1	1.01E-02	5.05E-02	1.08E-02	5.38E-02	15.2%
Mercury & compounds	0.6	1	1.30E-02	2.17E-02	1.94E-02	3.23E-02	9.2%
Acetaldehyde	470	1	2.2359	4.76E-03	2.54E+00	5.40E-03	1.5%
Acetone	67414	24	1.63E+00	2.42E-05	1.85E+00	2.75E-05	0.0%
Benzene	27	1	7.95E-02	2.94E-03	9.25E-02	3.42E-03	1.0%
Methyl ethyl ketone	13000	1	1.09E+00	8.41E-05	1.20E+00	9.23E-05	0.0%
Ethylbenzene	23699	24	6.61E-04	2.79E-08	7.91E-04	3.34E-08	0.0%
Formaldehyde	53.6	24	3.81E-01	7.10E-03	5.09E-01	9.51E-03	2.7%
Styrene	260	24	2.17E-03	8.33E-06	2.55E-03	9.83E-06	0.0%
Toluene	4113	24	2.01E-02	4.89E-06	2.23E-02	5.43E-06	0.0%
Xylenes	1185	24	2.77E-03	2.34E-06	3.48E-03	2.94E-06	0.0%
Hazard index (HI_ACUTE) (total)			**-**	**0.317**	**-**	**0.352**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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Table B15   Receptor 16 - Acute risk profile

Substance	REL (µg/m³)	Averaging period (h)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
			GLC* (µg/m³)	Hazard quotient	GLC* (µg/m³)	Hazard quotient	% of HI$_{ACUTE}$
Nitrogen dioxide	164	1	9.05E+00	5.52E-02	1.20E+01	7.34E-02	14.5%
Carbon monoxide	11250	8	3.08E+01	2.74E-03	5.21E+01	4.63E-03	0.9%
Sulfur dioxide	57.2	24	9.61E-01	1.68E-02	1.23E+00	2.14E-02	4.2%
Particulate matter < 10 µm	50	24	7.56E+00	1.51E-01	9.09E+00	1.82E-01	36.0%
Ammonia	1290	24	3.04E+01	2.36E-02	3.19E+01	2.47E-02	4.9%
Arsenic & compounds	0.2	1	1.48E-02	7.39E-02	1.48E-02	7.40E-02	14.6%
Boron & compounds	300	24	7.82E-03	2.61E-05	8.87E-03	2.96E-05	0.0%
Cadmium & compounds	0.03	24	3.32E-04	1.11E-02	3.54E-04	1.18E-02	2.3%
Nickel & compounds	0.2	1	8.22E-03	4.11E-02	8.32E-03	4.16E-02	8.2%
Mercury & compounds	0.6	1	2.82E-02	4.71E-02	2.22E-02	3.70E-02	7.3%
Acetaldehyde	470	1	8.8890	1.89E-02	9.56E+00	2.03E-02	4.0%
Acetone	67414	24	7.73E+00	1.15E-04	8.60E+00	1.28E-04	0.0%
Benzene	27	1	1.39E-01	5.14E-03	1.36E-01	5.05E-03	1.0%
Methyl ethyl ketone	13000	1	2.53E+00	1.95E-04	2.79E+00	2.15E-04	0.0%
Ethylbenzene	23699	24	3.95E-03	1.67E-07	4.03E-03	1.70E-07	0.0%
Formaldehyde	53.6	24	3.32E-01	6.19E-03	4.87E-01	9.09E-03	1.8%
Styrene	260	24	2.63E-03	1.01E-05	3.32E-03	1.28E-05	0.0%
Toluene	4113	24	1.60E-01	3.90E-05	1.64E-01	4.00E-05	0.0%
Xylenes	1185	24	1.98E-02	1.67E-05	2.07E-02	1.74E-05	0.0%
Hazard index (HI$_{ACUTE}$) (total)			**-**	**0.453**	**-**	**0.505**	**100.0%**
* 99.5th percentile concentration for 24-hour averaging periods; 99.9th percentile otherwise.							

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B2 CHRONIC RISK

Table B16   Receptor 1 – Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	1.52E-01	4.91E-03	1.53E-01	4.95E-03	6.9%
Sulfur dioxide	57	1.39E-02	2.44E-04	1.38E-02	2.43E-04	0.3%
Particulate matter < 10 µm	25	2.91E-01	1.16E-02	2.97E-01	1.19E-02	16.6%
Ammonia	76	4.99E-01	6.56E-03	1.81E-01	2.39E-03	3.3%
Arsenic & compounds	0.015	1.13E-04	7.52E-03	1.16E-04	7.76E-03	10.8%
Beryllium & compounds	0.007	9.82E-06	1.40E-03	8.79E-06	1.26E-03	1.7%
Cadmium & compounds	0.005	1.04E-05	2.08E-03	9.37E-06	1.87E-03	2.6%
Chromium (VI)	0.005	8.49E-06	1.70E-03	9.10E-06	1.82E-03	2.5%
Manganese & compounds	0.05	5.05E-04	1.01E-02	4.92E-04	9.84E-03	13.7%
Nickel & compounds	0.014	1.38E-04	9.83E-03	1.24E-04	8.83E-03	12.3%
Selenium & compounds	20	1.60E-04	8.00E-06	1.35E-04	6.75E-06	0.0%
Mercury & compounds	0.03	4.42E-04	1.47E-02	3.66E-04	1.22E-02	17.0%
Acetaldehyde	9	5.21E-02	5.79E-03	3.79E-02	4.21E-03	5.9%
Polycyclic aromatic hydrocarbons	0.0003	4.73E-07	1.58E-03	4.78E-07	1.59E-03	2.2%
Benzene	10	1.15E-03	1.15E-04	1.07E-03	1.07E-04	0.1%
Methyl ethyl ketone	5000	2.26E-02	4.52E-06	2.14E-02	4.28E-06	0.0%
Ethylbenzene	284	9.83E-05	3.46E-07	4.00E-05	1.41E-07	0.0%
Formaldehyde	9	2.39E-02	2.65E-03	2.57E-02	2.85E-03	4.0%
Styrene	900	1.39E-04	1.55E-07	1.39E-04	1.55E-07	0.0%
Toluene	411	2.07E-03	5.04E-06	1.37E-03	3.34E-06	0.0%
1,2,4-Trimethylbenzene	60	4.55E-04	7.59E-06	3.75E-04	6.25E-06	0.0%
1,3,5-Trimethylbenzene	60	2.04E-04	3.40E-06	9.55E-05	1.59E-06	0.0%
Xylenes	948	2.08E-04	2.20E-07	1.47E-04	1.55E-07	0.0%
Hazard index (HI$_{CHRONIC}$) (total)		-	**0.081**	-	**0.072**	**100.0%**

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Table B17　　Receptor 2 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of $HI_{CHRONIC}$
Nitrogen dioxide	31	1.69E-01	5.45E-03	1.69E-01	5.45E-03	11.2%
Sulfur dioxide	57	1.50E-02	2.63E-04	1.47E-02	2.59E-04	0.5%
Particulate matter < 10 µm	25	1.98E-01	7.91E-03	1.96E-01	7.82E-03	16.0%
Ammonia	76	2.36E-01	3.11E-03	9.58E-02	1.26E-03	2.6%
Arsenic & compounds	0.015	6.98E-05	4.65E-03	7.13E-05	4.75E-03	9.7%
Beryllium & compounds	0.007	6.78E-06	9.69E-04	6.15E-06	8.79E-04	1.8%
Cadmium & compounds	0.005	7.15E-06	1.43E-03	6.49E-06	1.30E-03	2.7%
Chromium (VI)	0.005	5.02E-06	1.00E-03	5.29E-06	1.06E-03	2.2%
Manganese & compounds	0.05	2.94E-04	5.87E-03	2.87E-04	5.73E-03	11.7%
Nickel & compounds	0.014	1.06E-04	7.57E-03	9.46E-05	6.76E-03	13.8%
Selenium & compounds	20	1.15E-04	5.76E-06	1.05E-04	5.26E-06	0.0%
Mercury & compounds	0.03	3.03E-04	1.01E-02	2.53E-04	8.43E-03	17.2%
Acetaldehyde	9	2.87E-02	3.19E-03	2.25E-02	2.50E-03	5.1%
Polycyclic aromatic hydrocarbons	0.0003	2.50E-07	8.34E-04	2.49E-07	8.30E-04	1.7%
Benzene	10	9.81E-04	9.81E-05	9.49E-04	9.49E-05	0.2%
Methyl ethyl ketone	5000	1.06E-02	2.12E-06	9.92E-03	1.98E-06	0.0%
Ethylbenzene	284	4.80E-05	1.69E-07	2.32E-05	8.16E-08	0.0%
Formaldehyde	9	1.47E-02	1.64E-03	1.57E-02	1.74E-03	3.6%
Styrene	900	6.92E-05	7.69E-08	6.83E-05	7.59E-08	0.0%
Toluene	411	1.08E-03	2.63E-06	7.87E-04	1.91E-06	0.0%
1,2,4-Trimethylbenzene	60	2.29E-04	3.81E-06	1.91E-04	3.18E-06	0.0%
1,3,5-Trimethylbenzene	60	9.55E-05	1.59E-06	4.71E-05	7.85E-07	0.0%
Xylenes	948	1.30E-04	1.37E-07	1.08E-04	1.14E-07	0.0%
Hazard index ($HI_{CHRONIC}$) (total)		**-**	**0.054**	**-**	**0.049**	**100.0%**

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Table B18   Receptor 3 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	4.42E-02	1.43E-03	4.63E-02	1.49E-03	3.1%
Sulfur dioxide	57	4.24E-03	7.44E-05	4.28E-03	7.52E-05	0.2%
Particulate matter < 10 µm	25	2.06E-01	8.23E-03	2.17E-01	8.69E-03	18.0%
Ammonia	76	2.95E-01	3.89E-03	1.00E-01	1.32E-03	2.7%
Arsenic & compounds	0.015	1.13E-04	7.52E-03	1.18E-04	7.89E-03	16.3%
Beryllium & compounds	0.007	6.68E-06	9.55E-04	6.29E-06	8.99E-04	1.9%
Cadmium & compounds	0.005	6.19E-06	1.24E-03	5.77E-06	1.15E-03	2.4%
Chromium (VI)	0.005	1.01E-05	2.01E-03	1.07E-05	2.15E-03	4.4%
Manganese & compounds	0.05	3.52E-04	7.04E-03	3.48E-04	6.95E-03	14.4%
Nickel & compounds	0.014	8.79E-05	6.28E-03	8.45E-05	6.04E-03	12.5%
Selenium & compounds	20	9.05E-05	4.53E-06	8.12E-05	4.06E-06	0.0%
Mercury & compounds	0.03	3.15E-04	1.05E-02	2.22E-04	7.40E-03	15.3%
Acetaldehyde	9	3.15E-02	3.50E-03	2.22E-02	2.46E-03	5.1%
Polycyclic aromatic hydrocarbons	0.0003	2.39E-07	7.97E-04	2.37E-07	7.90E-04	1.6%
Benzene	10	8.46E-04	8.46E-05	7.84E-04	7.84E-05	0.2%
Methyl ethyl ketone	5000	1.11E-02	2.21E-06	8.91E-03	1.78E-06	0.0%
Ethylbenzene	284	5.17E-05	1.82E-07	1.50E-05	5.27E-08	0.0%
Formaldehyde	9	8.32E-03	9.24E-04	8.65E-03	9.61E-04	2.0%
Styrene	900	4.25E-05	4.73E-08	3.98E-05	4.42E-08	0.0%
Toluene	411	1.33E-03	3.23E-06	8.86E-04	2.16E-06	0.0%
1,2,4-Trimethylbenzene	60	2.53E-04	4.21E-06	2.04E-04	3.40E-06	0.0%
1,3,5-Trimethylbenzene	60	1.16E-04	1.94E-06	5.01E-05	8.35E-07	0.0%
Xylenes	948	1.27E-04	1.34E-07	8.68E-05	9.15E-08	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	-	**0.054**		**-**	**0.048**	**100.0%**

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Table B19   Receptor 4 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	8.00E-02	2.58E-03	8.41E-02	2.71E-03	3.5%
Sulfur dioxide	57	7.72E-03	1.35E-04	7.72E-03	1.35E-04	0.2%
Particulate matter < 10 µm	25	3.50E-01	1.40E-02	3.65E-01	1.46E-02	18.7%
Ammonia	76	5.95E-01	7.83E-03	1.97E-01	2.59E-03	3.3%
Arsenic & compounds	0.015	1.63E-04	1.09E-02	1.67E-04	1.11E-02	14.3%
Beryllium & compounds	0.007	1.12E-05	1.60E-03	1.01E-05	1.45E-03	1.9%
Cadmium & compounds	0.005	1.09E-05	2.17E-03	9.79E-06	1.96E-03	2.5%
Chromium (VI)	0.005	1.39E-05	2.77E-03	1.45E-05	2.90E-03	3.7%
Manganese & compounds	0.05	6.08E-04	1.22E-02	5.86E-04	1.17E-02	15.0%
Nickel & compounds	0.014	1.47E-04	1.05E-02	1.37E-04	9.77E-03	12.5%
Selenium & compounds	20	1.51E-04	7.53E-06	1.28E-04	6.42E-06	0.0%
Mercury & compounds	0.03	4.57E-04	1.52E-02	3.49E-04	1.16E-02	14.9%
Acetaldehyde	9	5.76E-02	6.40E-03	3.90E-02	4.34E-03	5.6%
Polycyclic aromatic hydrocarbons	0.0003	3.99E-07	1.33E-03	3.93E-07	1.31E-03	1.7%
Benzene	10	1.12E-03	1.12E-04	1.02E-03	1.02E-04	0.1%
Methyl ethyl ketone	5000	2.06E-02	4.12E-06	1.56E-02	3.11E-06	0.0%
Ethylbenzene	284	1.03E-04	3.64E-07	2.87E-05	1.01E-07	0.0%
Formaldehyde	9	1.45E-02	1.61E-03	1.50E-02	1.67E-03	2.1%
Styrene	900	8.21E-05	9.12E-08	7.52E-05	8.36E-08	0.0%
Toluene	411	2.28E-03	5.54E-06	1.37E-03	3.33E-06	0.0%
1,2,4-Trimethylbenzene	60	5.05E-04	8.41E-06	4.02E-04	6.71E-06	0.0%
1,3,5-Trimethylbenzene	60	2.33E-04	3.88E-06	9.80E-05	1.63E-06	0.0%
Xylenes	948	2.22E-04	2.34E-07	1.41E-04	1.49E-07	0.0%
Hazard index (HI$_{CHRONIC}$) (total)		**-**	**0.089**	**-**	**0.078**	**100.0%**

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Table B20   Receptor 5 - Chronic risk profile

Substance	REL (µg/m^3)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m^3)	Hazard quotient	GLC (µg/m^3)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	4.02E-02	1.30E-03	4.36E-02	1.41E-03	2.9%
Sulfur dioxide	57	3.87E-03	6.79E-05	4.01E-03	7.04E-05	0.1%
Particulate matter < 10 µm	25	2.00E-01	7.98E-03	2.13E-01	8.54E-03	17.9%
Ammonia	76	3.00E-01	3.95E-03	9.99E-02	1.32E-03	2.8%
Arsenic & compounds	0.015	1.05E-04	7.03E-03	1.13E-04	7.53E-03	15.8%
Beryllium & compounds	0.007	6.34E-06	9.06E-04	6.01E-06	8.59E-04	1.8%
Cadmium & compounds	0.005	5.80E-06	1.16E-03	5.41E-06	1.08E-03	2.3%
Chromium (VI)	0.005	9.38E-06	1.88E-03	1.02E-05	2.05E-03	4.3%
Manganese & compounds	0.05	3.27E-04	6.54E-03	3.25E-04	6.49E-03	13.6%
Nickel & compounds	0.014	8.28E-05	5.91E-03	8.04E-05	5.74E-03	12.0%
Selenium & compounds	20	8.29E-05	4.15E-06	7.59E-05	3.80E-06	0.0%
Mercury & compounds	0.03	3.77E-04	1.26E-02	2.44E-04	8.14E-03	17.0%
Acetaldehyde	9	3.32E-02	3.69E-03	2.35E-02	2.62E-03	5.5%
Polycyclic aromatic hydrocarbons	0.0003	2.53E-07	8.44E-04	2.49E-07	8.31E-04	1.7%
Benzene	10	1.10E-03	1.10E-04	1.03E-03	1.03E-04	0.2%
Methyl ethyl ketone	5000	1.07E-02	2.14E-06	8.08E-03	1.62E-06	0.0%
Ethylbenzene	284	5.15E-05	1.81E-07	1.39E-05	4.91E-08	0.0%
Formaldehyde	9	8.90E-03	9.89E-04	9.15E-03	1.02E-03	2.1%
Styrene	900	4.15E-05	4.61E-08	3.81E-05	4.24E-08	0.0%
Toluene	411	1.43E-03	3.47E-06	9.75E-04	2.37E-06	0.0%
1,2,4-Trimethylbenzene	60	2.36E-04	3.94E-06	1.86E-04	3.10E-06	0.0%
1,3,5-Trimethylbenzene	60	1.12E-04	1.87E-06	4.43E-05	7.38E-07	0.0%
Xylenes	948	1.43E-04	1.50E-07	1.02E-04	1.08E-07	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	**-**		**0.055**	**-**	**0.048**	**100.0%**

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Table B21   Receptor 6 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	1.47E-01	4.75E-03	1.39E-01	4.48E-03	11.7%
Sulfur dioxide	57	1.29E-02	2.27E-04	1.22E-02	2.14E-04	0.6%
Particulate matter < 10 µm	25	1.53E-01	6.13E-03	1.50E-01	5.99E-03	15.7%
Ammonia	76	1.75E-01	2.30E-03	7.73E-02	1.02E-03	2.7%
Arsenic & compounds	0.015	5.78E-05	3.85E-03	5.91E-05	3.94E-03	10.3%
Beryllium & compounds	0.007	5.29E-06	7.55E-04	4.82E-06	6.89E-04	1.8%
Cadmium & compounds	0.005	5.54E-06	1.11E-03	4.98E-06	9.96E-04	2.6%
Chromium (VI)	0.005	4.20E-06	8.40E-04	4.44E-06	8.89E-04	2.3%
Manganese & compounds	0.05	2.12E-04	4.24E-03	2.10E-04	4.19E-03	11.0%
Nickel & compounds	0.014	8.37E-05	5.98E-03	7.36E-05	5.26E-03	13.7%
Selenium & compounds	20	9.28E-05	4.64E-06	8.56E-05	4.28E-06	0.0%
Mercury & compounds	0.03	2.30E-04	7.68E-03	1.92E-04	6.41E-03	16.8%
Acetaldehyde	9	2.11E-02	2.34E-03	1.67E-02	1.85E-03	4.9%
Polycyclic aromatic hydrocarbons	0.0003	2.00E-07	6.66E-04	2.00E-07	6.65E-04	1.7%
Benzene	10	8.05E-04	8.05E-05	7.57E-04	7.57E-05	0.2%
Methyl ethyl ketone	5000	7.27E-03	1.45E-06	6.55E-03	1.31E-06	0.0%
Ethylbenzene	284	3.49E-05	1.23E-07	1.77E-05	6.23E-08	0.0%
Formaldehyde	9	1.33E-02	1.48E-03	1.40E-02	1.56E-03	4.1%
Styrene	900	6.43E-05	7.14E-08	6.39E-05	7.11E-08	0.0%
Toluene	411	7.92E-04	1.93E-06	5.88E-04	1.43E-06	0.0%
1,2,4-Trimethylbenzene	60	1.53E-04	2.55E-06	1.27E-04	2.12E-06	0.0%
1,3,5-Trimethylbenzene	60	6.41E-05	1.07E-06	3.04E-05	5.06E-07	0.0%
Xylenes	948	1.01E-04	1.06E-07	8.50E-05	8.96E-08	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	**-**		**0.042**	**-**	**0.038**	**100.0%**

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Table B22   Receptor 7 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	5.38E-02	1.74E-03	5.46E-02	1.76E-03	0.9%
Sulfur dioxide	57	4.68E-03	8.22E-05	4.68E-03	8.21E-05	0.0%
Particulate matter < 10 µm	25	9.42E-01	3.77E-02	1.08E+00	4.34E-02	21.3%
Ammonia	76	1.22E-01	1.60E-03	4.64E-02	6.11E-04	0.3%
Arsenic & compounds	0.015	7.36E-04	4.91E-02	8.63E-04	5.75E-02	28.2%
Beryllium & compounds	0.007	2.89E-05	4.13E-03	3.31E-05	4.73E-03	2.3%
Cadmium & compounds	0.005	1.98E-05	3.96E-03	2.25E-05	4.49E-03	2.2%
Chromium (VI)	0.005	7.21E-05	1.44E-02	8.48E-05	1.70E-02	8.3%
Manganese & compounds	0.05	1.26E-03	2.53E-02	1.46E-03	2.91E-02	14.3%
Nickel & compounds	0.014	3.68E-04	2.63E-02	4.20E-04	3.00E-02	14.7%
Selenium & compounds	20	3.59E-04	1.80E-05	4.10E-04	2.05E-05	0.0%
Mercury & compounds	0.03	4.36E-04	1.45E-02	3.48E-04	1.16E-02	5.7%
Acetaldehyde	9	2.00E-02	2.22E-03	1.69E-02	1.88E-03	0.9%
Polycyclic aromatic hydrocarbons	0.0003	1.94E-07	6.47E-04	1.97E-07	6.57E-04	0.3%
Benzene	10	9.77E-04	9.77E-05	9.79E-04	9.79E-05	0.0%
Methyl ethyl ketone	5000	5.64E-03	1.13E-06	4.76E-03	9.51E-07	0.0%
Ethylbenzene	284	2.24E-05	7.87E-08	8.60E-06	3.03E-08	0.0%
Formaldehyde	9	8.47E-03	9.41E-04	8.63E-03	9.59E-04	0.5%
Styrene	900	2.64E-05	2.93E-08	2.51E-05	2.79E-08	0.0%
Toluene	411	1.29E-03	3.13E-06	1.19E-03	2.90E-06	0.0%
1,2,4-Trimethylbenzene	60	1.17E-04	1.95E-06	9.76E-05	1.63E-06	0.0%
1,3,5-Trimethylbenzene	60	4.80E-05	8.00E-07	2.22E-05	3.70E-07	0.0%
Xylenes	948	8.21E-05	8.66E-08	6.79E-05	7.16E-08	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	**-**	**0.183**		**-**	**0.204**	**100.0%**

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Table B23   Receptor 8 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of $HI_{CHRONIC}$
Nitrogen dioxide	31	3.54E-02	1.14E-03	3.61E-02	1.16E-03	0.6%
Sulfur dioxide	57	3.04E-03	5.33E-05	3.05E-03	5.35E-05	0.0%
Particulate matter < 10 µm	25	6.60E-01	2.64E-02	8.60E-01	3.44E-02	18.6%
Ammonia	76	2.25E-01	2.96E-03	8.11E-02	1.07E-03	0.6%
Arsenic & compounds	0.015	4.95E-04	3.30E-02	6.68E-04	4.45E-02	24.0%
Beryllium & compounds	0.007	2.03E-05	2.91E-03	2.61E-05	3.73E-03	2.0%
Cadmium & compounds	0.005	1.50E-05	2.99E-03	1.86E-05	3.71E-03	2.0%
Chromium (VI)	0.005	4.82E-05	9.64E-03	6.54E-05	1.31E-02	7.1%
Manganese & compounds	0.05	9.57E-04	1.91E-02	1.22E-03	2.43E-02	13.1%
Nickel & compounds	0.014	2.59E-04	1.85E-02	3.32E-04	2.37E-02	12.8%
Selenium & compounds	20	2.52E-04	1.26E-05	3.20E-04	1.60E-05	0.0%
Mercury & compounds	0.03	9.48E-04	3.16E-02	8.75E-04	2.92E-02	15.7%
Acetaldehyde	9	3.96E-02	4.40E-03	3.47E-02	3.86E-03	2.1%
Polycyclic aromatic hydrocarbons	0.0003	3.61E-07	1.20E-03	3.86E-07	1.29E-03	0.7%
Benzene	10	1.70E-03	1.70E-04	1.81E-03	1.81E-04	0.1%
Methyl ethyl ketone	5000	1.12E-02	2.23E-06	9.85E-03	1.97E-06	0.0%
Ethylbenzene	284	3.71E-05	1.31E-07	1.04E-05	3.65E-08	0.0%
Formaldehyde	9	1.06E-02	1.18E-03	1.10E-02	1.22E-03	0.7%
Styrene	900	2.12E-05	2.35E-08	1.82E-05	2.03E-08	0.0%
Toluene	411	3.13E-03	7.62E-06	3.18E-03	7.74E-06	0.0%
1,2,4-Trimethylbenzene	60	2.51E-04	4.18E-06	2.13E-04	3.55E-06	0.0%
1,3,5-Trimethylbenzene	60	9.41E-05	1.57E-06	4.58E-05	7.63E-07	0.0%
Xylenes	948	1.22E-04	1.29E-07	9.32E-05	9.83E-08	0.0%
Hazard index ($HI_{CHRONIC}$) (total)		**-**	**0.155**	**-**	**0.185**	**100.0%**

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Table B24   Receptor 9 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of $HI_{CHRONIC}$
Nitrogen dioxide	31	4.93E-02	1.59E-03	5.03E-02	1.62E-03	1.4%
Sulfur dioxide	57	4.42E-03	7.76E-05	4.44E-03	7.80E-05	0.1%
Particulate matter < 10 µm	25	6.14E-01	2.46E-02	6.78E-01	2.71E-02	22.6%
Ammonia	76	6.01E-01	7.90E-03	2.16E-01	2.84E-03	2.4%
Arsenic & compounds	0.015	2.52E-04	1.68E-02	2.80E-04	1.87E-02	15.6%
Beryllium & compounds	0.007	1.64E-05	2.34E-03	1.65E-05	2.36E-03	2.0%
Cadmium & compounds	0.005	1.45E-05	2.90E-03	1.41E-05	2.83E-03	2.4%
Chromium (VI)	0.005	2.15E-05	4.30E-03	2.42E-05	4.83E-03	4.0%
Manganese & compounds	0.05	9.07E-04	1.81E-02	9.27E-04	1.85E-02	15.5%
Nickel & compounds	0.014	2.13E-04	1.52E-02	2.20E-04	1.57E-02	13.1%
Selenium & compounds	20	1.78E-04	8.90E-06	1.69E-04	8.44E-06	0.0%
Mercury & compounds	0.03	7.23E-04	2.41E-02	5.17E-04	1.72E-02	14.4%
Acetaldehyde	9	6.86E-02	7.62E-03	5.08E-02	5.64E-03	4.7%
Polycyclic aromatic hydrocarbons	0.0003	4.29E-07	1.43E-03	4.21E-07	1.40E-03	1.2%
Benzene	10	1.38E-03	1.38E-04	1.25E-03	1.25E-04	0.1%
Methyl ethyl ketone	5000	2.15E-02	4.29E-06	1.65E-02	3.29E-06	0.0%
Ethylbenzene	284	9.28E-05	3.27E-07	2.15E-05	7.58E-08	0.0%
Formaldehyde	9	8.50E-03	9.44E-04	8.45E-03	9.39E-04	0.8%
Styrene	900	3.44E-05	3.82E-08	2.64E-05	2.93E-08	0.0%
Toluene	411	2.74E-03	6.67E-06	1.87E-03	4.56E-06	0.0%
1,2,4-Trimethylbenzene	60	6.75E-04	1.12E-05	5.75E-04	9.58E-06	0.0%
1,3,5-Trimethylbenzene	60	2.47E-04	4.11E-06	1.19E-04	1.98E-06	0.0%
Xylenes	948	2.63E-04	2.78E-07	1.84E-04	1.95E-07	0.0%
Hazard index ($HI_{CHRONIC}$) (total)		**-**	**0.128**	**-**	**0.120**	**100.0%**

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Table B25   **Receptor 10 - Chronic risk profile**

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	6.34E-02	2.04E-03	6.90E-02	2.23E-03	3.2%
Sulfur dioxide	57	6.14E-03	1.08E-04	6.44E-03	1.13E-04	0.2%
Particulate matter < 10 µm	25	3.49E-01	1.40E-02	3.75E-01	1.50E-02	21.7%
Ammonia	76	5.09E-01	6.70E-03	1.66E-01	2.18E-03	3.2%
Arsenic & compounds	0.015	1.27E-04	8.48E-03	1.35E-04	8.98E-03	13.0%
Beryllium & compounds	0.007	1.01E-05	1.44E-03	9.41E-06	1.34E-03	1.9%
Cadmium & compounds	0.005	9.13E-06	1.83E-03	8.45E-06	1.69E-03	2.4%
Chromium (VI)	0.005	1.01E-05	2.02E-03	1.09E-05	2.17E-03	3.1%
Manganese & compounds	0.05	5.18E-04	1.04E-02	5.13E-04	1.03E-02	14.8%
Nickel & compounds	0.014	1.33E-04	9.51E-03	1.29E-04	9.18E-03	13.2%
Selenium & compounds	20	1.24E-04	6.21E-06	1.09E-04	5.46E-06	0.0%
Mercury & compounds	0.03	4.06E-04	1.35E-02	3.07E-04	1.02E-02	14.8%
Acetaldehyde	9	5.28E-02	5.86E-03	3.60E-02	4.00E-03	5.8%
Polycyclic aromatic hydrocarbons	0.0003	2.84E-07	9.47E-04	2.82E-07	9.40E-04	1.4%
Benzene	10	1.17E-03	1.17E-04	1.07E-03	1.07E-04	0.2%
Methyl ethyl ketone	5000	1.64E-02	3.28E-06	1.24E-02	2.48E-06	0.0%
Ethylbenzene	284	8.74E-05	3.08E-07	2.28E-05	8.02E-08	0.0%
Formaldehyde	9	7.58E-03	8.42E-04	7.81E-03	8.67E-04	1.3%
Styrene	900	3.39E-05	3.77E-08	2.73E-05	3.04E-08	0.0%
Toluene	411	1.99E-03	4.84E-06	1.22E-03	2.96E-06	0.0%
1,2,4-Trimethylbenzene	60	4.22E-04	7.03E-06	3.41E-04	5.68E-06	0.0%
1,3,5-Trimethylbenzene	60	1.95E-04	3.24E-06	7.90E-05	1.32E-06	0.0%
Xylenes	948	2.11E-04	2.23E-07	1.41E-04	1.49E-07	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	-	**0.078**		-	**0.069**	**100.0%**

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Table B26   Receptor 11 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	1.03E-01	3.32E-03	1.11E-01	3.57E-03	2.6%
Sulfur dioxide	57	9.67E-03	1.70E-04	9.95E-03	1.75E-04	0.1%
Particulate matter < 10 µm	25	7.60E-01	3.04E-02	8.26E-01	3.30E-02	24.5%
Ammonia	76	1.12E+00	1.47E-02	3.55E-01	4.66E-03	3.5%
Arsenic & compounds	0.015	2.05E-04	1.37E-02	2.15E-04	1.44E-02	10.6%
Beryllium & compounds	0.007	2.03E-05	2.90E-03	1.89E-05	2.70E-03	2.0%
Cadmium & compounds	0.005	1.84E-05	3.68E-03	1.69E-05	3.37E-03	2.5%
Chromium (VI)	0.005	1.41E-05	2.82E-03	1.50E-05	3.00E-03	2.2%
Manganese & compounds	0.05	1.08E-03	2.16E-02	1.07E-03	2.13E-02	15.8%
Nickel & compounds	0.014	2.66E-04	1.90E-02	2.58E-04	1.84E-02	13.6%
Selenium & compounds	20	2.20E-04	1.10E-05	1.84E-04	9.19E-06	0.0%
Mercury & compounds	0.03	7.37E-04	2.46E-02	5.81E-04	1.94E-02	14.3%
Acetaldehyde	9	1.07E-01	1.19E-02	7.07E-02	7.86E-03	5.8%
Polycyclic aromatic hydrocarbons	0.0003	5.37E-07	1.79E-03	5.34E-07	1.78E-03	1.3%
Benzene	10	1.83E-03	1.83E-04	1.62E-03	1.62E-04	0.1%
Methyl ethyl ketone	5000	3.40E-02	6.81E-06	2.43E-02	4.87E-06	0.0%
Ethylbenzene	284	1.86E-04	6.56E-07	4.31E-05	1.52E-07	0.0%
Formaldehyde	9	1.15E-02	1.28E-03	1.18E-02	1.31E-03	1.0%
Styrene	900	6.02E-05	6.69E-08	4.51E-05	5.01E-08	0.0%
Toluene	411	3.93E-03	9.57E-06	2.22E-03	5.39E-06	0.0%
1,2,4-Trimethylbenzene	60	9.55E-04	1.59E-05	7.76E-04	1.29E-05	0.0%
1,3,5-Trimethylbenzene	60	4.32E-04	7.19E-06	1.77E-04	2.95E-06	0.0%
Xylenes	948	4.10E-04	4.33E-07	2.52E-04	2.66E-07	0.0%
Hazard index (HI$_{CHRONIC}$) (total)	-		**0.152**	-	**0.135**	**100.0%**

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Table B27   Receptor 13 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	5.01E-02	1.62E-03	5.13E-02	1.65E-03	7.7%
Sulfur dioxide	57	4.42E-03	7.76E-05	4.47E-03	7.85E-05	0.4%
Particulate matter < 10 µm	25	9.79E-02	3.91E-03	1.01E-01	4.04E-03	18.8%
Ammonia	76	1.14E-01	1.51E-03	4.50E-02	5.92E-04	2.8%
Arsenic & compounds	0.015	3.83E-05	2.55E-03	4.05E-05	2.70E-03	12.6%
Beryllium & compounds	0.007	3.01E-06	4.30E-04	2.84E-06	4.05E-04	1.9%
Cadmium & compounds	0.005	2.76E-06	5.52E-04	2.57E-06	5.15E-04	2.4%
Chromium (VI)	0.005	3.03E-06	6.07E-04	3.28E-06	6.56E-04	3.1%
Manganese & compounds	0.05	1.27E-04	2.54E-03	1.28E-04	2.56E-03	11.9%
Nickel & compounds	0.014	4.34E-05	3.10E-03	4.07E-05	2.91E-03	13.5%
Selenium & compounds	20	4.65E-05	2.32E-06	4.32E-05	2.16E-06	0.0%
Mercury & compounds	0.03	1.30E-04	4.32E-03	9.89E-05	3.30E-03	15.4%
Acetaldehyde	9	1.38E-02	1.53E-03	1.04E-02	1.15E-03	5.4%
Polycyclic aromatic hydrocarbons	0.0003	9.28E-08	3.09E-04	9.16E-08	3.05E-04	1.4%
Benzene	10	4.94E-04	4.94E-05	4.70E-04	4.70E-05	0.2%
Methyl ethyl ketone	5000	3.85E-03	7.69E-07	3.06E-03	6.12E-07	0.0%
Ethylbenzene	284	2.06E-05	7.24E-08	7.76E-06	2.73E-08	0.0%
Formaldehyde	9	4.72E-03	5.24E-04	4.92E-03	5.46E-04	2.5%
Styrene	900	1.93E-05	2.14E-08	1.82E-05	2.02E-08	0.0%
Toluene	411	5.10E-04	1.24E-06	3.57E-04	8.68E-07	0.0%
1,2,4-Trimethylbenzene	60	8.64E-05	1.44E-06	6.94E-05	1.16E-06	0.0%
1,3,5-Trimethylbenzene	60	3.98E-05	6.64E-07	1.58E-05	2.63E-07	0.0%
Xylenes	948	6.32E-05	6.66E-08	5.01E-05	5.28E-08	0.0%
Hazard index (HI$_{CHRONIC}$) (total)		**-**	**0.024**	**-**	**0.021**	**100.0%**

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Table B28   Receptor 14 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of HI$_{CHRONIC}$
Nitrogen dioxide	31	9.84E-02	3.18E-03	1.01E-01	3.25E-03	9.0%
Sulfur dioxide	57	8.40E-03	1.47E-04	8.50E-03	1.49E-04	0.4%
Particulate matter < 10 µm	25	1.71E-01	6.83E-03	1.75E-01	7.01E-03	19.5%
Ammonia	76	2.17E-01	2.86E-03	8.72E-02	1.15E-03	3.2%
Arsenic & compounds	0.015	4.77E-05	3.18E-03	5.00E-05	3.33E-03	9.3%
Beryllium & compounds	0.007	4.97E-06	7.11E-04	4.64E-06	6.62E-04	1.8%
Cadmium & compounds	0.005	4.97E-06	9.93E-04	4.59E-06	9.19E-04	2.6%
Chromium (VI)	0.005	3.18E-06	6.36E-04	3.43E-06	6.86E-04	1.9%
Manganese & compounds	0.05	2.26E-04	4.52E-03	2.25E-04	4.50E-03	12.5%
Nickel & compounds	0.014	7.40E-05	5.28E-03	6.89E-05	4.92E-03	13.7%
Selenium & compounds	20	7.40E-05	3.70E-06	6.76E-05	3.38E-06	0.0%
Mercury & compounds	0.03	2.03E-04	6.77E-03	1.73E-04	5.76E-03	16.0%
Acetaldehyde	9	2.48E-02	2.76E-03	1.88E-02	2.09E-03	5.8%
Polycyclic aromatic hydrocarbons	0.0003	1.50E-07	5.01E-04	1.49E-07	4.97E-04	1.4%
Benzene	10	6.44E-04	6.44E-05	6.09E-04	6.09E-05	0.2%
Methyl ethyl ketone	5000	7.12E-03	1.42E-06	5.59E-03	1.12E-06	0.0%
Ethylbenzene	284	3.72E-05	1.31E-07	1.36E-05	4.79E-08	0.0%
Formaldehyde	9	7.70E-03	8.56E-04	8.09E-03	8.98E-04	2.5%
Styrene	900	3.40E-05	3.78E-08	3.20E-05	3.56E-08	0.0%
Toluene	411	8.27E-04	2.01E-06	5.42E-04	1.32E-06	0.0%
1,2,4-Trimethylbenzene	60	1.96E-04	3.27E-06	1.63E-04	2.72E-06	0.0%
1,3,5-Trimethylbenzene	60	7.81E-05	1.30E-06	3.41E-05	5.69E-07	0.0%
Xylenes	948	1.03E-04	1.09E-07	7.86E-05	8.30E-08	0.0%
Hazard index (HI$_{CHRONIC}$) (total)		**-**	**0.039**	**-**	**0.036**	**100.0%**

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Table B29   Receptor 15 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of $HI_{CHRONIC}$
Nitrogen dioxide	31	1.92E-01	6.19E-03	1.97E-01	6.34E-03	15.9%
Sulfur dioxide	57	1.61E-02	2.82E-04	1.60E-02	2.81E-04	0.7%
Particulate matter < 10 µm	25	1.56E-01	6.25E-03	1.49E-01	5.97E-03	15.0%
Ammonia	76	1.18E-01	1.55E-03	5.85E-02	7.70E-04	1.9%
Arsenic & compounds	0.015	6.25E-05	4.16E-03	6.35E-05	4.23E-03	10.6%
Beryllium & compounds	0.007	5.62E-06	8.03E-04	5.13E-06	7.33E-04	1.8%
Cadmium & compounds	0.005	5.68E-06	1.14E-03	5.25E-06	1.05E-03	2.6%
Chromium (VI)	0.005	4.79E-06	9.58E-04	4.93E-06	9.86E-04	2.5%
Manganese & compounds	0.05	1.87E-04	3.74E-03	1.86E-04	3.71E-03	9.3%
Nickel & compounds	0.014	9.42E-05	6.73E-03	8.41E-05	6.01E-03	15.0%
Selenium & compounds	20	1.02E-04	5.10E-06	9.75E-05	4.88E-06	0.0%
Mercury & compounds	0.03	2.05E-04	6.85E-03	1.85E-04	6.16E-03	15.4%
Acetaldehyde	9	1.67E-02	1.86E-03	1.45E-02	1.61E-03	4.0%
Polycyclic aromatic hydrocarbons	0.0003	1.51E-07	5.02E-04	1.49E-07	4.96E-04	1.2%
Benzene	10	8.59E-04	8.59E-05	8.62E-04	8.62E-05	0.2%
Methyl ethyl ketone	5000	5.53E-03	1.11E-06	5.33E-03	1.07E-06	0.0%
Ethylbenzene	284	2.55E-05	8.98E-08	1.64E-05	5.78E-08	0.0%
Formaldehyde	9	1.27E-02	1.41E-03	1.34E-02	1.49E-03	3.7%
Styrene	900	5.29E-05	5.88E-08	5.25E-05	5.83E-08	0.0%
Toluene	411	5.84E-04	1.42E-06	4.71E-04	1.15E-06	0.0%
1,2,4-Trimethylbenzene	60	9.76E-05	1.63E-06	8.24E-05	1.37E-06	0.0%
1,3,5-Trimethylbenzene	60	3.93E-05	6.54E-07	1.87E-05	3.11E-07	0.0%
Xylenes	948	9.02E-05	9.51E-08	8.45E-05	8.92E-08	0.0%
Hazard index ($HI_{CHRONIC}$) (total)	**-**		**0.043**	**-**	**0.040**	**100.0%**

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Table B30   Receptor 16 - Chronic risk profile

Substance	REL (µg/m³)	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	Hazard quotient	GLC (µg/m³)	Hazard quotient	% of $HI_{CHRONIC}$
Nitrogen dioxide	31	1.47E-01	4.75E-03	1.46E-01	4.72E-03	1.7%
Sulfur dioxide	57	1.26E-02	2.20E-04	1.22E-02	2.14E-04	0.1%
Particulate matter < 10 µm	25	1.71E+00	6.85E-02	1.85E+00	7.41E-02	26.1%
Ammonia	76	1.85E+00	2.43E-02	6.84E-01	9.00E-03	3.2%
Arsenic & compounds	0.015	4.18E-04	2.78E-02	4.29E-04	2.86E-02	10.1%
Beryllium & compounds	0.007	4.08E-05	5.83E-03	3.91E-05	5.58E-03	2.0%
Cadmium & compounds	0.005	3.74E-05	7.48E-03	3.46E-05	6.93E-03	2.4%
Chromium (VI)	0.005	2.80E-05	5.61E-03	2.85E-05	5.70E-03	2.0%
Manganese & compounds	0.05	2.34E-03	4.67E-02	2.29E-03	4.58E-02	16.2%
Nickel & compounds	0.014	5.38E-04	3.84E-02	5.30E-04	3.79E-02	13.4%
Selenium & compounds	20	3.86E-04	1.93E-05	3.25E-04	1.62E-05	0.0%
Mercury & compounds	0.03	1.63E-03	5.44E-02	1.25E-03	4.15E-02	14.7%
Acetaldehyde	9	2.06E-01	2.29E-02	1.52E-01	1.69E-02	6.0%
Polycyclic aromatic hydrocarbons	0.0003	1.20E-06	3.99E-03	1.17E-06	3.88E-03	1.4%
Benzene	10	3.75E-03	3.75E-04	3.35E-03	3.35E-04	0.1%
Methyl ethyl ketone	5000	6.12E-02	1.22E-05	4.44E-02	8.87E-06	0.0%
Ethylbenzene	284	2.76E-04	9.73E-07	6.06E-05	2.13E-07	0.0%
Formaldehyde	9	1.86E-02	2.07E-03	1.85E-02	2.05E-03	0.7%
Styrene	900	9.09E-05	1.01E-07	6.56E-05	7.29E-08	0.0%
Toluene	411	7.24E-03	1.76E-05	4.59E-03	1.12E-05	0.0%
1,2,4-Trimethylbenzene	60	2.09E-03	3.48E-05	1.78E-03	2.96E-05	0.0%
1,3,5-Trimethylbenzene	60	7.46E-04	1.24E-05	3.56E-04	5.93E-06	0.0%
Xylenes	948	7.85E-04	8.28E-07	5.40E-04	5.70E-07	0.0%
Hazard index ($HI_{CHRONIC}$) (total)		**-**	**0.314**	**-**	**0.283**	**100.0%**

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B3 CARCINOGENIC RISK

Table B31   Receptor 1 – Carcinogenic risk profile

Substance	ICR $(\mu g/m^3)^{-1}$	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC $(\mu g/m^3)$	ICR increment	GLC $(\mu g/m^3)$	ICR increment	% of ICR_{TOTAL}
Arsenic & compounds	1.50E-03	1.13E-04	1.69E-07	1.16E-04	1.75E-07	31.4%
Beryllium & compounds	2.40E-03	9.82E-06	2.36E-08	8.79E-06	2.11E-08	3.8%
Cadmium & compounds	1.80E-03	1.04E-05	1.87E-08	9.37E-06	1.69E-08	3.0%
Chromium (VI)	1.20E-02	8.49E-06	1.02E-07	9.10E-06	1.09E-07	19.7%
Lead & compounds	1.20E-05	5.07E-04	6.08E-09	5.46E-04	6.56E-09	1.2%
Nickel & compounds	2.60E-04	1.38E-04	3.58E-08	1.24E-04	3.21E-08	5.8%
Acetaldehyde	9.00E-07	5.21E-02	4.69E-08	3.79E-02	3.41E-08	6.1%
Polycyclic aromatic hydrocarbons	6.00E-04	4.73E-07	2.84E-10	4.78E-07	2.87E-10	0.1%
Benzene	6.00E-06	1.15E-03	6.88E-09	1.07E-03	6.39E-09	1.2%
Ethylbenzene	2.50E-06	9.83E-05	2.46E-10	4.00E-05	1.00E-10	0.0%
Formaldehyde	6.00E-06	2.39E-02	1.43E-07	2.57E-02	1.54E-07	27.7%
Styrene	5.70E-07	1.39E-04	7.93E-11	1.39E-04	7.95E-11	0.0%
Cumulative ICR (ICR_{TOTAL}) (total)		-	**5.53E-07**	-	**5.55E-07**	**100.0%**

Table B32   Receptor 2 - Carcinogenic risk profile

Substance	ICR $(\mu g/m^3)^{-1}$	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC $(\mu g/m^3)$	ICR increment	GLC $(\mu g/m^3)$	ICR increment	% of ICR_{TOTAL}
Arsenic & compounds	1.50E-03	6.98E-05	1.05E-07	7.13E-05	1.07E-07	30.9%
Beryllium & compounds	2.40E-03	6.78E-06	1.63E-08	6.15E-06	1.48E-08	4.3%
Cadmium & compounds	1.80E-03	7.15E-06	1.29E-08	6.49E-06	1.17E-08	3.4%
Chromium (VI)	1.20E-02	5.02E-06	6.02E-08	5.29E-06	6.35E-08	18.3%
Lead & compounds	1.20E-05	3.26E-04	3.91E-09	3.45E-04	4.14E-09	1.2%
Nickel & compounds	2.60E-04	1.06E-04	2.75E-08	9.46E-05	2.46E-08	7.1%
Acetaldehyde	9.00E-07	2.87E-02	2.59E-08	2.25E-02	2.02E-08	5.9%
Polycyclic aromatic hydrocarbons	6.00E-04	2.50E-07	1.50E-10	2.49E-07	1.49E-10	0.0%
Benzene	6.00E-06	9.81E-04	5.88E-09	9.49E-04	5.70E-09	1.6%
Ethylbenzene	2.50E-06	4.80E-05	1.20E-10	2.32E-05	5.79E-11	0.0%
Formaldehyde	6.00E-06	1.47E-02	8.84E-08	1.57E-02	9.42E-08	27.2%
Styrene	5.70E-07	6.92E-05	3.94E-11	6.83E-05	3.90E-11	0.0%
Cumulative ICR (ICR_{TOTAL}) (total)		-	**3.46E-07**	-	**3.46E-07**	**100.0%**

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Table B33   Receptor 3 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	1.13E-04	1.69E-07	1.18E-04	1.78E-07	40.7%
Beryllium & compounds	2.40E-03	6.68E-06	1.60E-08	6.29E-06	1.51E-08	3.5%
Cadmium & compounds	1.80E-03	6.19E-06	1.11E-08	5.77E-06	1.04E-08	2.4%
Chromium (VI)	1.20E-02	1.01E-05	1.21E-07	1.07E-05	1.29E-07	29.5%
Lead & compounds	1.20E-05	4.59E-04	5.50E-09	4.93E-04	5.92E-09	1.4%
Nickel & compounds	2.60E-04	8.79E-05	2.29E-08	8.45E-05	2.20E-08	5.0%
Acetaldehyde	9.00E-07	3.15E-02	2.83E-08	2.22E-02	2.00E-08	4.6%
Polycyclic aromatic hydrocarbons	6.00E-04	2.39E-07	1.43E-10	2.37E-07	1.42E-10	0.0%
Benzene	6.00E-06	8.46E-04	5.07E-09	7.84E-04	4.70E-09	1.1%
Ethylbenzene	2.50E-06	5.17E-05	1.29E-10	1.50E-05	3.74E-11	0.0%
Formaldehyde	6.00E-06	8.32E-03	4.99E-08	8.65E-03	5.19E-08	11.9%
Styrene	5.70E-07	4.25E-05	2.42E-11	3.98E-05	2.27E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**4.29E-07**	**-**	**4.36E-07**	**100.0%**

Table B34   Receptor 4 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	1.63E-04	2.45E-07	1.67E-04	2.51E-07	39.0%
Beryllium & compounds	2.40E-03	1.12E-05	2.69E-08	1.01E-05	2.43E-08	3.8%
Cadmium & compounds	1.80E-03	1.09E-05	1.96E-08	9.79E-06	1.76E-08	2.7%
Chromium (VI)	1.20E-02	1.39E-05	1.66E-07	1.45E-05	1.74E-07	27.0%
Lead & compounds	1.20E-05	7.04E-04	8.45E-09	7.48E-04	8.98E-09	1.4%
Nickel & compounds	2.60E-04	1.47E-04	3.82E-08	1.37E-04	3.56E-08	5.5%
Acetaldehyde	9.00E-07	5.76E-02	5.19E-08	3.90E-02	3.51E-08	5.5%
Polycyclic aromatic hydrocarbons	6.00E-04	3.99E-07	2.39E-10	3.93E-07	2.36E-10	0.0%
Benzene	6.00E-06	1.12E-03	6.74E-09	1.02E-03	6.10E-09	0.9%
Ethylbenzene	2.50E-06	1.03E-04	2.59E-10	2.87E-05	7.18E-11	0.0%
Formaldehyde	6.00E-06	1.45E-02	8.70E-08	1.50E-02	9.03E-08	14.0%
Styrene	5.70E-07	8.21E-05	4.68E-11	7.52E-05	4.29E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**6.51E-07**	**-**	**6.43E-07**	**100.0%**

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Table B35   Receptor 5 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	1.05E-04	1.58E-07	1.13E-04	1.69E-07	39.8%
Beryllium & compounds	2.40E-03	6.34E-06	1.52E-08	6.01E-06	1.44E-08	3.4%
Cadmium & compounds	1.80E-03	5.80E-06	1.04E-08	5.41E-06	9.73E-09	2.3%
Chromium (VI)	1.20E-02	9.38E-06	1.13E-07	1.02E-05	1.23E-07	28.9%
Lead & compounds	1.20E-05	4.34E-04	5.21E-09	4.75E-04	5.70E-09	1.3%
Nickel & compounds	2.60E-04	8.28E-05	2.15E-08	8.04E-05	2.09E-08	4.9%
Acetaldehyde	9.00E-07	3.32E-02	2.99E-08	2.35E-02	2.12E-08	5.0%
Polycyclic aromatic hydrocarbons	6.00E-04	2.53E-07	1.52E-10	2.49E-07	1.50E-10	0.0%
Benzene	6.00E-06	1.10E-03	6.59E-09	1.03E-03	6.19E-09	1.5%
Ethylbenzene	2.50E-06	5.15E-05	1.29E-10	1.39E-05	3.49E-11	0.0%
Formaldehyde	6.00E-06	8.90E-03	5.34E-08	9.15E-03	5.49E-08	12.9%
Styrene	5.70E-07	4.15E-05	2.36E-11	3.81E-05	2.17E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**4.13E-07**	**-**	**4.25E-07**	**100.0%**

Table B36   Receptor 6 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	5.78E-05	8.67E-08	5.91E-05	8.86E-08	30.7%
Beryllium & compounds	2.40E-03	5.29E-06	1.27E-08	4.82E-06	1.16E-08	4.0%
Cadmium & compounds	1.80E-03	5.54E-06	9.97E-09	4.98E-06	8.96E-09	3.1%
Chromium (VI)	1.20E-02	4.20E-06	5.04E-08	4.44E-06	5.33E-08	18.5%
Lead & compounds	1.20E-05	2.55E-04	3.07E-09	2.69E-04	3.23E-09	1.1%
Nickel & compounds	2.60E-04	8.37E-05	2.18E-08	7.36E-05	1.91E-08	6.6%
Acetaldehyde	9.00E-07	2.11E-02	1.90E-08	1.67E-02	1.50E-08	5.2%
Polycyclic aromatic hydrocarbons	6.00E-04	2.00E-07	1.20E-10	2.00E-07	1.20E-10	0.0%
Benzene	6.00E-06	8.05E-04	4.83E-09	7.57E-04	4.54E-09	1.6%
Ethylbenzene	2.50E-06	3.49E-05	8.71E-11	1.77E-05	4.42E-11	0.0%
Formaldehyde	6.00E-06	1.33E-02	8.00E-08	1.40E-02	8.40E-08	29.1%
Styrene	5.70E-07	6.43E-05	3.66E-11	6.39E-05	3.64E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**2.89E-07**	**-**	**2.89E-07**	**100.0%**

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Table B37   Receptor 7 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	7.36E-04	1.10E-06	8.63E-04	1.29E-06	48.8%
Beryllium & compounds	2.40E-03	2.89E-05	6.93E-08	3.31E-05	7.95E-08	3.0%
Cadmium & compounds	1.80E-03	1.98E-05	3.56E-08	2.25E-05	4.04E-08	1.5%
Chromium (VI)	1.20E-02	7.21E-05	8.65E-07	8.48E-05	1.02E-06	38.4%
Lead & compounds	1.20E-05	2.76E-03	3.32E-08	3.23E-03	3.87E-08	1.5%
Nickel & compounds	2.60E-04	3.68E-04	9.56E-08	4.20E-04	1.09E-07	4.1%
Acetaldehyde	9.00E-07	2.00E-02	1.80E-08	1.69E-02	1.52E-08	0.6%
Polycyclic aromatic hydrocarbons	6.00E-04	1.94E-07	1.16E-10	1.97E-07	1.18E-10	0.0%
Benzene	6.00E-06	9.77E-04	5.86E-09	9.79E-04	5.87E-09	0.2%
Ethylbenzene	2.50E-06	2.24E-05	5.59E-11	8.60E-06	2.15E-11	0.0%
Formaldehyde	6.00E-06	8.47E-03	5.08E-08	8.63E-03	5.18E-08	2.0%
Styrene	5.70E-07	2.64E-05	1.51E-11	2.51E-05	1.43E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**2.28E-06**	**-**	**2.65E-06**	**100.0%**

Table B38   Receptor 8 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	4.95E-04	7.43E-07	6.68E-04	1.00E-06	47.5%
Beryllium & compounds	2.40E-03	2.03E-05	4.88E-08	2.61E-05	6.26E-08	3.0%
Cadmium & compounds	1.80E-03	1.50E-05	2.70E-08	1.86E-05	3.34E-08	1.6%
Chromium (VI)	1.20E-02	4.82E-05	5.78E-07	6.54E-05	7.85E-07	37.3%
Lead & compounds	1.20E-05	1.87E-03	2.24E-08	2.51E-03	3.01E-08	1.4%
Nickel & compounds	2.60E-04	2.59E-04	6.73E-08	3.32E-04	8.62E-08	4.1%
Acetaldehyde	9.00E-07	3.96E-02	3.57E-08	3.47E-02	3.12E-08	1.5%
Polycyclic aromatic hydrocarbons	6.00E-04	3.61E-07	2.17E-10	3.86E-07	2.32E-10	0.0%
Benzene	6.00E-06	1.70E-03	1.02E-08	1.81E-03	1.08E-08	0.5%
Ethylbenzene	2.50E-06	3.71E-05	9.28E-11	1.04E-05	2.59E-11	0.0%
Formaldehyde	6.00E-06	1.06E-02	6.35E-08	1.10E-02	6.58E-08	3.1%
Styrene	5.70E-07	2.12E-05	1.21E-11	1.82E-05	1.04E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**1.60E-06**	**-**	**2.11E-06**	**100.0%**

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Table B39   Receptor 9 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	2.52E-04	3.78E-07	2.80E-04	4.20E-07	44.1%
Beryllium & compounds	2.40E-03	1.64E-05	3.93E-08	1.65E-05	3.97E-08	4.2%
Cadmium & compounds	1.80E-03	1.45E-05	2.61E-08	1.41E-05	2.55E-08	2.7%
Chromium (VI)	1.20E-02	2.15E-05	2.58E-07	2.42E-05	2.90E-07	30.4%
Lead & compounds	1.20E-05	1.21E-03	1.46E-08	1.37E-03	1.65E-08	1.7%
Nickel & compounds	2.60E-04	2.13E-04	5.54E-08	2.20E-04	5.71E-08	6.0%
Acetaldehyde	9.00E-07	6.86E-02	6.17E-08	5.08E-02	4.57E-08	4.8%
Polycyclic aromatic hydrocarbons	6.00E-04	4.29E-07	2.58E-10	4.21E-07	2.53E-10	0.0%
Benzene	6.00E-06	1.38E-03	8.27E-09	1.25E-03	7.52E-09	0.8%
Ethylbenzene	2.50E-06	9.28E-05	2.32E-10	2.15E-05	5.38E-11	0.0%
Formaldehyde	6.00E-06	8.50E-03	5.10E-08	8.45E-03	5.07E-08	5.3%
Styrene	5.70E-07	3.44E-05	1.96E-11	2.64E-05	1.50E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**8.93E-07**	**-**	**9.53E-07**	**100.0%**

Table B40   Receptor 10 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	1.27E-04	1.91E-07	1.35E-04	2.02E-07	40.6%
Beryllium & compounds	2.40E-03	1.01E-05	2.41E-08	9.41E-06	2.26E-08	4.5%
Cadmium & compounds	1.80E-03	9.13E-06	1.64E-08	8.45E-06	1.52E-08	3.1%
Chromium (VI)	1.20E-02	1.01E-05	1.21E-07	1.09E-05	1.30E-07	26.2%
Lead & compounds	1.20E-05	6.43E-04	7.71E-09	7.05E-04	8.46E-09	1.7%
Nickel & compounds	2.60E-04	1.33E-04	3.46E-08	1.29E-04	3.34E-08	6.7%
Acetaldehyde	9.00E-07	5.28E-02	4.75E-08	3.60E-02	3.24E-08	6.5%
Polycyclic aromatic hydrocarbons	6.00E-04	2.84E-07	1.71E-10	2.82E-07	1.69E-10	0.0%
Benzene	6.00E-06	1.17E-03	7.02E-09	1.07E-03	6.42E-09	1.3%
Ethylbenzene	2.50E-06	8.74E-05	2.19E-10	2.28E-05	5.69E-11	0.0%
Formaldehyde	6.00E-06	7.58E-03	4.55E-08	7.81E-03	4.68E-08	9.4%
Styrene	5.70E-07	3.39E-05	1.93E-11	2.73E-05	1.56E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**4.96E-07**	**-**	**4.98E-07**	**100.0%**

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Table B41   Receptor 11 - Carcinogenic risk profile

Substance	ICR (μg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (μg/m³)	ICR increment	GLC (μg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	2.05E-04	3.07E-07	2.15E-04	3.23E-07	40.0%
Beryllium & compounds	2.40E-03	2.03E-05	4.87E-08	1.89E-05	4.53E-08	5.6%
Cadmium & compounds	1.80E-03	1.84E-05	3.31E-08	1.69E-05	3.04E-08	3.8%
Chromium (VI)	1.20E-02	1.41E-05	1.69E-07	1.50E-05	1.80E-07	22.3%
Lead & compounds	1.20E-05	1.27E-03	1.52E-08	1.40E-03	1.68E-08	2.1%
Nickel & compounds	2.60E-04	2.66E-04	6.93E-08	2.58E-04	6.70E-08	8.3%
Acetaldehyde	9.00E-07	1.07E-01	9.63E-08	7.07E-02	6.36E-08	7.9%
Polycyclic aromatic hydrocarbons	6.00E-04	5.37E-07	3.22E-10	5.34E-07	3.20E-10	0.0%
Benzene	6.00E-06	1.83E-03	1.10E-08	1.62E-03	9.71E-09	1.2%
Ethylbenzene	2.50E-06	1.86E-04	4.66E-10	4.31E-05	1.08E-10	0.0%
Formaldehyde	6.00E-06	1.15E-02	6.93E-08	1.18E-02	7.10E-08	8.8%
Styrene	5.70E-07	6.02E-05	3.43E-11	4.51E-05	2.57E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**8.21E-07**	**-**	**8.07E-07**	**100.0%**

Table B42   Receptor 13 - Carcinogenic risk profile

Substance	ICR (μg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (μg/m³)	ICR increment	GLC (μg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	3.83E-05	5.74E-08	4.05E-05	6.08E-08	36.6%
Beryllium & compounds	2.40E-03	3.01E-06	7.23E-09	2.84E-06	6.81E-09	4.1%
Cadmium & compounds	1.80E-03	2.76E-06	4.97E-09	2.57E-06	4.63E-09	2.8%
Chromium (VI)	1.20E-02	3.03E-06	3.64E-08	3.28E-06	3.94E-08	23.7%
Lead & compounds	1.20E-05	1.78E-04	2.13E-09	1.93E-04	2.31E-09	1.4%
Nickel & compounds	2.60E-04	4.34E-05	1.13E-08	4.07E-05	1.06E-08	6.4%
Acetaldehyde	9.00E-07	1.38E-02	1.24E-08	1.04E-02	9.33E-09	5.6%
Polycyclic aromatic hydrocarbons	6.00E-04	9.28E-08	5.57E-11	9.16E-08	5.49E-11	0.0%
Benzene	6.00E-06	4.94E-04	2.96E-09	4.70E-04	2.82E-09	1.7%
Ethylbenzene	2.50E-06	2.06E-05	5.14E-11	7.76E-06	1.94E-11	0.0%
Formaldehyde	6.00E-06	4.72E-03	2.83E-08	4.92E-03	2.95E-08	17.7%
Styrene	5.70E-07	1.93E-05	1.10E-11	1.82E-05	1.04E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**1.63E-07**	**-**	**1.66E-07**	**100.0%**

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Table B43   Receptor 14 - Carcinogenic risk profile

Substance	ICR (μg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (μg/m³)	ICR increment	GLC (μg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	4.77E-05	7.15E-08	5.00E-05	7.49E-08	33.1%
Beryllium & compounds	2.40E-03	4.97E-06	1.19E-08	4.64E-06	1.11E-08	4.9%
Cadmium & compounds	1.80E-03	4.97E-06	8.94E-09	4.59E-06	8.27E-09	3.7%
Chromium (VI)	1.20E-02	3.18E-06	3.81E-08	3.43E-06	4.12E-08	18.2%
Lead & compounds	1.20E-05	2.59E-04	3.11E-09	2.81E-04	3.38E-09	1.5%
Nickel & compounds	2.60E-04	7.40E-05	1.92E-08	6.89E-05	1.79E-08	7.9%
Acetaldehyde	9.00E-07	2.48E-02	2.24E-08	1.88E-02	1.70E-08	7.5%
Polycyclic aromatic hydrocarbons	6.00E-04	1.50E-07	9.01E-11	1.49E-07	8.94E-11	0.0%
Benzene	6.00E-06	6.44E-04	3.87E-09	6.09E-04	3.65E-09	1.6%
Ethylbenzene	2.50E-06	3.72E-05	9.29E-11	1.36E-05	3.40E-11	0.0%
Formaldehyde	6.00E-06	7.70E-03	4.62E-08	8.09E-03	4.85E-08	21.5%
Styrene	5.70E-07	3.40E-05	1.94E-11	3.20E-05	1.82E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**2.26E-07**	**-**	**2.26E-07**	**100.0%**

Table B44   Receptor 15 - Carcinogenic risk profile

Substance	ICR (μg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (μg/m³)	ICR increment	GLC (μg/m³)	ICR increment	% of ICR$_{TOTAL}$
Arsenic & compounds	1.50E-03	6.25E-05	9.37E-08	6.35E-05	9.52E-08	31.7%
Beryllium & compounds	2.40E-03	5.62E-06	1.35E-08	5.13E-06	1.23E-08	4.1%
Cadmium & compounds	1.80E-03	5.68E-06	1.02E-08	5.25E-06	9.44E-09	3.1%
Chromium (VI)	1.20E-02	4.79E-06	5.75E-08	4.93E-06	5.92E-08	19.7%
Lead & compounds	1.20E-05	2.70E-04	3.23E-09	2.79E-04	3.35E-09	1.1%
Nickel & compounds	2.60E-04	9.42E-05	2.45E-08	8.41E-05	2.19E-08	7.3%
Acetaldehyde	9.00E-07	1.67E-02	1.51E-08	1.45E-02	1.30E-08	4.3%
Polycyclic aromatic hydrocarbons	6.00E-04	1.51E-07	9.04E-11	1.49E-07	8.93E-11	0.0%
Benzene	6.00E-06	8.59E-04	5.15E-09	8.62E-04	5.17E-09	1.7%
Ethylbenzene	2.50E-06	2.55E-05	6.37E-11	1.64E-05	4.11E-11	0.0%
Formaldehyde	6.00E-06	1.27E-02	7.62E-08	1.34E-02	8.05E-08	26.8%
Styrene	5.70E-07	5.29E-05	3.01E-11	5.25E-05	2.99E-11	0.0%
Cumulative ICR (ICR$_{TOTAL}$) (total)		**-**	**2.99E-07**	**-**	**3.00E-07**	**100.0%**

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Table B45   Receptor 16 - Carcinogenic risk profile

Substance	ICR (µg/m³)⁻¹	Base Case (2.85Mtpa)		Expansion Case (3.3Mtpa)		
		GLC (µg/m³)	ICR increment	GLC (µg/m³)	ICR increment	% of ICR_{TOTAL}
Arsenic & compounds	1.50E-03	4.18E-04	6.27E-07	4.29E-04	6.44E-07	40.6%
Beryllium & compounds	2.40E-03	4.08E-05	9.80E-08	3.91E-05	9.38E-08	5.9%
Cadmium & compounds	1.80E-03	3.74E-05	6.73E-08	3.46E-05	6.23E-08	3.9%
Chromium (VI)	1.20E-02	2.80E-05	3.36E-07	2.85E-05	3.42E-07	21.6%
Lead & compounds	1.20E-05	2.75E-03	3.30E-08	3.01E-03	3.61E-08	2.3%
Nickel & compounds	2.60E-04	5.38E-04	1.40E-07	5.30E-04	1.38E-07	8.7%
Acetaldehyde	9.00E-07	2.06E-01	1.85E-07	1.52E-01	1.37E-07	8.6%
Polycyclic aromatic hydrocarbons	6.00E-04	1.20E-06	7.18E-10	1.17E-06	6.99E-10	0.0%
Benzene	6.00E-06	3.75E-03	2.25E-08	3.35E-03	2.01E-08	1.3%
Ethylbenzene	2.50E-06	2.76E-04	6.91E-10	6.06E-05	1.51E-10	0.0%
Formaldehyde	6.00E-06	1.86E-02	1.12E-07	1.85E-02	1.11E-07	7.0%
Styrene	5.70E-07	9.09E-05	5.18E-11	6.56E-05	3.74E-11	0.0%
Cumulative ICR (ICR_{TOTAL}) (total)		**-**	**1.62E-06**	**-**	**1.59E-06**	**100.0%**

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