APPENDIX 4: SPECIALIST STUDIES

APPENDIX 4.1 AIR QUALITY IMPACT ASSESSMENT

AIR QUALITY IMPACT ASSESSMENT

PROPOSED CHROME TANNING SALTS AND VITAMIN K COMPOUNDS PRODUCTION FACILITY

FOR

BROTHER CISA, NEWCASTLE, KWAZULU-NATAL

15 September 2020

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AIR QUALITY IMPACT ASSESSMENT REPORT

PROPOSED CHROME TANNING SALTS AND VITAMIN K COMPOUNDS PRODUCTION FACILITY
BROTHER CISA, NEWCASTLE, KWAZULU-NATAL

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15 September 2020

EXECUTIVE SUMMARY

BACKGROUND

EScience Associates (Pty) Ltd was appointed by Brother CISA (Pty) Ltd to undertake an air quality impact assessment to assess the impact of the proposed expansion of its existing product range at its Newcastle plant in KwaZulu Natal.

Brother CISA proposes to establish an inorganic and an organic process producing 50 000 t/a and 30 000 t/a of chrome tanning salts (CTS) respectively, as well as production of 2 000 t/a of synthetic vitamin K compounds.

The Brother CISA chrome chemicals facility in Newcastle is situated within the Newcastle Chemicals Park. The plant produces Sodium Dichromate Crystals, Sodium Dichromate (SDC) Solution, and Chromic Acid Crystals.

GN 893:2013 gazetted in terms of Section 21 of the National Environmental Management: Air Quality Act (Act 39 of 2004), is a list of activities which result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage. The proposed activities trigger the following listed activities in terms of GN 893:2013, as amended:

- Category 7: Inorganic Chemicals Industry, Subcategory 7.2 Production of Acids.
- Category 7: Inorganic Chemicals Industry, Subcategory 7.4 Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat

STUDY METHODOLOGY

A best practice approach utilising computerised numerical dispersion modelling techniques to predict the maximum ground level pollutant concentrations was used. In this respect, an assessment of the temporal and spatial distributions of ground level pollutant concentrations was undertaken through the following process:

- A review of international and South African ambient air quality standards and guidelines as well as international risk factors for pollutants of concern against which the predicted impact of the process was evaluated;
- Sourcing meteorological data from surrounding South African Weather Service stations, processing meteorological data into a format suitable for meso-scale modelling inputting and providing a description of the climate and atmospheric conditions impacting on the atmospheric dispersion potential proximal to the site;
- Compilation of an emissions inventory for the proposed expansion.
- Dispersion modelling and compilation of isopleth maps indicating predicted ground level concentrations of expected pollutants according to the applicable averaging periods and frequency of exceedance where relevant; The U.S. EPA approved California Puff (CALPUFF) dispersion modelling suite was employed.
- Air quality impact assessment including a comparison of predicted concentrations with national legal requirements and National Ambient Air Quality Standards (NAAQS) and international guidelines where relevant.

RESULTS AND CONCLUSIONS

The emissions quantification and subsequent prediction of ambient impact have been undertaken with conservativeness, with the effect that the modelled outcomes relating to emissions from the site are expected to be over-predictions. The modelling further does not account for wet deposition of the pollutants, thus further over-predicting atmospheric concentrations.

Three scenarios were modelled:

i. Scenario 1 – All proposed sources modelled at the minimum emission standards (i.e. maximum allowable emission concentrations) for the applicable regulated emissions per source as stipulated by Subcategory 7.2 and Subcategory 7.4 in GN893:2013, as amended.
ii. Scenario 2 - All current sources modelled at the measured emission rates as per the stack test reports.
iii. Scenario 3 - All proposed sources modelled at the minimum emission standards (i.e. maximum allowable emission concentrations) and all current sources modelled at the measured emission rates as per the stack test reports

SCENARIO 1: PROPOSED EMISSIONS MODELLED AT MAXIMUM ALLOWABLE EMISSIONS RATES

It is important to note that this scenario evaluates the potential impact of Brother CISA operating all its' proposed sources at the maximum allowable emissions rates on a continuous basis of 24h a day for 365 a year. This is in fact an exaggeration of the actual emissions as the sources do not have 100% uptime, and actual emissions vary. However, it demonstrates the worst case permitted emissions scenario and gives insight into the worst case impact that would occur if the site operated at the very limit of compliance with the emissions regulations.

PARTICULATE MATTER

PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the proposed operations are well within the regulatory South African 24-hour ambient air quality limit, 75 µg/m³.

PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the proposed operations are well within the regulatory South African annual ambient air quality limit, 40 µg/m³.

$PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the proposed operations are well within the regulatory South African 24-hour ambient air quality limit, 40 µg/m³.

$PM_{2.5}$ - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the proposed operations are well within the regulatory South African annual ambient air quality limit, 20 µg/m³.

SULPHUR DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations exceed the 1-hour limit, 350 µg/m³. The frequency of exceedance is however well within the regulatory maximum allowable number of exceedances per year. It is also notable that these exceedances occur within the industrial park within which occupational rather than environmental air quality limits apply.

24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

NITROGEN DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of NO_2 from the proposed operations are within the annual limit, 40 µg/m³.

HEXAVALENT CHROMIUM

1-HOUR

The maximum predicted ambient concentration from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m³ and 4.5 µg/m³, respectively.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer for a small area within the Newcastle Chemicals Complex is 1 in 100 000. Extending over the immediate surrounds of the site there is a lifetime carcinogenic risk in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000.

SULPHURIC ACID

1-HOUR

There is no Ambient Air Quality Standard set for Sulphuric Acid in South Africa. The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m^3 and 120 µg/m^3 respectively.

24-HOUR

Predicted maximum 24-h ambient concentrations from the operations are within the Ontario state limit of 5 µg/m^3.

ANNUAL

Predicted maximum ambient concentrations of H_2SO_4 from the operations are within the Michigan state limit of 1 µg/m^3 and the Massachusetts state limit of 2.72 µg/m^3.

SCENARIO 2: MODELLED AT MEASURED CURRENT EMISSIONS RATES

PARTICULATE MATTER

PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the 24-hour limit, 75 µg/m^3.

PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the annual ambient air quality limit, 40 µg/m^3.

$PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the 24-hour limit, 40 µg/m^3.

$PM_{2.5}$ - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the annual ambient air quality limit, 20 µg/m^3.

SULPHUR DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 1-hour limit, 350 µg/m^3.

24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m^3.

ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

NITROGEN DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of NO_2 from the operations are within the annual limit, 40 µg/m³.

HEXAVALENT CHROMIUM

1-HOUR

The maximum predicted ambient concentration from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m³ and 4.5 µg/m³, respectively.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum emissions from the existing plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, for a small area within site is 1:50 000. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. A small part of the Arbour Park residential area is exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk in the order of 1 in 1000 000.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The Predicted lifetime carcinogenic risk resulting from the maximum emissions from the existing plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000.

SCENARIO 3: CUMULATIVE EMISSIONS IMPACT

PARTICULATE MATTER

PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the 24-hour limit, 75 µg/m³.

PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the annual ambient air quality limit, 40 µg/m³.

$PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the 24-hour limit, 40 µg/m³.

PM2.5 - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the annual ambient air quality limit, 20 µg/m³.

SULPHUR DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations exceed the 1-hour limit, 350 µg/m³, however the predicted exceedances are all within the industrial boundary. The frequency of exceedance is well within the maximum allowable number of exceedances per year.

24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

NITROGEN DIOXIDE

1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of NO_2 from the operations are within the annual limit, 40 µg/m³.

HEXAVALENT CHROMIUM

1-HOUR

The maximum predicted ambient concentration from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m³ and 4.5 µg/m³, respectively.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, for a small area within site is 1:50 000. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. The Arbour Park residential area is predicted to be exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk in the order of 1 in1000 000. Considering that no receptors beyond the boundaries of the Newcastle

Chemicals Complex are predicted to experience lifetime carcinogenic risk greater than 1 in 500 000, the risk is considered acceptable.

PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The Predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in1000 000. Considering that no receptors beyond the boundaries of the Newcastle Chemicals Complex are predicted to experience lifetime carcinogenic risk greater than 1 in 500 000, the risk is considered acceptable.

SULPHURIC ACID

1-HOUR

There is no Ambient Air Quality Standard set for Sulphuric Acid in South Africa. The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m³ and 120 µg/m³ respectively.

24-HOUR

Predicted maximum 24-h ambient concentrations from the operations are within the Ontario state limit of 5 µg/m³.

ANNUAL

Predicted maximum ambient concentrations of H_2SO_4 from the operations are within the Michigan state limit of 1 µg/m³ and the Massachusetts state limit of 2.72 µg/m³.

RECOMMENDATIONS

In cognisance of the findings of the assessment, and provided that the proposed plant will meet the emissions limits stipulated, it is recommended that the proposed activities be authorised.

Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, it is recommended that Cr(VI) emissions limits as shown in the table below be applied to stacks where Cr(VI) emissions are anticipated.

Recommended Cr(VI) emissions limits

Point Source	Proposed Cr(VI) emissions limits (mg/Nm³)
CTS1 - CTS Organic Stack 1	0.035
CTS2 - CTS Organic Stack 2	0.035
CTS13 - CTS Organic Stack 13	0.035
CTS14 - CTS Organic Stack 14	0.035
CTS17 – CTS Inorganic Stack 1	0.01

These recommended limits are based on the following factors:

- These emissions limits result in acceptable Cr(VI) ambient concentrations as shown in sections 10.2.4.6 and 14.4.4
- These concentrations are considered achievable through the use of proposed emissions abatement technology;
- The recommended limits are more stringent than the German Technical Instructions on Air Quality Control (TA Luft) limit of 0.05 mg/Nm^3, which may be considered for reference purposes in the absence of a legislated South African emission limit.

It is recommended that the listed point source emissions be monitored in accordance with the stipulations of GN 893 of 2015 as amended, at least once per annum.

GLOSSARY

Glossary of Key Terms (adapted from NEMA, NEMAQA, and the US EPA (http://www.epa.gov/ttn/atw/nata/gloss1.html)

Ambient air:

In this assessment, ambient air refers to the air surrounding a person through which pollutants can be carried. This excludes air regulated in terms of the Occupational Health and Safety Act (No. 85 of 1993).

Background concentrations:

"Background concentrations" means the contributions to pollutant concentrations in ambient air resulting from sources other than the activities of concern.

Dispersion model:

A dispersion model is a computerised set of mathematical equations that uses emissions and meteorological information to simulate the behaviour and movement of air pollutants in the atmosphere. The results of a dispersion model are estimated ambient concentrations of individual air pollutants at specified locations.

Emission:

"Atmospheric emission" or "emission" means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution;

Frequency of Exceedance (FoE)

"Frequency of exceedance" means a frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value at a specific monitoring station, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard. This exceedance is applicable to a calendar year.

Inhalation:

Breathing. Once inhaled, contaminants can be deposited in the lungs, assimilated into the blood, or both.

Limit Value or Ambient Air Quality Limit

"Limit value" means a level fixed on the basis of scientific knowledge, with the aim of reducing harmful effects on human health (or the environment (or both)), to be attained within a given compliance period and not to be exceeded once attained.[1]

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[1] As per Section 1 of GN 1210:2009 – National Ambient Air Quality Standards, gazetted in terms of Section 9(1) of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004).

ABBREVIATIONS & ACRONYMS

AAL	Allowable Ambient Limit
ACGIH	American Conference of Governmental Industrial Hygienists
AEL	Atmospheric Emissions Licence
AGC	Ambient Guideline Concentration
AIR	Atmospheric Impact Report
Am^3/hr	Actual cubic metre per hour
AQIA	Air Quality Impact Assessment (or Air Pollution Impact Assessment)
B/F	Bag filter
CA or Cr_2O_7	Chromic Acid
CBD	Central Business District
CEPA	Canadian Environmental Protection Agency
Co_2	Carbon Dioxide
Cr	Chromium
Cr(VI) or Cr^{6+}	Hexavalent Chromium
DEC	Department of Environmental Conservation
DENR	Department of Environment and Natural Resources
DEFF	Department of Environment Forestry and Fisheries
DEP	Department of Environmental Protection
DEQ	Department of Environmental Quality
EIA	Environmental Impact Assessment
ESL	Effects Screening Level
ESP	Electrostatic Precipitator
EU	European Union
$FeCl_2$	Ferrous Chloride
FoE	Frequency of Exceedance
GN	Government Notice
GJ	Giga-Joule
H_2SO_4	Sulphuric Acid
hPa	Hecta Pascals
hr	Hour
IRIS	Integrated Risk Information System
IRSL	Initial Risk Screening Level
ITSL	Initial Threshold Screening Level
IUR	Inhalation Unit Risk
kPa	Kilopascals
magl	Metres above ground level
mamsl	Metres above mean sea level
MES	Minimum Emission Standards
MENV	Quebec Ministry of the Environment
mg/m^3	milligram per cubic metre
MOE	Ontario Ministry of Environment

MPC	Maximum Permissible Concentration
MW	Mega Watt
NAAQS	National Ambient Air Quality Standards
NaOH	Sodium Hydroxide
NEMA	National Environmental Management Act, № 107 OF 1998
NEMAQA	National Environment Management: Air Quality Act, № 39 Of 2004
NIOSH	National Institute for Occupational Safety and Health
Nm^3/hr	Normalised cubic metre per hour (273K, 101.3 kPa)
NO_2	Nitrogen Dioxide
O_2	Oxygen
OEHHA	Office of Environmental Health Hazard Assessment (California EPA)
REL	Reference Exposure Limit
RfC	Reference Concentration
SAWS	South African Weather Service
SDC/$Na_2Cr_2O_7$	Sodium Dichromate
SMC	Sodium Monochromate
SO_2	Sulphur Dioxide
SRSL	Secondary Risk Screening Level
t/a	Tonnes per annum
TCEQ	Texas Commission on Environmental Quality
TEL	Threshold Exposure Limit
TLV	Threshold Limit Values
TWA	Time weighted Average
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WHO	World Health Organization
WRF	Weather, Research and Forecast Model

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1 BACKGROUND

EScience Associates (Pty) Ltd was appointed by Brother CISA (Pty) Ltd to undertake an air quality impact assessment to inform an environmental impact assessment for the proposed expansion of their existing product range to include chrome tanning salts (CTS), and vitamin K compounds, at their chrome chemicals plant in Newcastle, KwaZulu Natal. The proposed expansion is subject to environmental authorisation in terms of the National Environmental Management Act (Act 107 of 1998) {NEMA} and atmospheric emissions licensing in terms of the National Environmental Management: Air Quality Act (Act 39 of 2004) {NEMAQA}.

The Brother CISA chrome chemicals facility is situated within the Newcastle Chemicals Park. The plant is authorised to produce various chrome chemicals products which include sodium dichromate (SDC), chromic acid, and chrome oxide. The plant was founded in 1996 and went into operation in 1998. It currently has an authorised production capacity of 140 000 tonnes per annum (t/a) of SDC equivalents (this includes 15 000 t/a of chromic acid, and 20 000 t/a of chrome oxide) and 20 000 t/a of sodium sulphate, as per environmental authorisation reference number DC25/0006/08/ AMND/2010.

Brother CISA proposes to establish an inorganic production process, and an organic process, producing 50 000 t/a and 30 000 t/a of CTS respectively. CISA will also establish production capacity for synthetic vitamin K compounds of 2 000 t/a.

This study has been undertaken to:

1. Predict the impact of the proposed processes on ambient air quality.
2. Predict the cumulative impact of the current and proposed processes on ambient air quality.
3. Provide recommendations where applicable for impact prevention and mitigation.
4. Where applicable provide recommendations for Environmental Authorisation and conditions thereto.
5. Provide recommendations in respect of monitoring requirements.
6. Provide input to the environmental impact assessment required to inform environmental authorisation decisions in respect of the proposed operations.
7. Inform atmospheric emissions licensing decisions in respect of the proposed operations.

2 ENTERPRISE DETAILS

2.1 ENTERPRISE NAME

Table 2-1: Enterprise details

Enterprise Name	Brother CISA (Pty) Ltd
Trading as	Brother CISA (Pty) Ltd
Type of Enterprise, e.g. Company/Close Corporation/Trust	Company
Company/Close Corporation/Trust Registration Number (Registration Numbers if Joint Venture)	1996/014329/07
Registered Address	1 Karbochem Road, Newcastle, 2940
Postal Address	Private Bag X6600, Newcastle, 2940
Telephone Number (General)	+27 34 370 7000
Fax Number (General)	+27 34 315 1976
Industry Type/Nature of Trade	Chromium Chemical Manufacturer
Land Use Zoning as per Town Planning Scheme	Industrial
Land Use Rights if outside Town Planning Scheme	N/A

Table 2-2: Contact details of responsible person

Responsible Person	Jacque Hunlun
Telephone Number	+27 34 370 7005
Cell Number	+27 83 633 1391
Fax Number	+27 34 315 1976
Email Address	Jacque.hunlun@brothercisa.com
After Hours Contact Details	+27 83 633 1391

2.2 LOCATION AND SITE DESCRIPTION

The Brother CISA chrome chemicals facility is situated within the Newcastle Chemical Park, Karbochem Road, Newcastle, in northern KwaZulu Natal.

Refer to Figure 2-1 for location of the facility, and Table 2-3 for further details of the site.

Table 2-3: Location and extent of the plant

Physical Address of the Plant	1 Karbochem Road, Newcastle, 2940
Description of Site (Where No Street Address)	N/A
Coordinates of Approximate	Latitude: 27.780936°S;

Centre of Operations	Longitude: 29.976462°E
Extent (km^2)	0.327
Elevation Above Mean Sea Level	1240
Province	Kwazulu-Natal
Metropolitan/District Municipality	Amajuba District Municipality
Local Municipality	Newcastle Local Municipality
Designated Priority Area (if applicable)	N/A

2.3 PROPERTY TITLE

Brother CISA's operations are undertaken on the properties listed in Table 2-4 below. The properties belong to the applicant.

Table 2-4: List of Properties

Property Registration Number (Surveyor-General Code)	(K252)NOHS 0221 0001 5432 000000
	(K252)NOHS 0221 0001 3661 000020
	(K252)NOHS 0221 0001 3661 000030
	(K252)NOHS 0221 0001 3661 000060
	(K252)NOHS 0221 0001 3661 000050
	(K252)NOHS 0221 0001 3744 000030

2.3.1 PRESENT LAND USE

The Brother CISA operations are located within the Newcastle Chemical Park. Immediately south of the Newcastle Airport, in the town of Newcastle, in northern KwaZulu Natal. The planned expansion is proposed to take place within the existing property.

The Newcastle Chemical Park is an industrial complex occupied by various industrial facilities although not all are in full operation:

- African Amines (Pty) Ltd;
- Karbochem (Pty) Ltd;
- KC Energy (Pty) Ltd;
- Brother CISA (Pty) Ltd;
- Newcastle Co-Generation; and,
- South African Calcium Carbide (SACC).

Existing disposal facilities border the eastern side of the site. The area to the west is mostly open veld, with small holdings located across the Karbochem road approximately 1 km away.

Arbor Park is the closest residential area and is approximately 1.5 km to the north west of the proposed site. The suburb of Kwamathukuza is approximately 2.7km to the east of the proposed site, and the Newcastle CBD is approximately 4 km North East of the site.

Although the area immediately adjacent to the site consists largely of open veld, Newcastle airport lies to the north and Karbochem cemetery (Roy Point Cemetery) to the south of the site. Ngagane Water Purification Plant is situated 2.5km to the south of the Brother CISA facility. Within a 5km radius, the majority of the surrounding land use to the south is undisturbed land and built up industrial and residential, with intermittent grasslands and shrubland to the north (Figure 2-1).

2.4 AIR QUALITY OFFICER

The site is located within the Amajuba District Municipality. The atmospheric emissions licensing authority (as defined in NEMAQA) resides with the Amajuba District Municipality.

2.5 ATMOSPHERIC EMISSION LICENCE AND OTHER AUTHORISATIONS

The site currently has an AEL with licence number AMAJUBA/LANX/2011/1.

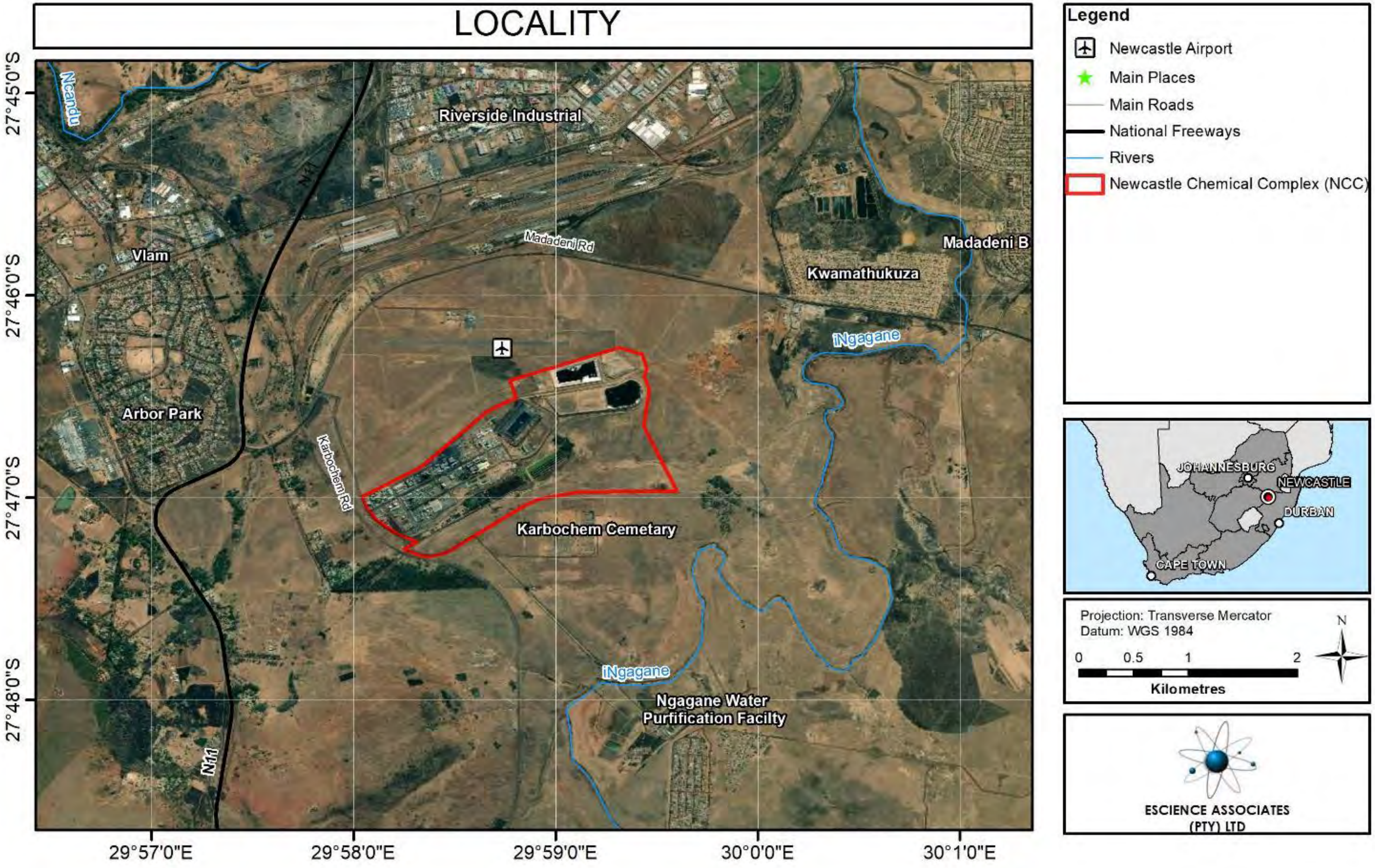

Figure 2-1: Satellite image –Site and immediate surroundings

3 NATURE OF THE PROCESS

3.1 LISTED ACTIVITIES

Activities listed in terms of S21 of NEMAQA which are relevant to the existing and proposed processes are summarised below. Refer to section 5.3 of this report for further detail on the legislative background.

3.1.1 CURRENT ACTIVITIES

Listed activities that the site is currently licenced to undertake are presented in Table 3-1 below.

Table 3-1: NEMAQA Listed Activities applicable to the current activities

Listed Activity Number	Category of Listed Activity	Listed Activity Name	Listed Activity Description
4.1	4. Metallurgical Industry	Drying and Calcining	Drying and calcining of mineral solids including ore.
4.9	4. Metallurgical Industry	Ferro-alloy Production	Production of alloys of iron with chromium, manganese, silicon or vanadium, the separation of titanium slag from iron-containing minerals using heat.
4.15	4. Metallurgical Industry	Processing of Arsenic, Antimony, Beryllium, Chromium and Silicon	The metallurgical production and processing of arsenic, antimony, beryllium, chromium and silicon and their compounds by the application of heat.

3.1.2 PROPOSED ACTIVITIES

Listed activities that are applicable to the proposed expansion are presented in Table 3-2 below.

Table 3-2: NEMAQA Listed Activities applicable to the proposed project

Listed Activity	Activity Description	Reason
Category 7: Inorganic Chemicals Industry Subcategory 7.2: Production of Acids	*The production, bulk handling and use in manufacturing of hydrofluoric, hydrochloric, nitric and sulphuric acid (including oleum) in concentration exceeding 10%.* *Processes in which oxides of sulphur are emitted*	Brother CISA proposes to use more than 100 tonnes/annum of sulfuric acid (H_2SO_4) in their chromium salts manufacturing process.

Table 3-2: NEMAQA Listed Activities applicable to the proposed project

Listed Activity	Activity Description	Reason
	through the production of acid sulphites of alkalis or alkaline earths or through the production of liquid sulphur or sulphurous acid. *Secondary production of hydrochloric acid through regeneration.*	
Category 7: Inorganic Chemicals Industry Subcategory 7.4: Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat	*Production, use or recovery of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium and their salts not covered elsewhere, excluding their use as catalyst.*	Brother CISA proposes to produce more than 1 ton Chrome Tanning Salts per month.

3.2 PROCESS DESCRIPTION

3.2.1 CURRENT ACTIVITIES

3.2.1.1 UNIT PROCESSES

Unit processes associated with the existing activities at the premises are shown in Table 3-3, as described in the site's Atmospheric Emissions Licence.

Table 3-3: Existing Unit Processes

Unit Process	Unit Process Function	Batch or Continuous Process
Ore Milling	Milling of ore to particle size required for processing	Continuous
Mixing	Mixing of raw materials for feed to kiln	Continuous
Roasting	Roasting of ore in a rotary kiln to oxidise chromium	Continuous
Leaching	Leaching of sodium monochromate from kiln roast	Continuous
Slurry Residue Filtration	Removal of residual sodium monochromate from residue discharged from the slurry tank	Continuous
Recycle material treatment	Homogenisation and drying of residue for recycling to kiln	Continuous
SMC purification &	Removal of vanadium and calcium from sodium mono-chromate solution and	Continuous

Table 3-3: Existing Unit Processes

Unit Process	Unit Process Function	Batch or Continuous Process
Concentration	subsequent concentration by evaporation	
SDC conversion	Conversion of sodium monochromate solution to sodium dichromate solution	Continuous
SDC crystallisation	Crystallisation of sodium dichromate	Continuous
Chromic acid production	Electrolysis of sodium dichromate to produce chromic acid	Continuous
Residue Treatment	Reduction of hexavalent chromium in residue to trivalent chromium	Continuous
Pilot Residue Direct Reduction	Direction reduction of residue in kiln	Continuous
Sodium Bicarbonate Calcining	Calcining of sodium bicarbonate to produce sodium carbonate for kiln	Continuous
Production of steam and carbon dioxide	Combustion of natural gas to produce process steam and capture of carbon dioxide from combustion off-gases	Continuous

3.2.2 PROPOSED ACTIVITIES

Brother CISA produces sodium dichromate (SDC) and various related chrome chemicals and by-products. Brother CISA proposes to expand its existing product range to include chrome tanning salts (CTS). It is intended to establish an inorganic and an organic process producing 50 000 t/a and 30 000 t/a each respectively, as well as synthetic vitamin K of 2 000 t/a.

One of the primary raw materials for producing these will be sodium dichromate (SDC) coming from the existing operations.

The manufacture of inorganic CTS involves the reaction of Sodium Dichromate (SDC) and Sulphur Dioxide gas (SO_2). The SO_2 gas is generated by burning sulphur in a furnace. The SO_2 gas from the burner is fed into a set of absorption columns where it reacts with, and reduces the SDC, to form CTS. This produces a CTS liquor which is then dried to form a powder. The powder along, with various additives, is then stored as product and may be bagged or supplied to clients in bulk.

To manufacture organic CTS and synthetic vitamin K compounds, methyl naphthalene and sulphuric acid are mixed with SDC to produce crystalline menadione. This is subsequently dissolved with heptane and sulphurated to produce menadione sodium bisulphite (MSB). Menadione sodium bisulphite is a water-soluble form of menadione, which belongs to the Vitamin K class of compounds. A portion of the MSB is then purified, dried and packaged, and the remainder is converted to menadione nicotinamide bisulphite (MNB). MNB is subsequently purified, dried and packaged. MNB is a bioactive source of vitamin K.

The bulk of sodium sulphate recovered as a by-product of the above is then used to produce organic CTS. The sodium sulphate is mixed with SDC, glycol, and sulphuric acid to produce CTS solution. The solution is concentrated by evaporation, mixed with further sodium sulphate and then dried. The dried powder along, with various additives, is then stored as product and may be bagged or supplied to clients in bulk.

3.2.2.1 UNIT PROCESSES - PROPOSED

Unit processes associated with the proposed activities at the premises are shown in Table 3-4.

Table 3-4: Proposed Unit Processes

Unit Process	Unit Process Function	Batch or Continuous Process
Inorganic Chrome Tanning Salts Production	SO_2 gas is fed into a set of absorption columns where it reacts with, and reduces the SDC, to form CTS	Continuous
Vitamin K Production	Crystalline menadione is dissolved with heptane and sulphurated to produce menadione sodium bisulphite (MSB). A portion of the MSB is then purified, dried and packaged, and the remainder is converted to menadione nicotinamide bisulphite (MNB).	Continuous
Organic Chrome Tanning Salts Production	Some sodium sulphate recovered as a by-product of the Vitamin K production is used to produce organic Chrome Tanning Salts (CTS). Sodium sulphate is mixed with SDC, glycol, and sulphuric acid to produce CTS solution. The solution is concentrated by evaporation, mixed with further sodium sulphate, and then dried.	Continuous

3.3 HOURS OF OPERATION

All unit processes may operate 24 hours a day 365 days per year excluding planned and unplanned maintenance.

3.4 GRAPHICAL PROCESS INFORMATION

3.4.1 CURRENT ACTIVITIES

The overall process flow diagram showing current activities is Figure 3-1.

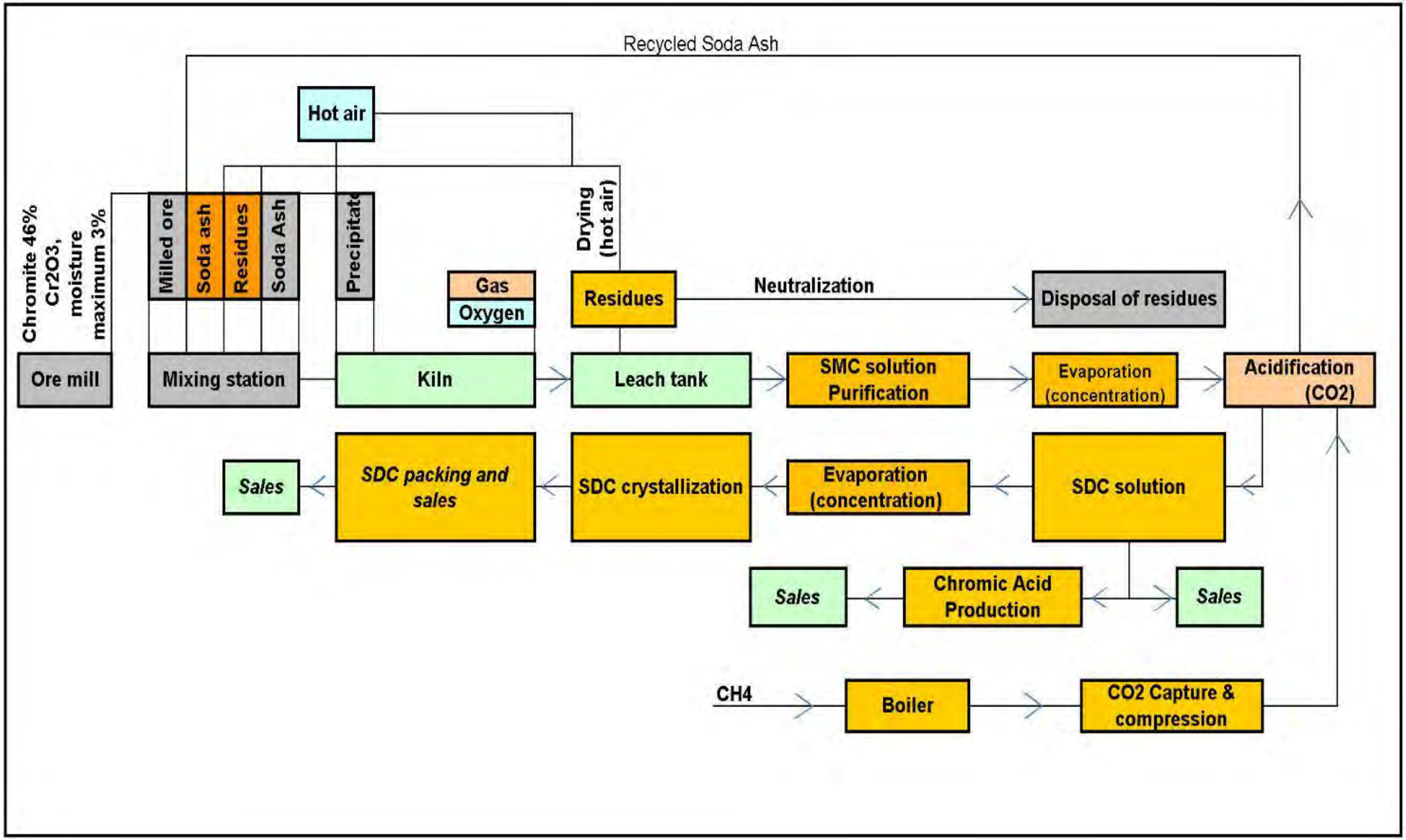

Figure 3-1: Overall process flow diagram - Current activities

3.4.2 PROPOSED ACTIVITIES

The manner in which the CTS plant will fit with the existing operation is shown in Figure 3-2. A detailed process description of the inorganic CTS process is shown in Figure 3-3. A detailed process description of the organic processes is presented in Figure 3-4 to Figure 3-7.

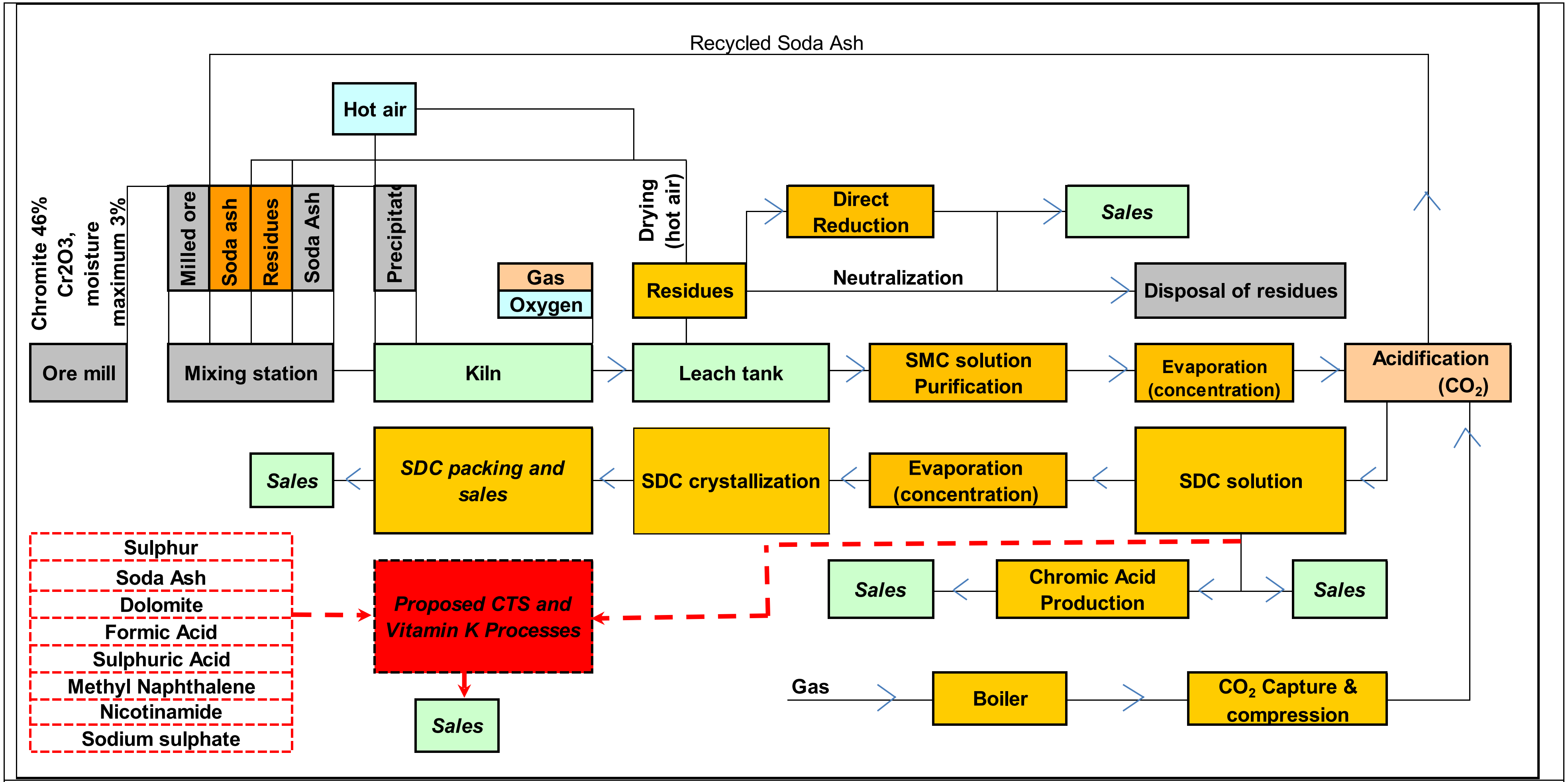

Figure 3-2: Full Plant Process Flow Diagram

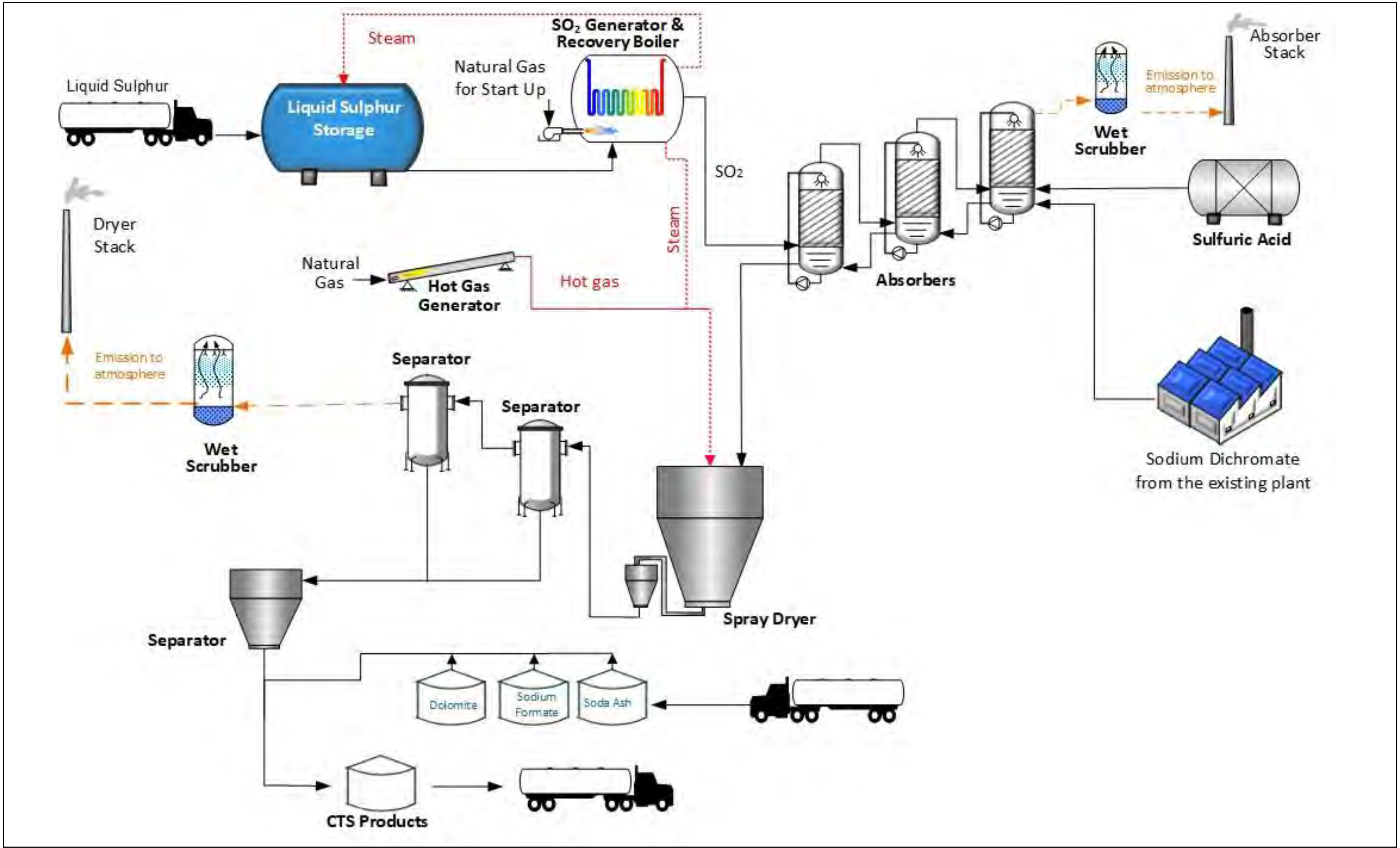

Figure 3-3: Inorganic CTS Process Flow Diagram

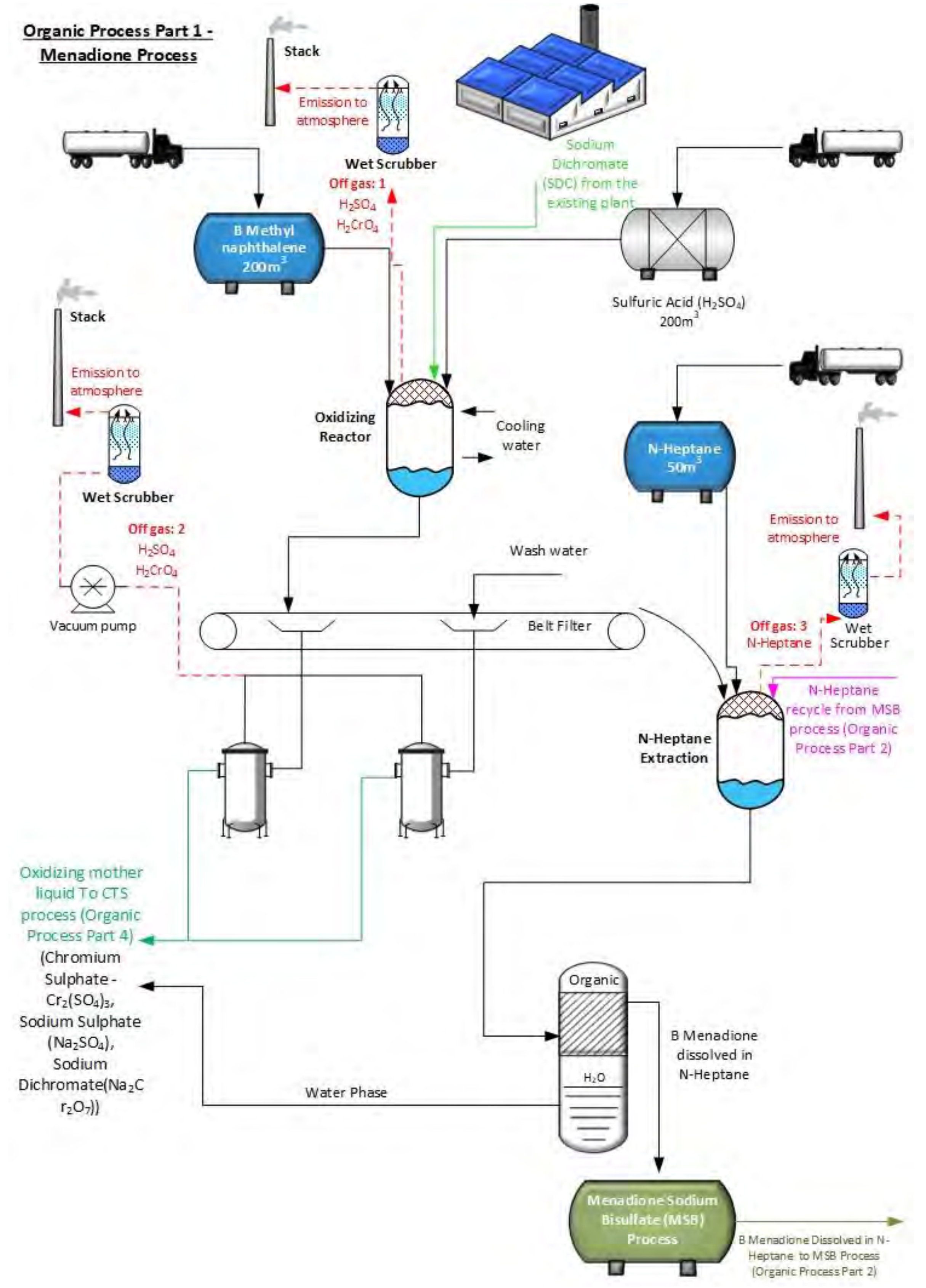

Figure 3-4: Organic Process Part 1 - Menadione Process

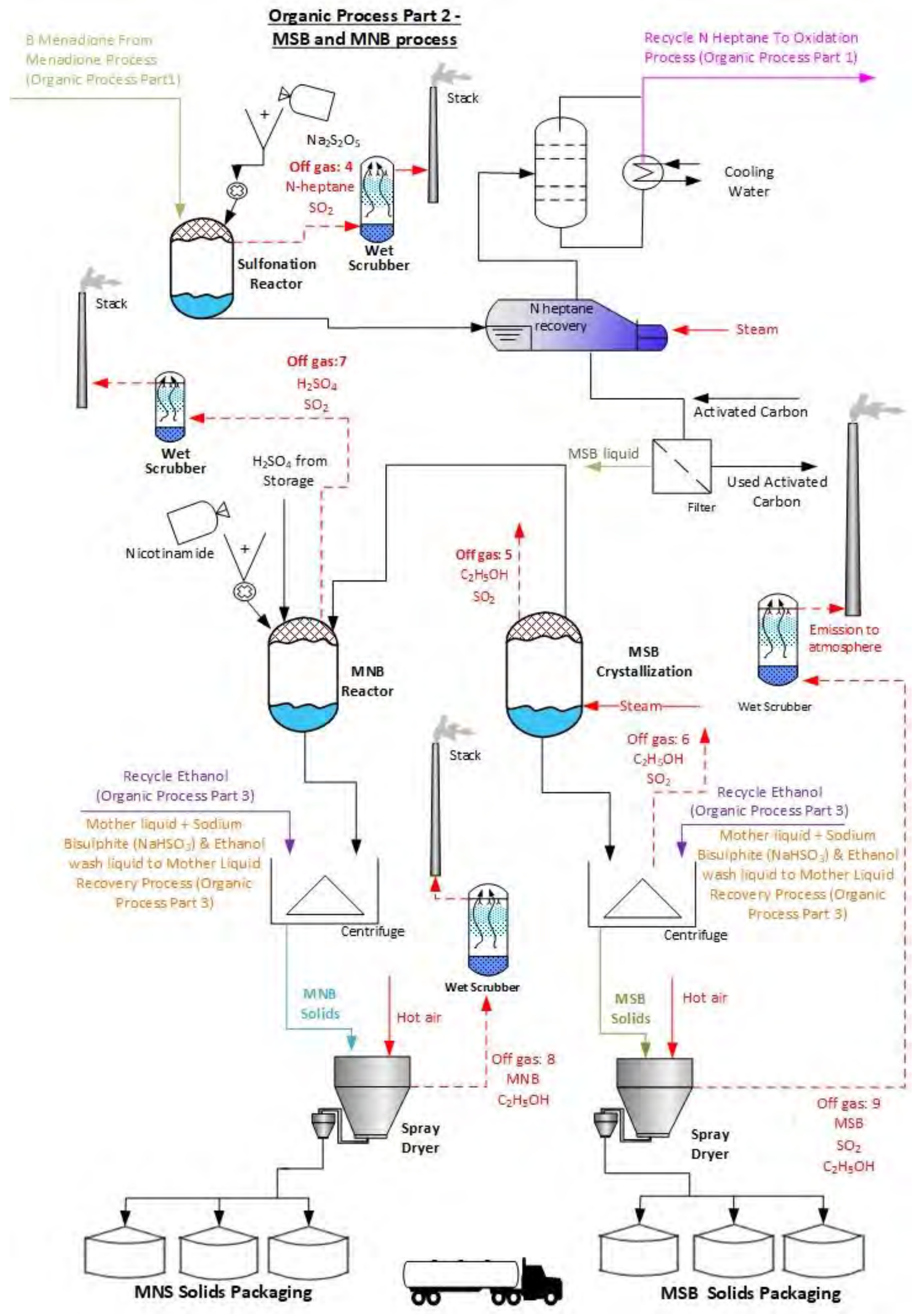

Figure 3-5: Organic Process Part 2 - Menadione sodium bisulphite (MSB) and menadione nicotinamide bisulphite (MNB) process

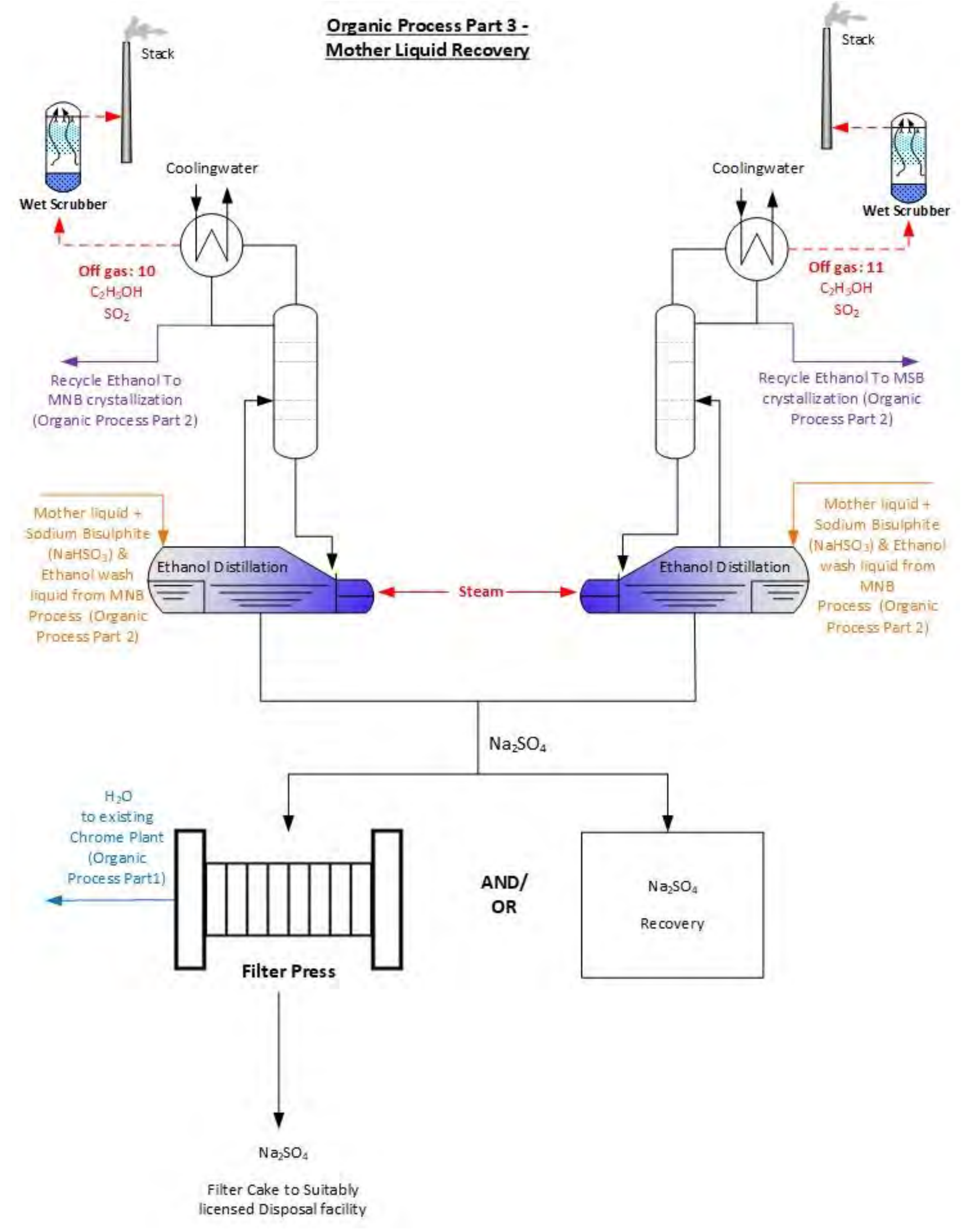

Figure 3-6: Organic Process Part 3 - Mother liquid recovery process

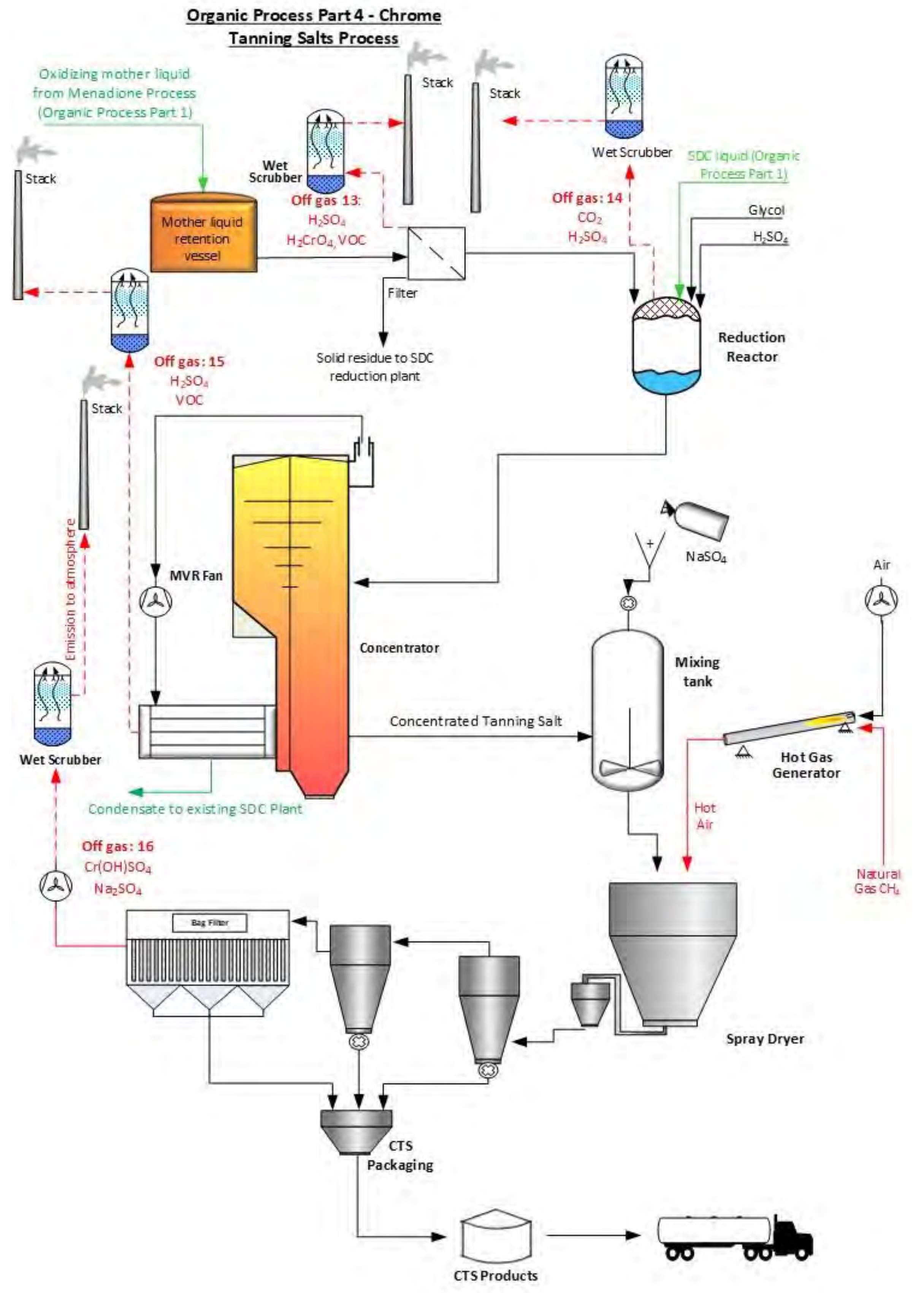

Figure 3-7: Organic Process Part 4 – Chrome Tanning Salts process

4 TECHNICAL INFORMATION

4.1 RAW MATERIALS USED

The raw materials used at the existing facility are listed in Table 4-1.

Table 4-1: Raw materials currently used at Brother CISA

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Design Consumption Rate (Volume)	Units (quantity/ period)
Chrome ore	180 000	180 000	Tons/yr
Soda ash	60 000	60 000	Tons/yr
Oxygen (O_2)	30 000	30 000	Tons/yr
Carbon dioxide (CO_2)	72 000	72 000	Tons/yr
Sulphur dioxide (SO_2)	2 400	2 400	Tons/yr
Sulphuric acid (H_2SO_4)	3 200	3 200	Tons/yr
Ferrous chloride ($FeCl_2$)	3 500	3 500	Tons/yr
Sodium hydroxide (NaOH)	10 000	10 000	Tons/yr
Cansoly Amine	50	50	Tons/yr

The proposed additional raw materials that will be used at the facility after the expansion are listed in Table 4-2

Table 4-2: Proposed additional raw materials to be used at Brother CISA

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Design Consumption Rate (Volume)	Actual Consumption Rate (Volume)	Units (quantity/ period)
Vitamin K Compounds Production				
B-methyl naphthalene	1950	1950	N/A	Tons/yr
Sulfuric acid	15083	15083	N/A	Tons/yr
Sodium dichromate	12285	12285	N/A	Tons/yr
n-heptane	78	78	N/A	Tons/yr
Sodium pyrosulfite	1424	1424	N/A	Tons/yr
nicotinamide	492	492	N/A	Tons/yr
Activated carbon	26	26	N/A	Tons/yr
ethanol	137	137	N/A	Tons/yr
Liquid alkali	1048	1048	N/A	Tons/yr
Liquid ammonia	26	26	N/A	Tons/yr
Organic CTS				

Table 4-2: Proposed additional raw materials to be used at Brother CISA

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Design Consumption Rate (Volume)	Actual Consumption Rate (Volume)	Units (quantity/ period)
Sodium dichromate	2607	2607	N/A	Tons/yr
glucose	882	882	N/A	Tons/yr
oxidized mother liquor	52075	52075	N/A	Tons/yr
sodium sulphate	3056	3056	N/A	Tons/yr
Inorganic CTS				
Sodium dichromate	25000	25000	N/A	Tons/yr
Molten Sulphur	12300	12300	N/A	Tons/yr
Sulfuric acid	576	576	N/A	Tons/yr
Dolomite	100	100	N/A	Tons/yr
Sodium Formate	25	25	N/A	Tons/yr
Soda Ash	100	100	N/A	Tons/yr

4.2 PRODUCTION RATES

Table 4-3: Chrome Chemical Production rates

Product Name	Authorised Maximum Production Capacity Permitted	Actual production Rates	Units (Quantity/ Period)
Existing Products*			
Total production of sodium dichromate equivalents.**	140 000	70 000	Tons/yr
Sodium dichromate	90 000	60 000	Tons/yr
Chromic Acid	15 000	7 500	Tons/yr
Chrome oxide	20 000	0	Tons/yr
Sodium Sulphate	20 000	0	
* As per environmental authorisation reference number DC25/0006/08/ AMND/2010 ** Total chromium product mix as SDC equivalent			
Proposed Additional Products			
Chrome Tanning Salts (Inorganic)	50 000	N/A	Tons/yr

Chrome Tanning Salts (Inorganic)	30 000	N/A	Tons/yr
Vitamin K Compounds	2 000	N/A	Tons/yr

4.3 MATERIALS USED IN ENERGY SOURCES

Table 4-4: Energy Sources Used

Energy Source	Sulphur Content of Fuel (%) (if applicable)	Ash Content of Fuel (%) (if applicable)	Maximum Permitted Consumption Rate (Volume)	Design Consumption Rate (Volume)	Actual Consumption Rate (Volume)	Units (Quantity/Period)
Current Total Energy Sources						
Electrical energy	N/A	N/A	90 000	90 000	80 000	MWH / annum
Natural gas	0.00000008%	N/A	2 200 000	2 200 000	1 654 000	GJ / annum
Proposed Total Energy Sources						
Electrical energy	N/A	N/A	220 000	175 000	175 000	MWH / annum
Natural gas	0.00000008%	N/A	3 200 000	3 000 000	3 000 000	GJ / annum

4.4 APPLIANCES AND ABATEMENT EQUIPMENT CONTROL TECHNOLOGY

Existing Air Pollution Control Technology is shown in Table 4-5. Proposed Air Pollution Control Technology is shown in Table 4-6.

Table 4-5: Air Pollution Control Technology - Existing

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
LD01	Ball Mill Baghouse / R02007	INA*	Bag house	2009		2009	INA*	Baghouse Ultra Pulse Dust Separator	25200 Nm³/hr	98	100
LD02	Yellow Soda Ash Bag Filter / R04013	INA*	Bag house	1997	Dalamatic Filters	1998	INA*	Baghouse Dust Separator	2400 Nm³/hr	98	100
LD03	White Soda Ash Bag Filter / R04014	INA*	Bag house	1997	Buhler Dalamatic Filters	1998	INA*	Baghouse Dust Separator	3600 Nm³/hr	98	100
LD04	Kiln ESP / G05022	INA*	Electrostatic Precipitator	1997	Bateman Elex Gas Cleaning	1998	2009	Bateman Electrostatic Precipitator	135000 Nm³/hr	99.5	100
LD05	Wet Mill Scrubber	R05049	Filter	1996	Triple M Eng. 15552-10A9	1998	2010	Venturi / Candle Filter	31000 Am³/hr	95	100
LD06	Belt Filter(B/F) Vacuum pumps	K06055/K06056	Vacuum pump	1996	DelkorTechnik LPH 11055	1998		Liquid ring vacuum pumps	5000 Nm³/hr	99.8	100

Table 4-5: Air Pollution Control Technology - Existing

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
LD07	B/F enclosure extraction scrubber	R06127	Wet Scrubber	1996	Trema RN10WET	1998		Rotary wet scrubber	5000 Nm^3/hr	95	100
LD08	Combined Stack Scrubber	R06146	Scrubber	2007	Cell Cote air pollution	2008	None	Horizontal crossflow	30000 Nm^3/hr	95	100
LD09	SO_2 Scrubber	R09037	Scrubber	1998	Triple M Eng.	1998	None	Absorption column	5000 Nm^3/hr	95	100
LD10	IMS effluent evaporator	G09405	Scrubber	2001	Titanium Industries	2002	None	Effluent evaporator	30 m^3/hr	95	100
LD12	Sodium Bicarbonate Candle filter	R13007 + R13010	Venturi scrubber + Candle filter	2010	PPTech	2017	none	Candle filter	10000 Nm^3/hr	95	100
LD14	Soda Calciner Candle filter	R14008 R14092	Baghouse + Candle filter	2010	PPTech	2017	none	Candle filter	10000 Nm^3/hr	98	100
LD16	Calciner Off-gas scrubber	D14131	Scrubber	2006	GEA-Niro AS	2006	2013	Venturi Wet Scrubber		95	100
LD17	SDC crystal drying scrubber	R23005	Scrubber	1996		1998	2001	Rotating disc off scrubber	20000 Nm^3/hr	95	100

Table 4-5: Air Pollution Control Technology - Existing

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
LD18	Hydrogen Scrubber	K43079	Scrubber	1997	Zimmerman & Jansen GEA	1998	None	Hydrogen Jet Scrubber	In 465 404m^3	95	100
LD19	Oxygen Scrubber	K43083	None	1997	Zimmerman & Jansen GEA	1998	None			95	100
LD20	CA crystallisation Vacuum pump	K44005	Vacuum pump	1997& 2003	Hi Vac GDH250GA	1998	None	Liquid ring vacuum pump	3000 Nm^3/hr	95	100
LD21	CA drying and packaging scrubber	200664 CIF8198A99	Scrubber	1998	Ventlex Venturi Scrubber	1998/2000	2000/2002	Titanium industries and ELCA Eng.	6000 Nm^3/hr	95	100
GB1	Boiler Stack 1	G72021	Stack	2012	none	2013	None	none	62000 Nm^3/hr	95	100
GB 3	MEA Plant Stack 1	D75011	Absorber	2012	none	2013	None	none	55000 Nm^3/hr	95	100

Table 4-6: Air Pollution Control Technology - Proposed

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity (Nm^3/h)	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)

Table 4-6: Air Pollution Control Technology - Proposed

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity (Nm³/h)	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
CTS1	CTS Organic Stack 1	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	69	99	98
CTS2	CTS Organic Stack 2	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	2000	99	98
CTS3	CTS Organic Stack 3	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	166	99	98
CTS4	CTS Organic Stack 4	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	254	99	98
CTS5	CTS Organic Stack 5	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	181	99	98
CTS6	CTS Organic Stack 6	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	97	99	98
CTS7	CTS Organic Stack 7	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	248	99	98
CTS8	CTS Organic Stack 8	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	1455	99	98

Table 4-6: Air Pollution Control Technology - Proposed

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity (Nm³/h)	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
CTS9	CTS Organic Stack 9	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	70	99	98
CTS10	CTS Organic Stack 10	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	306	99	98
CTS11	CTS Organic Stack 11	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	307	99	98
CTS12	CTS Organic Stack 12	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	1691	99	98
CTS13	CTS Organic Stack 13	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	2896	99	98
CTS14	CTS Organic Stack 14	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	1560	99	98
CTS15	CTS Organic Stack 15	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	5000	99	98
CTS16	CTS Organic Stack 16	Not in place	Alkali absorption tower	N/A	N/A	N/A	N/A	Alkali absorption tower	161713	99	98

Table 4-6: Air Pollution Control Technology - Proposed

Associated Source Code	Appliances			Air Pollution Control Technology							
	Appliance / Process Equipment Number	Appliance Serial Number	Appliance Type / Description	Appliance Manufacture Date	Product Name and Model	Commission Date	Date of Significant Modification / Upgrade	Technology Type	Design Capacity (Nm³/h)	Permitted Minimum Control Efficiency (%)	Permitted Minimum Utilisation (%)
CTS17	CTS Inorganic Stack 1	Not in place	absorbers	N/A	N/A	N/A	N/A	Absorbers	20 000	99	98
CTS17	CTS Inorganic Stack 1	Not in place	Candle filter	N/A	N/A	N/A	N/A	Candle filter	20 000	99	98
CTS18	CTS Inorganic Stack 2	Not in place	Cyclones	N/A	N/A	N/A	N/A	Cyclones	200 000	99	98
CTS18	CTS Inorganic Stack 2	Not in place	Bag filter	N/A	N/A	N/A	N/A	Bag filter	200 000	99	98

5 ATMOSPHERIC EMISSIONS

Source specific data such as source type, height and diameter, emission rates and exit conditions (temperature, velocity and flow rate) are required for dispersion modelling.

An emissions inventory for current operations was formulated based on measured data and data stipulated in Brother CISA's Atmospheric Emissions Licence.

An emissions inventory for the proposed expansions was formulated based on the applicable emissions standards and process information provided by Brother CISA.

It must be noted that the processes are undertaken within enclosed equipment and vessels with extraction via abatement equipment where applicable. No fugitive emission sources of potential significance have been identified, and therefore it is reasonably concluded that fugitive emissions will be insignificant.

5.1 POINT SOURCE PARAMETERS

Existing point source parameters are shown in Table 5-1. Proposed point source parameters are shown in Table 5-2. Note that the stacks are not all sequentially numbered as some stacks have been rerouted or combined overtime.

Table 5-1: Point Source Parameters - Existing

Point Source Number	Point Source Name	Latitude (UTM) South	Longitude (UTM) East	Height of release (magl)	Height above nearby building (m)	Diameter at stack tip/vent exit (m)	Actual gas exit temperature (°C)	Actual gas volumetric flow (m^3/hr)	Actual gas exit velocity (m/s)
LD 01	Ball Mill Off-Gas Bag House	6923.472	793.247	46.3	2	0.60	75.5	24 290	23.85
LD 02	Yellow Soda Ash Bag Filter / R04013	6923.479	793.263	35.4	2	0.07	64.5	5 750	21.90
LD 03	White Soda Ash Silo Extraction System	6923.483	793.255	35.4	2	0.065	31.0	1 072	4.60
LD 04	Kiln ESP / G05022	6923.473	793.312	50.0	15	3.10	214.0	263 447	9.70
LD 05	Wet Mill Scrubber	6923.484	793.370	30.0	30	1.00	90.5	35 425	12.55
LD 07	B/F enclosure extraction scrubber	6923.484	793.314	18.4	2	0.33	29.0	5 430	17.65
LD 08	Combined Stack Scrubber	6923.528	793.351	28.0	2	1.00	38.0	30 853	10.95
LD 09	SO_2 Scrubber	6293.528	793.351	21.9	2	0.38	29.0	6 104	14.95
LD 10	IMS Evaporator Stack	6923.519	793.318	27.0	2	0.21	98.0	2 577	20.67
LD 12	Sodium Bicarbonate Candle filter	6923.543	793.296	25.0	2	0.44	34.5	6 230	11.35

Table 5-1: Point Source Parameters - Existing

Point Source Number	Point Source Name	Latitude (UTM) South	Longitude (UTM) East	Height of release (magl)	Height above nearby building (m)	Diameter at stack tip/vent exit (m)	Actual gas exit temperature (°C)	Actual gas volumetric flow (m^3/hr)	Actual gas exit velocity (m/s)
LD 14	Soda Calciner Candle filter	6923.541	793.302	24.9	2	0.44	44.5	7 025	12.85
LD 16	Calciner Off-gas scrubber	6923.546	793.335	24.0	2	0.44	75.0	1 925	3.55
LD 17	SDC crystal drying scrubber	6923.510	793.354	27.1	2	1.07	30.5	19 897	6.15
LD 18	Hydrogen Scrubber	6923.613	793.432	15.8	2	0.21	28.5	397	3.50
LD 19	Oxygen Scrubber	6923.602	793.445	19.9	2	0.20	34.0	263.5	2.35
LD 20	CA crystallisation Vacuum pump	6923.591	793.441	17.3	2	0.14	29.0	177	3.15
LD 21	CA drying and packaging scrubber	6923.591	793.429	16.8	2	0.44	37.5	11 394	20.85
LD 22	Tank farm scrubber	6923.505	793.272	16.8	2	0.25	34.0	1 550	8.80
GB 1	Boiler Stack 1	6923.698	793.466	25.0	2	1.49	51.0	22 162	3.50
GB 2	CO_2 Absorption Stack	6923.701	793.471	25.0	2	0.80	40.0	30 435	16.65

Table 5-2: Point Source Parameters – Proposed

Point Source Number	Point Source Name	Latitude (UTM) South	Longitude (UTM) East	Height of release (magl)	Height above nearby building (m)	Diameter at stack tip/vent exit (m)	Actual gas exit temperature (°C)	Actual gas volumetric flow (m3/hr)	Actual gas exit velocity (m/s)
CTS1	CTS Organic Stack 1	6923.62554	793.53287	25	2	0.05	40	78.568	11.115
CTS2	CTS Organic Stack 2	6923.62554	793.53287	25	2	0.2	35	2256.4	20.0
CTS3	CTS Organic Stack 3	6923.62554	793.53287	25	2	0.08	60	202.1	11.2
CTS4	CTS Organic Stack 4	6923.62554	793.53287	25	2	0.08	35	287.1	15.9
CTS5	CTS Organic Stack 5	6923.62554	793.53287	25	2	0.08	35	204.2	11.3
CTS6	CTS Organic Stack 6	6923.62554	793.53287	25	2	0.05	35	109.7	15.5
CTS7	CTS Organic Stack 7	6923.62554	793.53287	25	2	0.08	35	279.7	15.5
CTS8	CTS Organic Stack 8	6923.62554	793.53287	25	2	0.2	70	1827.6	16.2
CTS9	CTS Organic Stack 9	6923.62554	793.53287	25	2	0.05	50	83.2	11.8
CTS10	CTS Organic Stack 10	6923.62554	793.53287	25	2	0.1	70	384.7	13.6
CTS11	CTS Organic Stack 11	6923.62554	793.53287	25	2	0.1	70	385.8	13.6
CTS12	CTS Organic Stack 12	6923.62554	793.53287	25	2	0.25	200	2930.0	16.6
CTS13	CTS Organic Stack 13	6923.62554	793.53287	25	2	0.3	50	3426.6	13.5
CTS14	CTS Organic Stack 14	6923.62554	793.53287	25	2	0.25	100	2131.5	12.1
CTS15	CTS Organic Stack 15	6923.62554	793.53287	25	2	0.35	70	6282.1	18.1
CTS16	CTS Organic Stack 16	6923.62554	793.53287	25	2	2	100	220948.5	19.5
CTS17	CTS Inorganic Stack 1	6923.62554	793.53287	25	2	0.8	80	25860.8	14.3
CTS18	CTS Inorganic Stack 2	6923.62554	793.53287	25	2	2.2	60	243956.0	17.8

5.2 POINT SOURCE EMISSION RATES (NORMAL OPERATING CONDITIONS)

The current emissions rates are given in Table 5-3. These are based on measured stack emissions over the past 5 years.

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
LD 01	Ball Mill Off-Gas Bag House	PM	0.036	1 Hour	Continuous
		Cr^{+6}	BDL	1 Hour	Continuous
		NO_x	1.201	1 Hour	Continuous
		SO_2	0.042	1 Hour	Continuous
		VOC	0.000062	1 Hour	Continuous
LD 02	Yellow Soda Ash Bag Filter/R04013	PM	0.006	1 Hour	Continuous
		Cr^{+6}	0.000001	1 Hour	Continuous
		NO_x	0.005	1 Hour	Continuous
		SO_2	0.00029	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 03	White Soda Ash Silo Extraction System	PM	0.00040	1 Hour	Continuous
		Cr^{+6}	BDL	1 Hour	Continuous
		NO_x	0.001	1 Hour	Continuous
		SO_2	0.000060	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 04	Kiln ESP/G05022	PM	0.075	1 Hour	Continuous

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
		Cr^{+6}	0.0002	1 Hour	Continuous
		NO_x	7.967	1 Hour	Continuous
		SO_2	1.588	1 Hour	Continuous
		VOC	0.009	1 Hour	Continuous
LD 05	Wet Mill Scrubber	PM	0.014	1 Hour	Continuous
		Cr^{+6}	0.0001	1 Hour	Continuous
		NO_x	0.026	1 Hour	Continuous
		SO_2	0.002	1 Hour	Continuous
		VOC	0.0000045	1 Hour	Continuous
LD 07	B/F Enclosure Extraction Scrubber	PM	0.002	1 Hour	Continuous
		Cr^{+6}	0.0000006	1 Hour	Continuous
		NO_x	0.005	1 Hour	Continuous
		SO_2	0.0003	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 08	Combined Stack Scrubber	PM	0.012	1 Hour	Continuous
		Cr^{+6}	0.00001	1 Hour	Continuous
		NO_x	0.027	1 Hour	Continuous
		SO_2	0.002	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
LD 09	SO_2 Scrubber	PM	0.002	1 Hour	Continuous
		Cr^{+6}	0.000002	1 Hour	Continuous
		NO_x	0.006	1 Hour	Continuous
		SO_2	0.0003	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 10	IMS Evaporator Stack	PM	0.006	1 Hour	Continuous
		Cr^{+6}	0.0000000004	1 Hour	Continuous
		NO_x	0.031	1 Hour	Continuous
		SO_2	0.003	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 12	Sodium Bicarbonate Candle Filter	PM	0.002	1 Hour	Continuous
		Cr^{+6}	0.00009	1 Hour	Continuous
		NO_x	0.006	1 Hour	Continuous
		SO_2	0.0003	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 14	Soda Calciner Candle Filter	PM	0.011	1 Hour	Continuous
		Cr^{+6}	0.000009	1 Hour	Continuous
		NO_x	0.006	1 Hour	Continuous
		SO_2	0.0004	1 Hour	Continuous

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
		VOC	BDL	1 Hour	Continuous
LD 16	Calciner Off-Gas Scrubber	PM	0.0005	1 Hour	Continuous
		Cr^{+6}	0.00002	1 Hour	Continuous
		NO_x	0.001	1 Hour	Continuous
		SO_2	0.00009	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 17	SDC Crystal Drying Scrubber	PM	0.042	1 Hour	Continuous
		Cr^{+6}	0.00003	1 Hour	Continuous
		NO_x	0.018	1 Hour	Continuous
		SO_2	0.0006	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 18	Hydrogen Scrubber	PM	0.00005	1 Hour	Continuous
		Cr^{+6}	0.00000007	1 Hour	Continuous
		NO_x	0.0005	1 Hour	Continuous
		SO_2	0.238	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 19	Oxygen Scrubber	PM	0.00006	1 Hour	Continuous
		Cr^{+6}	0.000005	1 Hour	Continuous
		NO_x	0.0002	1 Hour	Continuous

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
		SO_2	0.00001	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 20	CA Crystallization Vacuum pump	PM	0.00005	1 Hour	Continuous
		Cr^{+6}	0.0000007	1 Hour	Continuous
		NO_x	0.0002	1 Hour	Continuous
		SO_2	0.00001	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
LD 21	CA Drying and Packaging Scrubber	PM	0.004	1 Hour	Continuous
		Cr^{+6}	0.00007	1 Hour	Continuous
		NO_x	0.013	1 Hour	Continuous
		SO_2	0.0006	1 Hour	Continuous
		VOC	0.022	1 Hour	Continuous
LD 22	Tank Farm Scrubber	PM	0.002	1 Hour	Continuous
		Cr^{+6}	BDL	1 Hour	Continuous
		NO_x	0.000005	1 Hour	Continuous
		SO_2	0.0000003	1 Hour	Continuous
		VOC	BDL	1 Hour	Continuous
GB 1	Boiler Stack 1	PM	0.057	1 Hour	Continuous
		Cr^{+6}	BDL	1 Hour	Continuous

Table 5-3: Brother CISA current point sources emission rates

Point Source number	Point source name	Pollutant name	Average emission rate		Duration of emissions
			(g/s)	Averaging period	
		NO_x	0.375	1 Hour	Continuous
		SO_2	0.164	1 Hour	Continuous
		VOC	0.0002	1 Hour	Continuous
GB 3	CO_2 Absorption Stack	PM	0.304	1 Hour	Continuous
		Cr^{+6}	BDL	1 Hour	Continuous
		NO_x	1.325	1 Hour	Continuous
		SO_2	0.283	1 Hour	Continuous
		VOC	0.0002	1 Hour	Continuous

BDL – Below Detectable Limit. The stack test reports indicate the that the pollutant was not detectable.

Emissions rates for the proposed activities are given in Table 5-4.

Table 5-4: Brother CISA point sources emissions rates for proposed activities

Point Source number	Point source name	Pollutant name	Average emission rate			Duration of emissions
			(mg/Nm^3)	(g/s)	Averaging period	
CTS1	CTS Organic Stack 1	Sulphuric Acid (H_2SO_4) (reported as SO_3)	25	0.000476	1 Hour	Continuous
		Chromic Acid (H_2CrO_4) (reported as Cr^{+6})	0.035*	0.00000067	1 Hour	Continuous
CTS2	CTS Organic Stack 2	H_2SO_4 (reported as SO_3)	25	0.0139	1 Hour	Continuous

Table 5-4: Brother CISA point sources emissions rates for proposed activities

Point Source number	Point source name	Pollutant name	Average emission rate			Duration of emissions
			(mg/Nm³)	(g/s)	Averaging period	
		H_2CrO_4 (reported as Cr^{+6})	0.035*	0.0000194	1 Hour	Continuous
CTS3	CTS Organic Stack 3	N-Heptane (reported as VOC)	40 000	1.84	1 Hour	Continuous
CTS4	CTS Organic Stack 4	N-Heptane (reported as VOC)	40 000	2.83	1 Hour	Continuous
		SO_2	350	0.0247	1 Hour	Continuous
CTS5	CTS Organic Stack 5	SO_2	350	0.0176	1 Hour	Continuous
		Ethanol (C_2H_5OH) (reported as VOC)	40 000	2.01	1 Hour	Continuous
CTS6	CTS Organic Stack 6	SO_2	350	0.00945	1 Hour	Continuous
		C_2H_5OH (reported as VOC)	40 000	1.08	1 Hour	Continuous
CTS7	CTS Organic Stack 7	H_2SO_4 (reported as SO_3)	25	0.00172	1 Hour	Continuous
		SO_2	350	0.0241	1 Hour	Continuous
CTS8	CTS Organic Stack 8	C_2H_5OH (reported as VOC)	40 000	16.2	1 Hour	Continuous
		MNB (reported as PM)	10	0.00404	1 Hour	Continuous
CTS9	CTS Organic Stack 9	SO_2	350	0.00683	1 Hour	Continuous
		C_2H_5OH (reported as VOC)	40 000	0.781	1 Hour	Continuous
		MSB (reported as PM)	10	0.000195	1 Hour	Continuous
CTS10	CTS Organic Stack 10	SO_2	350	0.0298	1 Hour	Continuous
		C_2H_5OH (reported as VOC)	40 000	3.40	1 Hour	Continuous

Table 5-4: Brother CISA point sources emissions rates for proposed activities

Point Source number	Point source name	Pollutant name	Average emission rate			Duration of emissions
			(mg/Nm^3)	(g/s)	Averaging period	
CTS11	CTS Organic Stack 11	SO_2	350	0.0299	1 Hour	Continuous
		C_2H_5OH (reported as VOC)	40 000	3.41	1 Hour	Continuous
CTS12	CTS Organic Stack 12	CO_2	127315	59.8	1 Hour	Continuous
		NH_3	50	0.0235	1 Hour	Continuous
		NO_X	50	0.0235	1 Hour	Continuous
CTS13	CTS Organic Stack 13	H_2SO_4 (reported as SO_3)	25	0.0201	1 Hour	Continuous
		H_2CrO_4 (reported as Cr^{+6})	0.035*	0.0000282	1 Hour	Continuous
		MNQ (reported as PM)	10	0.00804	1 Hour	Continuous
CTS14	CTS Organic Stack 14	H_2SO_4 (reported as SO_3)	25	0.0108	1 Hour	Continuous
		H_2CrO_4 (reported as Cr^{+6})	0.035*	0.0000152	1 Hour	Continuous
		CO_2	92177	39.9	1 Hour	Continuous
		MNQ (reported as PM)	10	0.00433	1 Hour	Continuous
CTS15	CTS Organic Stack 15	H_2SO_4 (reported as SO_3)	25	0.0347	1 Hour	Continuous
		MNQ (reported as PM)	10	0.0139	1 Hour	Continuous
CTS16	CTS Organic Stack 16	H_2SO_4 (reported as SO_3)	25	1.12	1 Hour	Continuous
		Cr(OH)SO4 (reported as PM)	10	0.449	1 Hour	Continuous
		Na_2SO_4 (reported as PM)	10	0.449	1 Hour	Continuous
CTS17	CTS Inorganic Stack 1	Cr^{+6}	0.01*	0.0000556	1 Hour	Continuous
		SO_3	25	0.139	1 Hour	Continuous

Table 5-4: Brother CISA point sources emissions rates for proposed activities

Point Source number	Point source name	Pollutant name	Average emission rate			Duration of emissions
			(mg/Nm^3)	(g/s)	Averaging period	
		SO_2	350	1.94	1 Hour	Continuous
		$Cr(OH)SO_4$ (reported as PM)	10	0.0556	1 Hour	Continuous
		Na_2SO_4 (reported as PM)	10	0.0556	1 Hour	Continuous
CTS18	CTS Inorganic Stack 2	SO_3	25	1.39	1 Hour	Continuous
		SO_2	350	19.4	1 Hour	Continuous
		$Cr(OH)SO_4$ (reported as PM)	10	0.0556	1 Hour	Continuous
		Na_2SO_4 (reported as PM)	10	0.0556	1 Hour	Continuous

* Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, It is recommended that Cr(VI) emissions limits as shown in Table 14-1 be applied to stacks where Cr(VI) emissions are anticipated.

5.3 POINT SOURCE MAXIMUM EMISSIONS RATES (START-UP, SHUT-DOWN, UPSET AND MAINTENANCE CONDITIONS) – PROPOSED EXPANSION

5.3.1 SHUT-DOWN AND MAINTENANCE CONDITIONS

Start up and Shut-down emissions are anticipated to be less than normal operating conditions due to there being lower material throughputs during these phases. Thus the maximum rates should be the same as those emissions shown in Table 5-3 and Table 5-4.

There will be no emissions of significance during planned maintenance and shutdowns. Process producing emissions will be stopped in the event of abatement equipment failure.

5.4 FUGITIVE EMISSIONS (AREA AND/OR LINE SOURCES)

There were no area and/or line sources found on site.

5.5 EMERGENCY INCIDENTS

There were no reported emergency incidents in the past 2 years.

6 APPLICABLE LEGISLATION

6.1 SECTION 24 ENVIRONMENTAL RIGHT

Section 24 of the Constitution provides the following:

"Everyone has the right -

a. to an environment that is not harmful to their health or well-being; and

b. to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that -

  i. prevent pollution and ecological degradation;

  ii. promote conservation; and

  iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

6.2 NEMA AND DUTY OF CARE

NEMA constitutes the primary law in terms of which integrated environmental management and environmental impact assessment is carried out and applied in South Africa in pursuance of the abovementioned environmental right.

NEMA places a duty of Care on all persons who may cause significant pollution or degradation of the environment. Specifically, Section 28 of the act states:

"28 (1) Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

(2) Without limiting the generality of the duty in subsection (1), the persons on whom subsection (1) imposes an obligation to take reasonable measures, include an owner of land or premises, a person in control of land or premises, or a person who has a right to use the land or premises on which or in which-

(a) any activity or process is or was performed or undertaken; or

(b) any other situation exists, which causes, has caused or is likely to cause significant pollution or degradation of the environment.

(3) The measures required in terms of subsection (1) may include measures to- investigate, assess and evaluate the impact on the environment; inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment; cease, modify or control any act, activity or process causing the pollution or degradation; contain or prevent the movement of pollutants or the causant of degradation; eliminate any source of the pollution or degradation; or remedy the effects of the pollution or degradation."

In the context of this Air Quality Impact Assessment (AQIA), the impact of Brother CISA (Pty) Ltd has been assessed and evaluated to determine the significance of the factory's impact on air quality and subsequently inform decisions with respect to air quality management.

6.3 AIR QUALITY LEGISLATION IN SOUTH AFRICA

The National Environmental Air Quality Act (NEMAQA) (Act 39 of 2004), provides the environmental legal basis for management of air quality in South Africa. in the Act focuses on Air Quality Management from an ambient air quality management approach.

Further to the "duty of care" previously discussed in terms of NEMA, NEMAQA defines air pollution as:

""air pollution" means any change in the composition of the air caused by smoke, soot, dust (including fly-ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances;"

NEMAQA is effects-based legislation, with the result that activities that result in atmospheric emissions are to be managed through the setting of environmental health based ambient air quality standards. Facilities with potential impacts on air quality should ideally be assessed not only in terms of its individual contribution, but in terms of its additive contribution to baseline ambient air quality i.e. cumulative effects must be considered.

6.3.1 NATIONAL AMBIENT AIR QUALITY STANDARDS

According to S9 of NEMAQA:

> *"(1) The Minister, by notice in the Gazette-*
>
> *(a) must identify substances or mixtures of substances in ambient air which through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to health, well-being or the environment or which the Minister reasonably believes present such a threat; and*
>
> *(b) must, in respect of each of those substances or mixtures of substances, establish national standards for ambient air quality, including the permissible amount or concentration of each such substance or mixture of substances in ambient air; …"*

The Minister of Water and Environmental Affairs published limits for ambient air quality in Government Notice № 1210 of 24 December 2009, in terms of S9(1) of NEMAQA, as shown in Table 6-1.

Table 6-1: National Ambient Air Quality Standards - GN 1210:2009

Pollutant	Averaging period	Conc. µg/m^3	FOE*	Compliance date
PM_{10}	24-hours	75	4	Immediate
	Annual	40	0	Immediate
NO_2	1-hour	200	88	Immediate
	Annual	40	0	Immediate
SO_2	10-min (running)	500	526	Immediate

	1-hour	350	88	Immediate
	24-hours	125	4	Immediate
	Annual	50	0	Immediate
CO	1-hour	30 000	88	Immediate
	8-hours (running)^	10 000	11	Immediate

* FOE – Permitted Frequency of Exceedance in occurrences per year

^ Calculated on 1-Hourly averages.

The Ministry of Water and Environmental Affairs further published limits for $PM_{2.5}$ on the 29th June 2012, in terms of S9(1) of NEMAQA, as shown in Table 6-2.

Table 6-2: National Ambient Air Quality Standards for $PM_{2.5}$ - GN 486:2012

Pollutant	Averaging period	Conc. µg/m³	FOE*	Compliance date
$PM_{2.5}$	24-hours	40	4	Immediate
		25	4	01 January 2030
	Annual	20	0	Immediate
		15	0	01 January 2030

* FOE – Permitted Frequency of Exceedance in occurrences per year

6.3.2 MINIMUM EMISSION STANDARDS AND ATMOSPHERIC EMISSIONS LICENSING

S21 of NEMAQA provides for the minister (or MEC) to:

> *"…publish a list of activities which result in atmospheric emissions and which the Minister or MEC reasonably believes have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage;…"*

S22 of NEMAQA states that no person may, without a provisional atmospheric emission licence or an atmospheric emission licence, conduct a listed activity.

Accordingly, the minister published the *"List Of Activities Which Result In Atmospheric Emissions Which Have Or May Have A Significant Detrimental Effect On The Environment, Including Health, Social Conditions, Economic Conditions, Ecological Conditions Or Cultural Heritage"*. The list of activities was published in GN 248 of 2010, and subsequently superseded by GN 893 on 22 November 2013, and subsequently amended by GN 551 in 2015, in accordance with S21 of NEMAQA.

Brother CISA's existing activities fall within:

- Subcategory 4.15 (Processing of chromium to produce chromium chemicals), Subcategory 4.9 (Smelting of residue to produce a high chrome steel) and
- Subcategory 4.1 (Drying of chromite ore) of the listings.

The following apply to the proposed expansion:

- Category 7: Inorganic Chemicals Industry; Subcategory 7.2: *Production of Acids.*

  Reason: Brother CISA proposes to use more than 100 tonnes/annum of sulfuric acid (H_2SO_4) in their chromium salts manufacturing process.
- Category 7: Inorganic Chemicals Industry; Subcategory 7.4: *Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat*

  Reason: Brother CISA proposes to produce more than 1 ton Chrome Tanning Salts per month.

The required air emission standards, set in terms of the NEMAQA S21 Minimum Emission Standards, applicable to the proposed facility are given in Table 6-3 and. The standards for "new plant" will apply.

Table 6-3: GN 893:2013, as amended - Subcategory 7.2

Title	Subcategory 7.2: Production of Acids		
Description:	The production, bulk handling and or use in manufacturing of hydrofluoric, hydrochloric, nitric and sulphuric acid (including oleum) in concentration exceeding 10%. Processes in which oxides of sulphur are emitted through the production of acid sulphites of alkalis or alkaline earths or through the production of liquid sulphur or sulphurous acid. Secondary production of hydrochloric acid through regeneration.		
Application:	All installations producing, handling and or using more than 100 tons per annum of any of the listed compounds (Excluding metallurgical processes related activities regulated under category 4).		
Substance or mixture of substances		Plant status	mg /Nm³ at 273 K, 101.3 kPa
Common name	Chemical symbol		
Total fluoride measured as Hydrogen Fluoride (from processes in which HF is evolved)	F as HF	New	5
		Existing	30
Hydrogen chloride (from primary production of hydrochloric acid)	HCl	New	15
		Existing	25
Hydrogen chloride (from secondary production of hydrochloric acid)	HCl	New	30
		Existing	100
Sulphur Dioxide	SO_2	New	350
		Existing	2800
Sulphuric acid mist and sulphur trioxide expressed as SO_3 (from processes in which SO_3 is evolved).	SO_3	New	25
		Existing	100
Oxides of Nitrogen	NOx expressed as NO_2	New	350
		Existing	2000

Table 6-4: GN 893:2013, as amended - Subcategory 7.4

Title	Subcategory 7.4: Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat.

Table 6-4: GN 893:2013, as amended - Subcategory 7.4

Description	Production, use or recovery of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium and their salts not covered elsewhere, excluding their use as catalyst.		
Application	All installations producing or using more than 1 ton per month.		
Substance or mixture of substances		Plant Status	mg/Nm^3 at 273 K and 101.3 kPa.
Common name	Chemical symbol		
Particular matter	N/A	New	10
		Existing	25

6.4 AMBIENT AIR QUALITY STANDARDS FOR ATMOSPHERIC POLLUTANTS OF POTENTIAL CONCERN

6.4.1 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR PM$_{10}$

The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery and Pope, 1994).

Air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), inhalable particulates or PM$_{10}$ (i.e. particulates with an aerodynamic diameter of equal to or less than 10 µm in diameter), and respirable particulates or PM$_{2.5}$ (i.e. particulates with an aerodynamic diameter of equal to or less than 2.5 µm in diameter). Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm , an effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM$_{10}$ and PM$_{2.5}$ are of concern due to their health impact potentials. As indicated previously, such fine particles can be deposited in, and can be damaging to, the lower airways and gas-exchanging portions of the lung.

PM$_{10}$ limits and standards issued nationally and abroad are documented in *Table 6-5*.

Table 6-5 : Air Quality Standards for Inhalable Particulates - PM_{10}

Authority	Maximum 24-hour Concentration	Annual Average Concentration
	µg/m³	µg/m³
RSA (NEMAQA)	75[a]	40
Australian Standards[b]	50	-
European Community[c]	50	40
United Kingdom[d]	50	40
United States EPA[e]	150	-
World Health Organization[f]	20	50

Notes:

- (a). Not to be exceeded more than four times in one year.
- (b). Australian Ambient Air Quality Standards. (http://www.deh.gov.au/atrnosphere/airaualitv/standards.htrnl). Not to be exceeded more than 5 days per year. Compliance by 2008.
- (c). European Commission EU Air Quality Directive (2008/50/EC), WHO, 2006, Air quality guidelines: Global update 2005. https://www.eea.europa.eu/themes/air/air-quality-standards
- (d). UK Air Quality Objectives. https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf.
- (e). US National Ambient Air Quality Standards (www.ena.gov/air/Criteria.htrnl). Not to be exceeded more than once per year on average over 3 years.
- (f). WHO Ambient (outdoor) Air Quality and Health Guideline values. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health, 2 May 2018.

6.4.2 AIR QUALITY STANDARDS & GUIDELINES FOR PM2.5

The health effects of the finer particulates are significant. International and South African recognition is held for the importance of guidelines for this pollutant. International and South African guidelines are as documented in *Table 6-6*.

Table 6-6 : Air Quality Standards for Inhalable Particulates – $PM_{2.5}$

Authority	Maximum 24-hour Concentration	Annual Average Concentration
	µg/m³	µg/m³
RSA (NEMAQA)	40[a]	20
Australian Standards[b]	25	8
European Community[c]	-	25
United Kingdom[d]	25	10
United States EPA[e]	35	15
World Health Organization[f]	25	10

Notes:

- (a). Not to be exceeded more than four times in one year.
- (b). Australian Ambient Air Quality Standards. (http://www.deh.gov.au/atrnosphere/airaualitv/standards.htrnl).
- (c). European Commission EU Air Quality Directive (2008/50/EC), WHO, 2006, Air quality guidelines: Global update 2005. https://www.eea.europa.eu/themes/air/air-quality-standards.
- (d). UK Air Quality Objectives. https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf.
- (e). US National Ambient Air Quality Standards (www.ena.gov/air/Criteria.htrnl).
- (f). WHO Ambient (outdoor) Air Quality and Health Guideline values. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health 2 May 2018.

6.4.3 AIR QUALITY STANDARDS AND GUIDELINES FOR DUSTFALL AND DUST CONTROL REGULATIONS

The National Dust Control Regulations GN 827:2013, prescribe general measures for the control of dust in all areas. Dustfall standards for acceptable dustfall rates are given in *Table 6-7* for residential and non-residential areas. The regulations also provide a method to be used for measuring dustfall rate and guideline for locating sampling points, the method to be used is AST D1739:1970, or equivalent method approved by any internationally recognised body.

Table 6-7: GN827:2013 Acceptable dustfall rates

Restriction Areas	Dustfall rate (D) (mg/m^2/day, 30-days average)	Permitted frequency of exceeding fall rate
Residential area	D <600	Two within a year, not sequential months
Non-residential area	600< D <1200	Two within a year, not sequential months

6.4.4 AIR QUALITY STANDARDS & GUIDELINES FOR SULPHUR DIOXIDE

Exposure to sulphur dioxide (SO_2) may cause upper respiratory irritation, inflammation of the respiratory tract, aggravation of asthma and chronic bronchitis and have a detrimental effect on lung function. When SO_2 combines with water, it forms sulfuric acid, this is the main component of acid rain which is a cause of deforestation (WHO, 2018). Ambient air quality guidelines and standards issued for various countries and organisations for sulphur dioxide are given in *Table* 6-8. Although the South African limits are in line with most of the international limits shown, it is important to note that the WHO air quality guidelines (WHO AQGs) published in 2000 for sulphur dioxide were significantly revised in 2005 (WHO, 2005). Although the 10-minute AQG of 500 µg/m^3 remained unchanged, the previously published daily guideline was significantly reduced from 125 µg/m^3 to 20 µg/m^3. However, WHO set an intermediate interim 24h ambient guideline target of 50 µg/m^3 based on controlling either motor vehicle emissions, industrial emissions and/or emissions from power production. It is noted that this would be a reasonable and feasible goal for some developing countries (it could be achieved within a few years) which would lead to significant health improvements that, in turn, would justify further improvements (such as aiming for the AQG value) (WHO 2005).

The previous daily guideline was based on epidemiological studies. WHO (2005) refers to more recent evidence which suggests the occurrence of health risks at lower concentrations. Although WHO (2005) acknowledges the considerable uncertainty as to whether sulphur dioxide is the pollutant responsible for the observed adverse effects (may be due to ultra-fine particles or other correlated substances), it took the decision to publish a stringent daily guideline in line with the precautionary principle. WHO (2005) stipulates an annual guideline is not needed for the protection of human health, since compliance with the 24-hour level will assure sufficiently low levels for the annual average.

Table 6-8 : Air quality standards for Sulphur Dioxide (SO_2)

Table 6-8 : Air quality standards for Sulphur Dioxide (SO_2)

Authority	Maximum 10-minute Average	Maximum 1-hour Average	Maximum 24-hour Average	Annual Average
	µg/m^3	µg/m^3	µg/m^3	µg/m^3
RSA (NEMAQA)(a)	500	350	125	50
Australian Standards*(b)		530	210	53
European Community(c)		350	125	
United Kingdom(d)		350	125	
United States EPA*(e)	200			
World Health Organization(f)	500		125(g) (20)(h)	

Notes:
(a). Not to be exceeded more than the allowable number of exceedances.
(b). Australian Ambient Air Quality Standards. (http://www.deh.gov.au/atrnosphere/airaualitv/standards.htrnl).
(c). European Commission EU Air Quality Directive (2008/50/EC), WHO, 2006, Air quality guidelines: Global update 2005. https://www.eea.europa.eu/themes/air/air-quality-standards
(d). UK Air Quality Objectives. https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf.
(e). US National Ambient Air Quality Standards (www.ena.gov/air/Criteria.htrnl).
(f). WHO Ambient (outdoor) Air Quality and Health Guideline values. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health 2 May 2018.
(g). WHO Interim target.
(h). WHO proposed final air quality guideline.

*Values calculated using European commission conversion factor. https://uk-air.defra.gov.uk/assets/documents/reports/cat06/0502160851_Conversion_Factors_Between_ppb_and.pdf

6.4.5 AIR QUALITY STANDARDS & GUIDELINES FOR NITROGEN OXIDES

Ambient air quality guidelines and standards issued for various countries and organisations for sulphur dioxide are given in Table 6-9. The South African limit threshold is in line with other international limits, but the 1-hour frequency of exceedances allowed is less stringent.

Table 6-9 : Air Quality Standards for Nitrogen Dioxide (NO_2)

Authority	Maximum 1-hour Concentration	Annual Concentration
	µg/m^3	µg/m^3
RSA (NEMAQA)(a)	200	40
Australian Standards*(b)	230	57
European Community(c)	200	40
United Kingdom(d)	200	40
United States EPA*(e)	192	101
World Health Organization(f)	200	40

Notes:
(a). Not to be exceeded more than the allowable number of exceedances.
(b). Australian Ambient Air Quality Standards. (http://www.deh.gov.au/atrnosphere/airaualitv/standards.htrnl).
(c). European Commission EU Air Quality Directive (2008/50/EC), WHO, 2006, Air quality guidelines: Global update 2005. Not to be exceeded more than 35 times a year. https://www.eea.europa.eu/themes/air/air-quality-standards
(d). UK Air Quality Objectives. Not to be exceeded more than 18 times a year. https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf.
(e). US National Ambient Air Quality Standards (www.ena.gov/air/Criteria.htrnl).
(f). WHO Ambient (outdoor) Air Quality and Health Guideline values. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health 2 May 2018.

*Value calculated using European commission conversion factor. https://uk-air.defra.gov.uk/assets/documents/reports/cat06/0502160851_Conversion_Factors_Between_ppb_and.pdf.

6.4.6 AIR QUALITY IMPACTS STANDARDS & GUIDELINES FOR SULPHURIC ACID

The most important toxicokinetic issue concerning sulphuric acid aerosols is deposition in the respiratory tract. Once deposited in the respiratory tract, the high moisture content of this environment results in the rapid dissociation of sulphuric acid into hydrogen ions (H^+) and hydrated sulphate ion, which readily combine with other ions present in the body. Some neutralisation of the acid droplets can occur, prior to deposition due to the normal excretion of endogenous ammonia in the respiratory tract. The H^+ is either neutralized, buffered by the mucous layer or is absorbed by the tissues in the respiratory tract. Following this deposition and neutralisation process, any H^+ that does not react with, or is buffered by the mucous layer is absorbed by the tissues in the respiratory tract. The hydrated sulphate anion from sulphuric acid is absorbed into the bloodstream and enters the body's electrolyte pool. Sulphate is a normal constituent of blood and is a metabolite of sulphur-containing amino acids. The human body's electrolyte pool for sulphate anions is believed to be large. The body will excrete any excess sulphate in the electrolyte pool via the urine. Therefore, sulphate from sulphuric acid is excreted in the urine, and likely plays no specific toxicological roles.

Sulphuric acid is a direct irritant that exerts its effects at the site of contact. Symptoms of acute inhalation exposure to sulphuric acid include lung irritation, coughing, and shortness of breath. High exposure levels can result in pulmonary oedema and severe shortness of breath. There is considerable variation in response due to exposure, depending on such factors as concentration, aerosol size, relative humidity, breathing rate, age, health status, and level of physical activity. Asthmatics appear to be particularly sensitive to the pulmonary irritation produced by exposure to sulphuric acid. In human studies of healthy individuals, mild respiratory function has been reported at exposure concentrations as low as 350 µg/m³, and latent effects following a single exposure have been reported at a concentration of 450 µg/m³. (Ontario Ministry of the Environment, 2007)

There is no Ambient Air Quality Standard set for Sulphuric Acid in South Africa. In Ontario the 24-hour Ambient Air Quality Standard for sulphuric acid is 5 µg/m³ based on the respiratory effects of the compound. Alberta, Canada, has a 1-hour ambient average limit of 10 µg/m³, whereas California and Michigan, USA have 1-hour ambient average limits of 120 µg/m³. The Alberta Air Quality Standards indicate that the 1-hour ambient average limit of 10 µg/m³ is adopted from the State of Texas, USA. However, when reviewing the Texas standards, it is clear that the 1-hour limit is 50 µg/m³. It is unclear whether or not there is an error in the Alberta Standard. The Alberta standard is thus not used in this assessment, and the Texas limit of 50 µg/m³ is adopted for this assessment as the most stringent of the remaining sources.

Michigan and Massachusetts, USA have annual ambient average limits of 1 and 2.72 µg/m³, respectively (Table 6-10).

Table 6-10: Air Quality Standards for Sulphuric Acid (H_2SO_4)

Authority	Maximum 1-hour Concentration	Maximum 24-hour Concentration	Annual Concentration
	µg/m³	µg/m³	µg/m³
Alberta, Canada(a)	10		
Texas, USA	50	15	
California, USA(c)	120		1
Ontario, Canada(d)		5	
Massachusetts, USA(e)			2.72
Michigan, USA(f)	120		1

Notes:

(a). Alberta, 2009, Alberta Ambient Air Quality Objectives and Guidelines.

(b). Texas Natural Resource Conservation Commission Chapter 112 - Control of Air Pollution From Sulfur Compounds 112.41 Control Of Sulfuric Acid. Emissions Limits: https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/112%60.pdf

(c). California, 2010, OEHHA Acute, 8-hour and Chronic Reference Exposure Levels (RELs).

(d). Ontario's Ambient Air Quality Criteria, 2012, Standards Development Branch Ontario Ministry of the Environment.

(e). MassDEP Ambient Air Toxics Guidelines, Massachusetts Government, Department of Energy and Environmental Affairs, https://www.mass.gov/service-details/massdep-ambient-air-toxics-guidelines#Background

(f). Michigan Department Environmental Quality - Air Quality Division, List of Screening Levels (ITSL, IRSL and SRSL) in Alphabetical Order,

6.4.7 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR HEPTANE

Heptane vapour is heavier than ambient air (CAMEO, 1999), as a result the chemical does not readily disperse from the source. Inhalation symptoms are generally associated with irritation of the respiratory tract, coughing and difficulty breathing. Inhalation of large quantities of n-heptane can potentially lead to suffocation. The US EPA classifies n-heptane as non-carcinogenic to human health (USEPA, 1993). There is no Ambient Air Quality Standard set for Heptane in South Africa. In Ontario, Canada and Vermont, USA the 24-hour ambient air quality standard for n-heptane is 11 000 and 7 000 µg/m³, respectively. Michigan, USA has an 8-hour ambient average limit of 3 500 µg/m³ (Table 6-11).

Table 6-11: Air Quality Standards for Heptane (-n)

Authority	Maximum 8-hour Concentration	Maximum 24-hour Concentration
	µg/m³	µg/m³
Ontario, Canada(a)		11 000
Michigan, USA(b)	3 500	
Vermont, USA(c)		7 000

Notes:

a) Ontario's Ambient Air Quality Criteria, 2012, Standards Development Branch Ontario Ministry of the Environment

b) Michigan Department Environmental Quality - Air Quality Division, List of Screening Levels (ITSL, IRSL and SRSL) in Alphabetical Order, https://www.michigan.gov/documents/deq/deq-aqd-toxics-ITSLALPH_244167_7.pdf

c) State of Vermont, 2007, Air Pollution Control Regulations.

6.4.8 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR ETHANOL

Ethanol is a primary alcohol, also known as ethyl alcohol. Ethanol is a volatile, organic liquid mainly used as an antiseptic drug, a polar solvent, a neurotoxin, a central nervous system depressant, a teratogenic agent, a disinfectant, and an Escherichia coli (E. coli) metabolite. Ethanol is flammable in both states of gas and liquid. Inhalation exposure to ethanol may result in irritation of the air passages, dizziness, and suffocation. Contact exposure to liquid ethanol may cause skin irritation and burning. The most hazardous effects of ethanol are the vapours released during combustion, these vapours may be irritating, corrosive and/or toxic to human health (ERG, 2016). Ontario, Canada and Massachusetts, USA have 1-hour ambient average limits of 19 000 and 51.24 µg/m^3, respectively. Massachusetts, USA has an annual ambient average limit of 51.24 µg/m^3 (Table 6-12).

Table 6-12: Air Quality Standards for Ethanol (VOC)

Authority	Maximum 1-hour Concentration	Annual Average Concentration
	µg/m^3	µg/m^3
Ontario, Canada[(a)]	19 000	
Massachusetts, USA[(b)]	51.24	51.24

Notes:

a) Ontario's Ambient Air Quality Criteria, 2012, Standards Development Branch Ontario Ministry of the Environment

b) MassDEP Ambient Air Toxics Guidelines, Massachusetts Government, Department of Energy and Environmental Affairs, https://www.mass.gov/service-details/massdep-ambient-air-toxics-guidelines#Background

6.4.9 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR MENADIONE SODIUM BISULPHITE (MSB)

Menadione sodium bisulphite (MSB) is an organic sodium salt. MSB is a synthetically produced vitamin K_3. Inhalation of MSB may cause human health hazards including irritation of the eyes, respiratory tract, and skin. The response due to MSB exposure by the immune system may lead to lung damage. Excessive inhalation of the particulates within impaired respiratory systems, containing existing diseases or respiratory conditions such as bronchitis, may incur further disability of respiratory functions (SCBT, 2009). No international or South African air quality standards for MSB had been identified at the time of reporting.

6.4.10 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR MENADIONE NICOTINAMIDE BISULPHITE (MNB)

Menadione Nicotinamide Bisulphite (MNB) is a yellowish odourless powder. MNB is a synthetically produced vitamin K_3. The health effects of MNB have not been extensively assessed, although MNB occurs in the atmosphere as dust particles of <50 µm (EFSA, 2004), as a result inhalation of dust is assessed. Inhalation of MNB may result in irritation of the respiratory pathways. No international or South African air quality standards for MNB had been identified at the time of reporting.

6.4.11 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR SODIUM SULPHATE

Sodium sulphate is an organic salt that occurs in almost all fresh water and salt waters. Sodium sulphate is produced in vast amounts for use in industry such as the manufacture of detergents, glass and paper. Sodium sulphate is present in households, in laundry powders ranging from 20.8% to 56.7% (HERA, 2006). Due to exposure to large amounts of sodium sulphate, the salt is not considered to have adverse human health effects. Localised peak environmental concentrations may be detrimental to flora and fauna. No international or South African air quality standards for Sodium Sulphate had been identified at the time of reporting.

6.4.12 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR AMMONIA

Ammonia is a naturally occurring, colourless, acrid-smelling gas. It is widely used in a variety of manufacturing processes but is mostly used as a fertilizer. Much of the ammonia in air results from the decomposition of organic matter and other biological activities. Ammonia vapour is an irritant to the eyes and the respiratory tract. Damage to the bronchial epithelium and the alveolar membrane have been documented at high concentrations while severe acute over-exposure can lead to death within minutes. Ammonia in high concentrations (liquid or gas) will kill most organisms. Nonetheless, since it is readily diluted and degraded in air, it does not stay airborne for more than a week. Ammonia from accidental spills or emissions does not persist in the environment. However, elevated ammonia concentrations over a long period of time may occur where there are intensive manure applications and animal farming activities, and which may eventually be detrimental to the environment. (Ontario Ministry of the Environment, 2001).

There is no Ambient Air Quality Standard set for Ammonia in South Africa. Ontario, Canada and Massachusetts, USA have 24-hour ambient average limits of 100 µg/m³. Massachusetts, USA also has an annual ambient average limit of 100 µg/m³ (Table 6-13).

Table 6-13: Air Quality Standards for Ammonia (NH_3)

Authority	Maximum 1-hour Concentration	Maximum 24-hour Concentration	Annual Concentration
	µg/m³	µg/m³	µg/m³
Alberta, Canada[(a)]	1 400		
California, USA[(b)]		200	
Ontario, Canada[(c)]		100	
Massachusetts, USA[(d)]		100	100
Michigan, USA[(e)]	350		
New Zealand[(f)]			8
Vermont, USA[(g)]			100

Table 6-13: Air Quality Standards for Ammonia (NH_3)

Authority	Maximum 1-hour Concentration	Maximum 24-hour Concentration	Annual Concentration
	µg/m³	µg/m³	µg/m³

Notes:
(a). Alberta, 2009, Alberta Ambient Air Quality Objectives and Guidelines.
(b). California, 2010, OEHHA Acute, 8-hour and Chronic Reference Exposure Levels (RELs).
(c). Ontario's Ambient Air Quality Criteria, 2012, Standards Development Branch Ontario Ministry of the Environment.
(d). MassDEP Ambient Air Toxics Guidelines, Massachusetts Government, Department of Energy and Environmental Affairs, https://www.mass.gov/service-details/massdep-ambient-air-toxics-guidelines#Background
(e). Michigan Department Environmental Quality - Air Quality Division, List of Screening Levels (ITSL, IRSL and SRSL) in Alphabetical Order, https://www.michigan.gov/documents/deq/deq-aqd-toxics-ITSLALPH_244167_7.pdf.
(f). New Zealand, 2002, Ambient Air Quality Guidelines, 2002 Update.
(g). State of Vermont, 2007, Air Pollution Control Regulations.

6.4.13 AIR QUALITY IMPACT, STANDARDS & GUIDELINES FOR CHROMIUM COMPOUNDS

Elemental chromium (Cr) does not occur in nature, but is present in ores, primarily chromite ($FeCr_2O_4$). Chromite is the primary source of chromium for Brother CISA's operations and is transformed to hexavalent chromium products as noted in 3.1.1 of this report. The proposed processes will produce trivalent chromium products. Only two of the several oxidation states of chromium, Cr(III) and Cr(VI), are reviewed herein based on the anticipated emissions from the site and the stability of these oxidation states in the ambient environment.

Chromium(III) is poorly absorbed, regardless of the route of exposure, whereas chromium(VI) is more readily absorbed. Animal studies show that Cr(VI) is generally more toxic than Cr(III), but neither oxidation state is very toxic by the oral route (RAIS, 1992). In cognisance of this, and in cognisance of emissions to the atmosphere with subsequent dispersion to potential receptors being the pathway of most likely significance, this assessment focuses on environmental exposure via inhalation.

According to Ontario Ministry of Environment, studies in rats have examined the lethality of hexavalent chromium compounds, including chromium trioxide, sodium chromate and potassium chromate. The 4-hour LC_{50}[1] values ranged from 29 mg/m^3 in females exposed to potassium chromate up to 137 mg/m^3 in males exposed to chromium trioxide (Ontario 2004).

According to the U.S. Department of Energy (DOE), Office of Environmental Management, estimated acute exposure Cr(VI) LC_{50} values for humans range from 5 mg/m^3 for zinc chromate to 94 mg/m^3 for potassium dichromate. The inhalation of chromium can cause nasal ulcers and perforation of the nasal septum. The perforation lesions do not disappear when exposure ceases. Nasal irritation has been observed following short-term exposure to chromium levels of <0.01 mg/m^3 (RAIS, 1992).

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[1] LC_{50} is the mean concentration resulting in 50% lethality of an exposed population and is a measure of toxicity.

In respect of animals acute exposure the estimated LC_{50} values in the Sprague Dawley rat (males and females combined) exposed to Cr(VI) compounds are: 158 mg/m^3 for ammonium dichromate, 104 mg/m^3 for sodium chromate, and 94 mg/m^3 for potassium dichromate. Clinical signs of toxicity include respiratory distress and irritation and body weight loss. Lethality data were not found for Cr(III) compounds (RAIS, 1992).

These exposure levels are orders of magnitude higher than those anticipated for ambient exposure due to Brother CISA's emissions and thus chronic exposure is the focus of the assessment.

Results of occupational epidemiologic studies of chromium-exposed workers are consistent across investigators and study populations. Dose response relationships have been established for chromium exposure and lung cancer. Chromium-exposed workers are exposed to both Cr (III) and Cr(VI) compounds. However, because only Cr(VI) has been found to be carcinogenic in animal studies, it was concluded that only Cr(VI) should be classified as a human carcinogen" (U.S. EPA, 1991)

6.4.13.1 TOXICOLOGY OF CR(VI)

The following toxicological review of chromium is focused primarily on the inhalation route of exposure.

The key criterion for assessing the risk of inhalation exposure to Cr(VI) compounds is their carcinogenic potential. Cr(VI) is known to be carcinogenic in humans by the inhalation route of exposure. The International Agency for Research on Cancer (IARC, 1990) concluded that there is sufficient evidence in humans for the carcinogenicity of hexavalent chromium compounds as encountered in chromate production, chromate pigment production and chromium plating industries (where inhalation is the primary route of exposure).

As the bronchial tree is the major target organ for carcinogenic effects of Cr(VI) compounds, and cancer primarily occurs following inhalation exposure, uptake in the respiratory organs is of great significance in respect of the subsequent risk of cancer in humans).

According to the International Agency for Research on Cancer (IARC) there is sufficient evidence in humans for the carcinogenicity of Cr(VI) compounds. Cr(VI) compounds cause cancer of the lung. Also positive associations have been observed between exposure to Cr(VI) compounds and cancer of the nose and nasal sinuses. There is sufficient evidence in experimental animals for the carcinogenicity of Cr(VI) compounds.
Cr(VI) compounds are carcinogenic to humans (Group 1) (IARC, 2012).

Following oral exposure, absorption of chromium in the gastrointestinal tract is low, at an estimated 5% or less. Studies on the uptake of Cr(VI) compounds in the gastrointestinal tract indicate that the rate of uptake is to a great extent governed by the water solubility of the compounds. Results from in vitro studies indicate that gastrointestinal juices are capable of reducing Cr(VI) to Cr(III); however, data from in vivo studies are insufficient to demonstrate whether this reduction process has the capacity to eliminate any differences in absorption between ingested Cr(VI) and Cr(III) compounds. Pulmonary cells have been shown in vitro to have some capacity to reduce hexavalent chromium; however, this capacity is low compared to that of liver cells (WHO, 2000).

According to WHO (2000), chrome ulcers, corrosive reactions on the nasal septum, acute irritative dermatitis and allergic eczematous dermatitis have also been recorded among subjects exposed to Cr(VI) compounds.

6.4.13.2 RISK ASSESSMENT UNIT RISK COEFFICIENTS AS BASIS FOR STANDARDS

The World Health Organization (WHO) and some countries, most notably the US, have based air quality standard setting on quantitative risk assessment methods. This approach seeks to extrapolate occupational and other data to lower concentrations and therefore to quantify the additional risk of cancer at concentrations likely to occur in the environment. There are many ways in which this extrapolation can be made depending upon the assumed mechanism of carcinogenesis. It should be noted that quantitative risk estimates should not be regarded as being equivalent to the true cancer risk but represent plausible upper bounds which may vary widely according to the assumptions on which they are based (WHO, 2000). Quantitative risk assessment gives a unit risk factor which can be used to calculate the concentrations of an airborne pollutant associated with a particular level of excess lifetime cancer risk. This means over and above other existing cases, also known as incremental cancer risk

In this respect the WHO (2000) calculates that if it assumed that a linear dose–response relationship between exposure to Cr(VI) compounds and lung cancer exists, that no safe level of Cr(VI) can be recommended; however, the WHO does not adequately differentiate between species of Cr(VI) compounds and extrapolates to estimate them. At an air concentration of Cr(VI) of 1 µg/m^3, the lifetime risk for lung cancer is estimated to be 1:25 (derived by averaging the results of studies of four cohorts of chromate production workers (WHO, 2000)).

Reference Concentration (RfC) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a no observable adverse effects level (NOAEL), lowest observable adverse effects level (LOAEL), or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used.

The RfC for non-cancer effects arising from exposure to Cr(VI), in the form of chromic acid mists and dissolved Cr(VI) aerosols, is 8 ng/m^3 (0.008 µg/m^3) based on nasal septum atrophy in exposed workers. This is an estimate of an airborne concentration that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfC for non-cancer effects arising from exposure to Cr(VI) as particulates is 100 ng/m^3 (0.10 µg/m^3) based on the results of a 90 day study in rats. The confidence of the USEPA in their RfCs for chromic acid mists and Cr(VI) dusts are low and medium, respectively. The same agency has estimated the unit risk factor for lifetime (lung) cancer risk arising from exposure to Cr(VI) to be 1.2×10^{-2} per µg/m^3 in air (USEPA, 1998). It should be noted this is a unitless risk per µg/m^3 of Cr(VI) in ambient air.

Care should be taken when deriving air quality standards from unit risk coefficients such as those proposed by the WHO and US EPA because of the inherent uncertainty involved in extrapolating from observed effects at high levels of exposure to responses at the much lower concentrations commonly associated with environmental exposure. Uncertainty factors have been factored into these “safe” levels. Uncertainty factors are incorporated for human interindividual variation, interspecies extrapolating (e.g from animals to humans), extrapolating from high to low concentrations, and extrapolating from acute to chronic exposure, amongst others. A selected NOAEL or benchmark dose/concentration may have various factors and depending on how many factors of uncertainty these may range from 10 to 1000, with a 100-fold default value being common (WHO 2008).

In the context of this assessment the intent is to undertake a predictive risk assessment. Therefore, the inhalation unit risk values and international ambient air quality standards are used to determine the potential risk associated with lifetime exposure to ambient concentrations of Cr(VI) resulting from Brother CISA's predicted emissions.

6.4.13.3 EXISTING AIR QUALITY GUIDELINES FOR CHROMIUM COMPOUNDS

Internationally, there is an increasing trend towards the specification of air quality limits for certain metals and various international standards for chromium compounds have been set by various environmental authorities including various US States and EU Countries. Notably neither the federal US government nor the EU governing council have set standards for chromium and its compounds. The German Technical Instructions on Air Quality Control (TA Luft) are in place to protect the environmental and human health from harmful effects of air pollution (TA Luft, 2002). The technical instructions identify Cr(VI) as a carcinogenic substance, hence the emission concentration of waste gas of a new installation may not exceed 0.05 mg/m^3.

It is notable from Table 6-14 below that there are numerous international ambient air quality standards which exist for Cr(VI) and that these vary significantly in magnitude and are based on varying methodologies and source data. A sound scientific basis for selecting a single ambient standard for chronic exposure assessment is not possible within the scope of this study. However, it is notable that both WHO and US EPA have inhalation unit risks for cancer risk assessment and therefore a cancer risk assessment approach based on lifetime exposure provides a sound basis for chronic exposure assessment. Notably, given that there is one ambient air quality standard for acute exposure (hourly), that standard will accordingly be used to address acute exposure.

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
Canada (CEPA)	0.66 µg/m^3 (TC_{05}) For hexavalent chromium	Lung cancer in chromate production plant workers (Mancuso, 1975)	1993	A Tumorigenic Concentration (TC_{05}) is the concentration generally in air associated with a 5% increase in incidence or mortality due to tumours. The TC_{05} of 0.66 µg/m^3 corresponds to a concentration of 1.32x10^{-5} µg/m^3 of chromium (VI) in air for an increased cancer risk of 1x10^{-6}.
	4.6 µg/m^3 (TC_{05}) For total chromium	Lung cancer in chromate production plant workers (Mancuso, 1975)	1993	The TC_{05} of 4.6 µg/m^3 corresponds to a concentration of 0.011µg/m^3 of chromium (total) in air for an increased cancer risk of 1x10^{-6}.
Alberta	1.0 µg/m^3 (1-hour average)	Based on Texas' short-term ESL for chromium (metal)	2000	Ambient Air Quality Guideline.
Manitoba	4.5 µg/m^3 (1-hour average)	Basis is unknown	1985	Maximum Acceptable Level Concentration.
Ontario (MOE)	5 µg/m^3 (½-hour average, POI) For di-, tri- and hexavalent forms 1.5 µg/m^3 (24-hour AAQC) For di-, tri- and hexavalent forms	Health considerations	1982	Half-hour Point of Impingement standard. 1-Hour Ambient Air Quality Criterion (AAQC).
Ontario	3.5x10^{-4} µg/m^3	Ambient Air Quality	2012	Ambient Air Quality Guideline.

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[1] Guidelines in this table can refer to: guidelines, risk-specific concentrations based on cancer potencies, and non-cancer-based reference concentrations.

[2] Date here refers to when the health-based guideline background report or original legislative initiative was issued. The sources were the respective agency documents. For the US EPA, date refers to when the latest review of the RfC was conducted, if applicable, or the date the IRIS database was accessed, in the case where no RfC has been developed

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
	(24-hour average) For hexavalent chromium	Criteria		
	7x10^{-5} μg/m^3 (Annual average) For hexavalent chromium		2012	Ambient Air Quality Guideline.
Quebec (MENV)	8.0x10^{-5} μg/m^3 (Annual average) For hexavalent chromium	Based on the US EPA's inhalation unit cancer risk of 1.2x10^{-2} (μg/m^3)$^{-1}$	1998	Air Quality Criteria – the criteria value is the concentration of chromium (VI) in air associated with an increased cancer risk of 1x10^{-6}.
	4x10^{-3} μg/m^3 (Annual average) For hexavalent chromium	Basis is unknown	2014	Ambient Air Quality Guideline.
US EPA (IRIS)	8x10^{-3} μg/m^3 (RfC) For chromic acid mists and dissolved Cr(VI)aerosols	Observed nasal septum atrophy (Hedenstierna, 1983)	1998	Reference Concentration for inhalation (RfC).
	0.1 μg/m^3 (RfC) For hexavalent chromium particulates	Lactate dehydrogenase in bronchioalveolar lavage fluid (Glaser et al., 1990; Malsch et al., 1994)	1998	
	8x10^{-5} (μg/m^3)$^{-1}$ For hexavalent chromium	Increased incidence of lung cancer in exposed workers (Mancuso, 1975)	1998	1x10^{-6} additional cancer risk based on an inhalation unit risk of 1.2x10^{-2} (μg/m^3)$^{-1}$.
California (OEHHA)	0.2 μg/m^3 (Chronic REL for hexavalent chromium compounds)	Bronchoalveolar hyperplasia in rats (Glaser et al., 1990)	2001	Chronic Reference Exposure Level for hexavalent chromium compounds.
	0.002 μg/m^3 (Chronic REL for chromium trioxide as chromic acid mist)	Nasal atrophy, nasal mucosal ulcerations, nasal septal	2001	Chronic Reference Exposure Level for chromium trioxide as chromic acid mist.

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
		perforations, transient pulmonary function changes in humans (Lindberg and Hedenstierna, 1983)		
	7.0x10^{-6} µg/m^{3} (Cancer effect for chromium compounds)	Lung cancer deaths among employees of a chromate plant (Mancuso, 1975)	1986	1x10^{-6} additional cancer risk based on a unit risk of 1.5x10^{-1} (µg/m^{3})$^{-1}$.
Louisiana (DEP)	0.01 µg/m^{3} (annual)	TLV-TWA from ACGIH	1997	Ambient air standard.
Massachusetts (DEP)	0.003 µg/m^{3} (24-hour, TEL) 1.0x10^{-4} µg/m^{3} (annual, AAL) For chromic acid	Based on NIOSH's TWA-REL of 1.0 µg/m^{3}	1995	Threshold Effects Exposure Limit (TEL). Allowable Ambient Limit (AAL).
	1.36 µg/m^{3} (24-hour, TEL) 0.68 µg/m^{3} (annual, AAL) For chromium (metal)	Based on the ACGIH's TLV-TWA of 500 µg/m^{3}		
	0.003 µg/m^{3} (24-hour, TEL) 1.0x10^{-4} µg/m^{3} (annual, AAL) For hexavalent chromium compounds	Based on NIOSH's TWA-REL of 1.0 µg/m^{3}		
Michigan (DEQ)	0.5 µg/m^{3} (24-hour average ITSL) For chromic (+3) oxide and chromium (+3) hydroxide	Based on respiratory tract effects observed in exposed rats (Derelanko et al. 1999)	2000	Initial Threshold Screening Level. Used for permitting.
	0.008 µg/m^{3} (24-hour ITSL) 8.3x10^{-5} µg/ m^{3} (annual IRSL) 8.3x10^{-4} µg/ m^{3} (annual SRSL) These values were derived for hexavalent chromium mist	Based on the US EPA's RfC Based on the US EPA's inhalation unit risk Based on the US EPA's inhalation unit risk	1998	Initial Threshold Screening Level. Used for permitting. Initial Risk Screening Level (IRSL). Secondary Risk Screening Level (SRSL).

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
	0.1 µg/m^{3} (24-hour ITSL) 8.3x10^{-5} µg/ m^{3} (annual IRSL) 8.3x10^{-4} µg/ m^{3} (annual SRSL) These values were derived for hexavalent chromium particulate	Based on the US EPA's RfC Based on the US EPA's inhalation unit risk Based on the US EPA's inhalation unit risk	1998	Initial Threshold Screening Level. Used for permitting. Initial Risk Screening Level (IRSL). Secondary Risk Screening Level (SRSL).
	5 µg/ m^{3} (8-hour ITSL) For trivalent chromium	Based on the ACGH's TLV-TWA	1995	Initial Threshold Screening Level. Used for permitting.
	0.1 µg/m^{3} (Annual average) For hexavalent chromium	Basis is unknown	2017	Ambient Air Quality Guideline.
New Jersey (DEP)	8.0x10^{-3} µg/ m^{3} (RfC) For chromic acid mists (Cr VI) and dissolved hexavalent chromium aerosols	Based on the US EPA's RfC	2003	Reference Concentration for Inhalation.
	0.1 µg/m^{3} For hexavalent chromium particulates	Based on the US EPA's RfC	2003	
	2.0x10^{-3} µg/m^{3} For total chromium	Based on the US EPA's HEAST (1997)	2003	
	8x10^{-5} µg/m^{3} For hexavalent chromium	Based on the US EPA's inhalation unit risk value	2003	1x10^{-6} additional cancer risk based on a unit risk of 1.2x10^{-2} (µg/m^{3})$^{-1}$.
New York (DEC)	4.2x10^{-5} – 6.3x10^{-5} µg/m^{3} (annual, AGCs) For various chromic acid compounds	Based on the chronic REL of the OEHHA for chromium trioxide as chromic acid mist	2003	The values for the individual compounds were adjusted based on the ratio of the molecular weights.
	1.2 µg/m^{3} (annual, AGC) For chromium (elemental)	Based on the ACGIH's TLV-TWA	2003	Ambient Guideline Concentration. Used for permitting.
	4.5x10^{-5} – 0.59 µg/m^{3} (annual, AGCs) For various chromium compounds	Based on the ACGIH's TLV-TWA	2003	The values for the individual compounds were adjusted based on the ratio of the molecular weights.

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
	0.1 µg/m³ (annual, AGC) For trivalent chromium	Based on the ACGIH's TLV-TWA	2003	Ambient Guideline Concentration. Used for permitting.
	2.0×10^{-5} µg/m³ (annual, AGC) For hexavalent chromium	Based on the chronic REL of the OEHHA for chromium trioxide as chromic acid mist	2003	Ambient Guideline Concentration. Used for permitting.
North Carolina (DENR)	0.62 µg/m³ (24-hour, AAL) For soluble chromate compounds, as hexavalent chromium equivalent	Basis is unknown.	1987	Acceptable ambient level (AAL). Used for permitting.
	8.3×10^{-5} µg/m³ For bioavailable chromate pigments and non-specific hexavalent chromium compounds, as hexavalent chromium equivalent	Based on the US EPA's inhalation unit risk	1987	1×10^{-6} additional cancer risk based on a unit risk of 1.2×10^{-2} (µg/m³)$^{-1}$.
Texas (TCEQ)	1.0 µg/m³ (1-hour ESL) 0.1 µg/m³ (annual ESL) For chromium metal and chromium (II) and (III) compounds	TLV from ACGIH	Not stated	Short-term Effects Screening Level. Long-term Effects Screening Level. Used for permitting.
	0.1 µg/m³ (1-hour ESL) 0.01 µg/m³ (annual ESL) For chromium trioxide, chromic acid, chromate and hexavalent chromium compounds			
	4.3×10^{-3} µg/m³ (Annual average) For Hexavalent chromium	Based on an inhalation unit risk factor (URF) of 2.3x10-3 per µg/m³ and a no significant risk level of 1 in 100 000 excess cancer risk, and	2014	Ambient Air Quality Guidelines.

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments
		applicable to all forms of Cr(VI) compounds.		
Vermont	8.3×10^{-5} µg/m^3 (Annual average) For hexavalent chromium	Air Pollution Control Regulations	2007	Ambient Air Quality Guidelines.
The Netherlands (RIVM)	2.5×10^{-5} µg/m^3 (annual, target value) 2.5×10^{-3} µg/m^3 (annual, MPC)	Based on the WHO inhalation unit risk for hexavalent chromium	1999	Maximum Permissible Concentration (MPC). The MPC is used for emissions permitting purposes. The target value represents a long-term air quality goal.
New Zealand	1.1×10^{-3} µg/m^3 (Annual average) For hexavalent chromium	Top end of WHO values but lower than the US EPA's carcinogen value.	2002	Ambient Air Quality Guideline.
European Union (EU)	21 µg/m^3 (HT25)	Based on the US EPA's inhalation unit risk of 1.2×10^{-2} (µg/m^3)$^{-1}$	2002	The HT25 is human dose equivalent of the chronic daily dose rate which will give 25% of the animals' tumours at a specific tissue (Sanner et al., 2002).
WHO (Europe)	2.5×10^{-5} µg/m^3 For hexavalent chromium	Increased incidence of cancer in exposed chromate workers. The inhalation unit risk value was derived by calculating the geometric mean of the accepted study lifetime risks identified by the WHO [range of risk estimates from 0.13-0.011 (µg/m^3)$^{-1}$]	2000	Ambient air guideline value. 1×10^{-6} additional cancer risk based on a derived unit risk of 4×10^{-2} (µg/m^3)$^{-1}$.

[1] Guidelines in this table can refer to: guidelines, risk-specific concentrations based on cancer potencies, and non-cancer-based

Table 6-14: Summary of Existing Air Quality Guidelines for Chromium (Ontario, 2004)

Agency	Guideline Value[1]	Basis of Guideline[2]	Date	Comments

reference concentrations.

[2] Date here refers to when the health-based guideline background report or original legislative initiative was issued. The sources were the respective agency documents. For the US EPA, date refers to when the latest review of the RfC was conducted, if applicable, or the date the IRIS database was accessed, in the case where no RfC has been developed

6.4.13.4 DEFINING ACCEPTABLE RISK

The notion that there is some level of risk that everyone will find acceptable is a difficult idea to reconcile and yet, without such a baseline, it may never be possible to set guideline values and standards, given that life can never be risk free.

One definition of acceptable risk that has been widely accepted in environmental regulation, is if lifetime exposure to a carcinogenic substance increases a person's chance of developing cancer by one chance in a million or less. This level, which has come to be taken as 'essentially zero', was apparently derived in the US in the 1960s during the development of guidelines for safety testing in animal studies. A figure, for the purposes of discussion, of 1 chance in 100 million (or 10^{-8}) of developing cancer was put forward as safe. This figure was adopted by the Food and Drug Administration in 1973, but amended to one in a million in 1977. This level of 10^{-6} has been seen as something of a gold standard ever since. The US Environmental Protection Agency (EPA) typically uses a target reference risk range of 1 in 10 000 to 1 in 1 000 000 (or 10^{-4} to 10^{-6}) for carcinogens in drinking water, which is in line with World Health organization (WHO) guidelines for drinking water quality which, where practical, base guideline values for genotoxic carcinogens on the upper bound estimate of an excess lifetime cancer risk of 1 in 100 000 (or 10^{-5}) (Adapted from WHO 2001).

According to WHO 2001, similar approaches have been adopted elsewhere and for other risks. In the UK, for example, the Health and Safety Executive (HSE) adopted the following levels of risk, in terms of the probability of an individual dying in any one year:

- 1 in 1000 as the 'just about tolerable risk' for any substantial category of workers for any large part of a working life.
- 1 in 10,000 as the 'maximum tolerable risk' for members of the public from any single non-nuclear plant.
- 1 in 100,000 as the 'maximum tolerable risk' for members of the public from any new nuclear power station.
- 1 in 1,000,000 as the level of 'acceptable risk' at which no further improvements in safety need to be made.

These probabilities may alternatively be represented as a percentage probability of occurring as illustrated in Table 6-15 below (Adapted from WHO 2001).

Table 6-15: Risk expressed as a probability of occurring

Percentage likelihood	Fraction	Risk description
0.1% to 0.01%	1 in 1 000 to 1 in 10 000	'just about tolerable risk' for any substantial category of workers for any large part of a working life
0.01% to 0.001%	1 in 10 000 to 1 in 100 000	maximum tolerable risk' for members of the public from any single non-nuclear plant
0.001% to 0.0001%	1 in 100 000 to 1 in 1 000 000	maximum tolerable risk' for members of the public from any new nuclear power station
Less than 0.0001%	Less than 1 in 1 000 000	'acceptable risk' at which no further improvements in safety need to be made

In general, regulatory agencies tend to use default approaches for carcinogens. For risks calculated to be linear at low doses, agencies use acceptable risk levels ranging from 1 in 10 000 to 1 in 1 000 000 (or 10^{-4} to 10^{-6}) (Niemi 2013).

The cancer risk range that is deemed acceptable in various parts of the world is from 1 in 10 000 to 1 in 1 000 000. This risk range reflects a de minimis lifetime risk that is so trivial that any action to reduce risk is not warranted (Kocher and Hoffman, 1994).

Accordingly, life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed to be within the de minimis range. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

7 BACKGROUND LEVELS OF AMBIENT AIR POLLUTION

Measured air quality data for the site and surrounds is not readily available with the exception of Brother CISA's ambient Cr(VI) sampling stations. The nearest ambient air quality monitoring station according to the South African Air Quality Information System (SAAQIS), is an Eskom ambient air quality monitoring station located 5km north of the town of Volksrust. The station monitors SO_2, PM_{10}, $PM_{2.5}$, and various meteorological parameters. This is approximately 52km north of the proposed site and is not anticipated to be representative of the conditions at the site.

Although there was a meteorological station at the Newcastle Airport, the South African Weather Service (SAWS) and the Newcastle Local Municipality have indicated that the station was decommissioned in March of 2017 and there are no other monitoring stations in operation within the Newcastle municipality. Data availed for 2012 to 2015 has been used in this study where applicable.

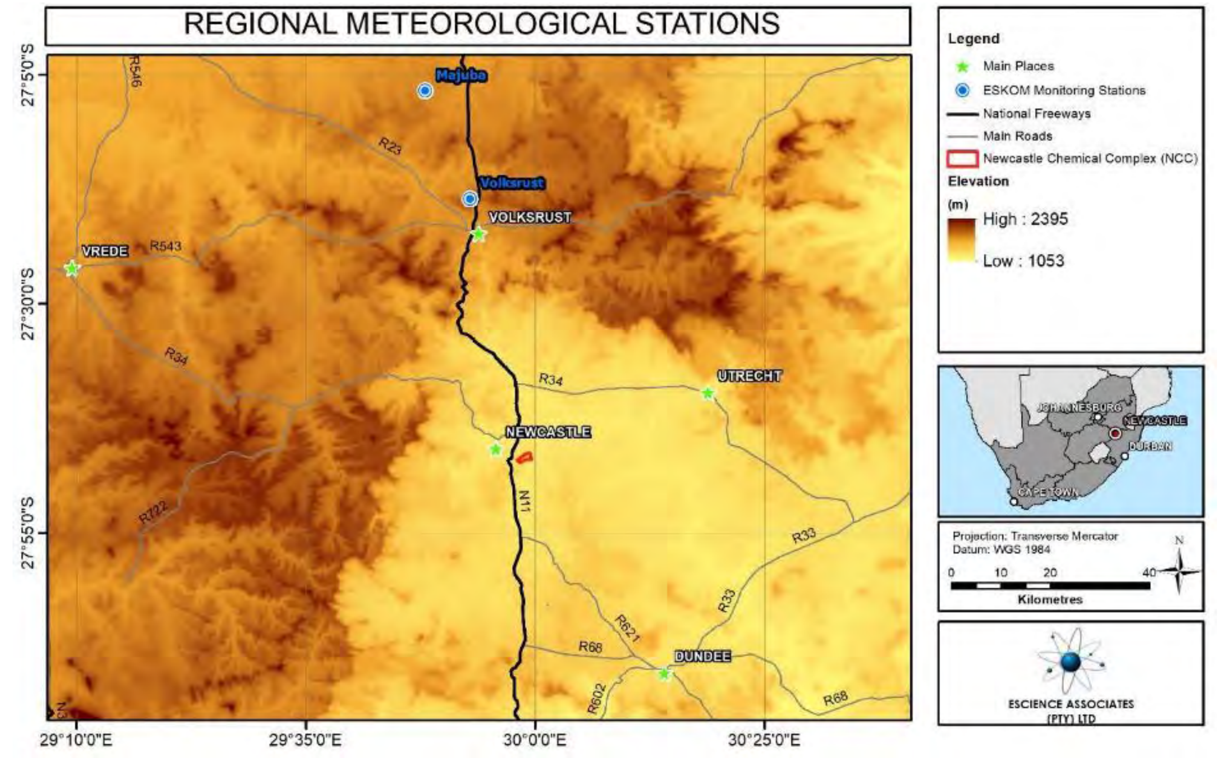


Figure 7-1: Location of meteorological stations within proximity to site.

Given the above, it is not possible to assess the background levels of ambient pollutants at the proposed site using measured data. There is potential for seasonal elevation of ambient pollutant loads resulting from surrounding industrial activities, however these activities are relatively distant from the site. Industrial operations that have previously operated within the industrial park have largely ceased operations. The N11 highway is approximately 1km away and is not expected to have a significant impact on ambient air quality at the proposed site. The airfield adjacent to the site is also not a potentially significant source of pollutants due to its infrequent aviation activity. In cognisance of this, it has not been deemed impractical and superfluous to undertake a cumulative impact assessment. This study focuses on the ambient impact related to emissions from Brother CISA's existing and proposed operations.

7.1 CSIR AMBIENT MONITORING DATA

In April 1998, an air quality monitoring network was established in Newcastle, KwaZulu Natal. Before the chrome chemicals plant came into operation, monitoring areas were identified based on isopleths from a dispersion modelling exercise in 1996, which took the predicted chromium emissions into consideration. In addition to the results of the dispersion modelling, the network was designed based on the accessibility of sites and availability of power and security. The CSIR has been managing this network since 1998.

Total Suspended Particulate Matter (TSP), Total Chromium (Cr(III) + Cr(VI)) and hexavalent chromium (Cr(VI) are currently being monitored at the following four sites:

- Station A: Effluent Plant about 0.3 km south of the plant.
- Station B: Arbor Park School about 2.9 km west of the plant.
- Station C: Keyway Motors about 2.5 kilometres east of the plant.
- Station D: Airport about 1 km north of the plant.

The locations are shown in Figure 7-2.

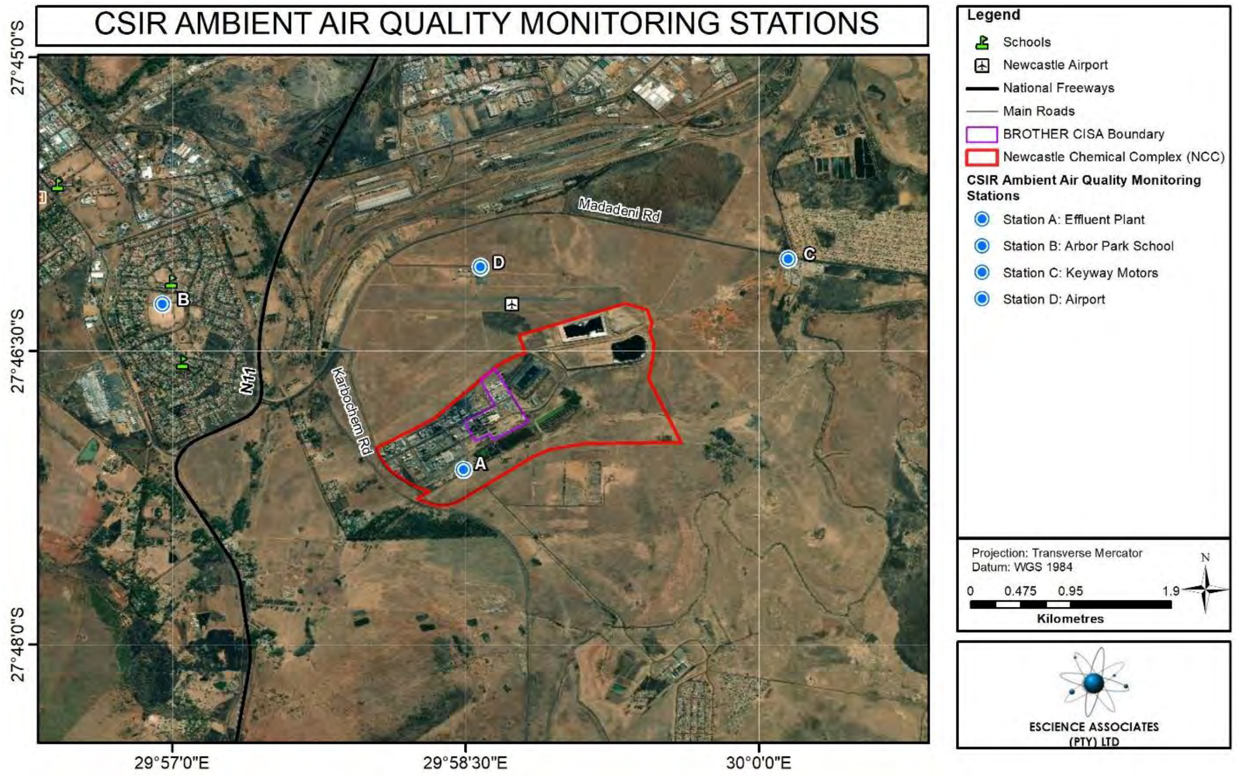


Figure 7-2: Locations of CSIR ambient monitoring stations

The Cr(VI), Total Cr and TSP concentrations measured between 25 September 2018 and 13 September 2019 are presented in Table 7-1.

Table 7-1: Measured Average concentrations of CrVI, Total Cr and TSP from 25/09/18 to 13/09/2019

Monitoring Period	Location and Sample No.	Cr(VI) (µg/m^3)	Total Cr (µg/m^3)	TSP (mg/m^3)
Period 1 (16 days) 25/09/18- 11/10/18	A1	<0.0001	0.003	0.014
	B1	<0.0001	0.001	0.018
	C1	<0.0001	<0.001	0.001
	D1	<0.0001	0.032	0.018
Period 2 (22 days) 11/10/18 - 01/11/18	A2	<0.0001	0.005	0.006
	B2	<0.0001	0.002	0.011
	C2	<0.0001	<0.001	0.001
	D2	<0.0001	<0.001	0.015
Period 3 (21 days) 01/11/18 - 22/11/18	A3	<0.0001	<0.001	0.005
	B3	<0.0001	0.013	0.008
	C3	<0.0001	<0.001	0.001
	D3	<0.0001	0.002	0.017
Period 4 (21 days) 22/11/18 - 13/12/18	A4	<0.0001	0.011	0.007
	B4	<0.0001	0.006	0.005
	C4	<0.0001	0.001	0.003
	D4	<0.0001	0.003	0.014
Period 5 (35 days) 13/12/18- 17/01/19	A5	<0.0001	0.003	0.012
	B5	<0.0001	0.003	0.011
	C5	<0.0001	0.001	0.004
	D5	<0.0001	0.006	0.016
Period 6 (25 days) 17/01/19 - 11/02/19	A6	<0.0001	0.006	0.001
	B6	<0.0001	0.002	0.003
	C6	<0.0001	0.001	0.003
	D6	<0.0001	0.006	0.012
Period 7 (23 days) 11/02/19 - 05/03/19	A7	<0.0001	0.002	0.007
	B7	<0.0001	<0.001	0.002
	C7	<0.0001	<0.001	0.002
	D7	<0.0001	0.004	0.014
Period 8 (22 days) 05/03/19 - 27/03/19	A8	<0.0001	0.001	0.004
	B8	<0.0001	<0.001	0.002
	C8	<0.0001	<0.001	0.003
	D8	<0.0001	0.011	0.014
Period 9 (21 days) 27/03/19 - 17/04/19	A9	<0.0001	<0.001	0.001
	B9	<0.0001	0.001	0.006
	C9	<0.0001	<0.001	0.004
	D9	<0.0001	0.004	0.014
Period 10 (22 days) 17/04/19- 08/05/19	A10	<0.0001	0.002	0.001
	B10	<0.0001	<0.001	0.003
	C10	<0.0001	<0.001	<0.001
	D10	<0.0001	0.005	0.019
Period 11 (22 days) 08/05/19- 30/05/19	A11	<0.0001	0.002	0.001
	B11	<0.0001	0.002	0.017
	C11	<0.0001	<0.001	<0.001
	D11	<0.0001	0.002	0.007

Table 7-1: Measured Average concentrations of CrVI, Total Cr and TSP from 25/09/18 to 13/09/2019

Monitoring Period	Location and Sample No.	Cr(VI) (µg/m^3)	Total Cr (µg/m^3)	TSP (mg/m^3)
Period 12 (21 days) 30/05/19- 19/06/19	A12	<0.0001	0.002	0.003
	B12	<0.0001	0.001	0.012
	C12	<0.0001	<0.001	0.001
	D12	<0.0001	0.013	0.030
Period 13 (18 days) 19/06/19 - 10/07/19	A13	<0.0001	<0.001	0.004
	B13	<0.0001	<0.001	0.006
	C13	<0.0001	<0.001	0.008
	D13	<0.0001	0.002	0.038
Period 14 (22 days) 10/07/19 -01/08/19	A14	<0.0001	0.001	0.001
	B14	<0.0001	<0.001	0.005
	C14	ND**	ND**	ND**
	D14	<0.0001	0.007	0.045
Period 15 (21 days) 01/08/19 -22/08/19	A14	<0.0001	0.001	0.002
	B14	<0.0001	0.001	0.013
	C14	ND**	ND**	ND**
	D14	<0.0001	0.005	0.042
Period 16 (22 days) 22/08/19 -13/09/19	A14	<0.0001	0.002	0.003
	B14	<0.0001	0.002	0.015
	C14	ND**	ND**	ND**
	D14	<0.0001	0.005	0.040

Note. A: Effluent Plant; B: Arbor Park School; C: Keyway Motors; D: Airport.

ND** no data due to a pump malfunction and subsequent pump failure at station C.

Figure 7-3 shows the Cr(VI) monitoring results for phase 12 (2008/2009) to phase 22 (2018/2019) of the monitoring programme.

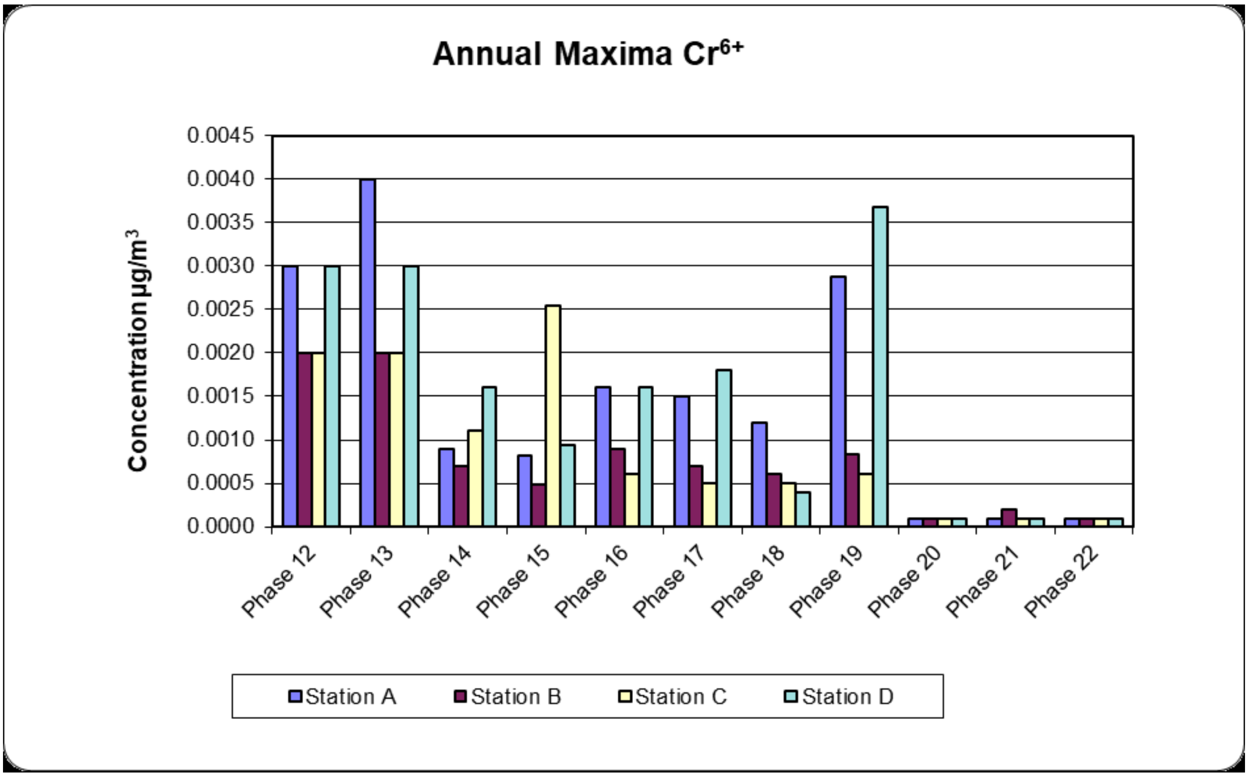


Figure 7-3: Annual maxima concentrations for Cr(VI) - Phases 12 - 22

As shown in Figure 7-3, the concentrations measured for Cr(VI) during phase 20 (2016/2017) and phase 21(2017/2018), were all below the analytical detection limit of 0.0001 µg/m^3, except for a concentration of 0.0002 µg/m^3 detected at station B (Arbor park school). The concentrations measured for Cr(VI) during phase 22 (18/19), were below the analytical detection limit (0.0001 µg/m^3) for all four of the monitoring stations.

8 DISPERSION MODELLING

Atmospheric dispersion modelling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. Atmospheric dispersion models use mathematical algorithms that simulate the dispersion and transformation of pollutants in the atmosphere. They are used to estimate or predict the downwind concentration of air pollutants emitted from various sources. Dispersion models are also used to assist in the design and assessment of various control strategies and abatement technologies for emissions reductions.

Air pollution models attempt to numerically solve the relationship between emissions and ambient concentrations of pollutants by means of mathematical algorithms which enable the modelling of pollutant dispersal and reaction. It takes into consideration the factors that have resulted in these concentrations - such as the emission sources, meteorological processes and any physical or chemical transformations. Numerical "models" are used to describe complex systems of interacting physical, chemical, and biological processes. These models consist of sets of mathematical equations that attempt to describe processes observed in nature, allowing scientists to create replicas of natural systems with a computer, so that the causes and effects of system behaviour may be better understood.

The primary focus of dispersion modelling for regulatory applications (new and existing facilities) is to assess compliance against air pollution standards by predicting deposition flux rates, ambient concentration and frequency of exceedance of air quality standards for all criteria pollutants listed in the NEMAQA for which ambient standards have been set. Additionally, dispersion modelling is the primary tool to determine the relative contribution of the facility to the air pollution burden within the modelling domain. This is achieved by scenario modelling to identify the individual contribution of significant known background industrial point source emitters, household emitters and the site’s specific emissions. The objective of undertaking source specific simulations is also to identify the extent of the scale and transport of air pollution from background sources to the site. This assessment enables the air pollution burden / contribution of significant known source emitters, including low level emitters (e.g. stacks less than 50m in height) within a 5km radius of the plant, at the local scale and all other industrial emitters (listed activities and high emitters) beyond 5km radius of the plant to be quantified. The physical properties and meteorological conditions of the atmospheric boundary layer (into which pollutants disperse) will largely influence the extent to which air pollution disperse / accumulate at various temporal scales (daily, seasonally, and annually).

8.1 DESCRIPTION OF THE DISPERSION MODEL

There are a number of dispersion models that have been developed around the world. The widely used CALPUFF dispersion model is one such example.

The simulation of pollutant emissions from the Brother CISA (Pty) Ltd plant was undertaken with the well-known and widely used CALPUFF (version 5.8, US-EPA approved) dispersion model. The CALPUFF model is freely available and can be downloaded from the website: http://www.src.com/.

8.1.1 CALPUFF SUITE OF MODELS

The CALPUFF system consists of a suite of models: CALMET (used to model 3-D meteorology for CALPUFF), CALPUFF (to compute pollution dispersion simulations and visibility assessments) and CALPOST (used for post-processing of CALPUFF output data). The CALMET/CALPUFF modelling system can accurately simulate atmospheric dispersion on transport scales from tens of meters to tens of kilometres (near-field) and from tens of kilometres to hundreds of kilometres (far-field) (US EPA 1998). Furthermore, CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal (Scire *et al*., 2000).

CALMET can simulate fine-scale three-dimensional wind flows in complex terrain (Scire *et al.*, 2000). CALMET has parameterizations to perform wind field adjustments of terrain, such as slope flows and terrain blocking effects. CALMET creates gridded 3-D wind fields and CALPUFF performs dispersion simulations along the wind vectors created by CALMET. This model combination is a major departure from past US-EPA Guideline models that have relied on a single hourly wind vector that applied over the entire modelling domain run in a steady-state mode. The CALMET and CALPUFF approach allows for dynamic wind fields that change spatially and temporally, a characteristic that is true to the real world.

CALMET/CALPUFF was developed to take whatever observational wind data are available and adjust the flow fields to be consistent with the fine-scale terrain in CALMET. The adjustments made by CALMET introduce structure to the flow field that is consistent with the terrain, even in areas where observations do not exist. In complex terrain regions, the representativeness of observational data is often quite limited spatially. Often the wind flow at just a few hundred meters from an anemometer can be completely different as a result of terrain-induced effects. These terrain effects on the wind flow may have a substantial impact on the predicted concentrations produced by the dispersion model.

8.1.2 CALPUFF / CALMET CHARACTERISTICS

There have been several journal papers, conference presentations and EPA documents related to the evaluation of CALPUFF and the meteorological model CALMET. The following provides a brief summary of the conclusions from several of these references and summarises CALMET/CALPUFF’s abilities as follows:

- The CALMET model used to generate the 3-D wind fields for the CALPUFF model can provide very good representations of the wind field, especially over complex terrain, or in coastal regions
- CALPUFF model results have been compared with ambient measurements of the tracer SF_6 after it has been released from existing stacks. The conclusions of several studies are that:
    - CALPUFF tends to over-predict concentrations but is typically within a factor of two of the observed concentrations. Predicted values within a factor of two is a criterion suggested by the EPA (US EPA 1998) and
    - Maximum concentrations predicted by CALPUFF are higher than observed concentrations, while average concentrations predicted by CALPUFF tend to be close to the average observed concentrations (US EPA 1998)

8.1.3 MODEL INPUT DATA

Dispersion models require input data including meteorological data (for example wind speed and direction, temperature, humidity) and emissions data such as source location and height, diameter and exit velocity, temperature and flow rate. Input data types required for the CALMET/CALPUFF model system and for this study include: emissions source data, meteorological data and land cover/land use data. Parameters required depend on the source type (point, line, area or volume). CALPUFF requires input data in the form of modelled 3-D gridded meteorological fields. Other inputs include stack parameter data for point sources. These include source geo-location, height and diameter. Emissions and process data are also required. These include exit velocity, temperature and flow rate.

Meteorological data was obtained from the Weather, Research and Forecast Model (WRF) which is a mesoscale, prognostic atmospheric model. WRF makes use of observed data to accurately model meteorology over a regular grid that has a coarser resolution than CALMET. The use of mesoscale model data in CALMET is advantageous compared to using observed data. More data points are provided than observed data and it provides upper air conditions. The higher number of data points increases accuracy in CALMET when deriving fine scale flow patterns. Meteorology is an essential requirement and is the principal factor to the dispersion of pollutants in the atmosphere. Important meteorological factors that directly impact the dispersion of a pollutant include wind speed and direction, atmospheric turbulence which is related to vertical dispersion, and vertical temperature profiles associated with absolutely stable layers that affect vertical dispersion.

Geophysical data requirements include land use type and terrain elevation. Land use categories and terrain of the surrounding region are discussed in their relevant subsections. These features (land use and terrain) have a strong influence on wind speed and turbulence, which are key components for dispersion.

8.1.4 GEOPHYSICAL DATA INPUT AND GENERAL DESCRIPTION OF THE AREA

Geophysical data requirements include land use type and terrain elevation. Land use categories and terrain of the surrounding region are discussed in their relevant subsections. These features (land use and terrain) have a strong influence on wind speed and turbulence, which are key components for dispersion.

8.2 TOPOGRAPHY

Figure 8-1 demonstrates the topography in the region of interest surrounding the Brother CISA site. The region forms part of South Africa’s elevated inland plateau. The topography is relatively complex ranging from 900 mamsl in the east to elevations of above 2000 mamsl in the northwest with the central parts of the municipality at approximately 1200 m.

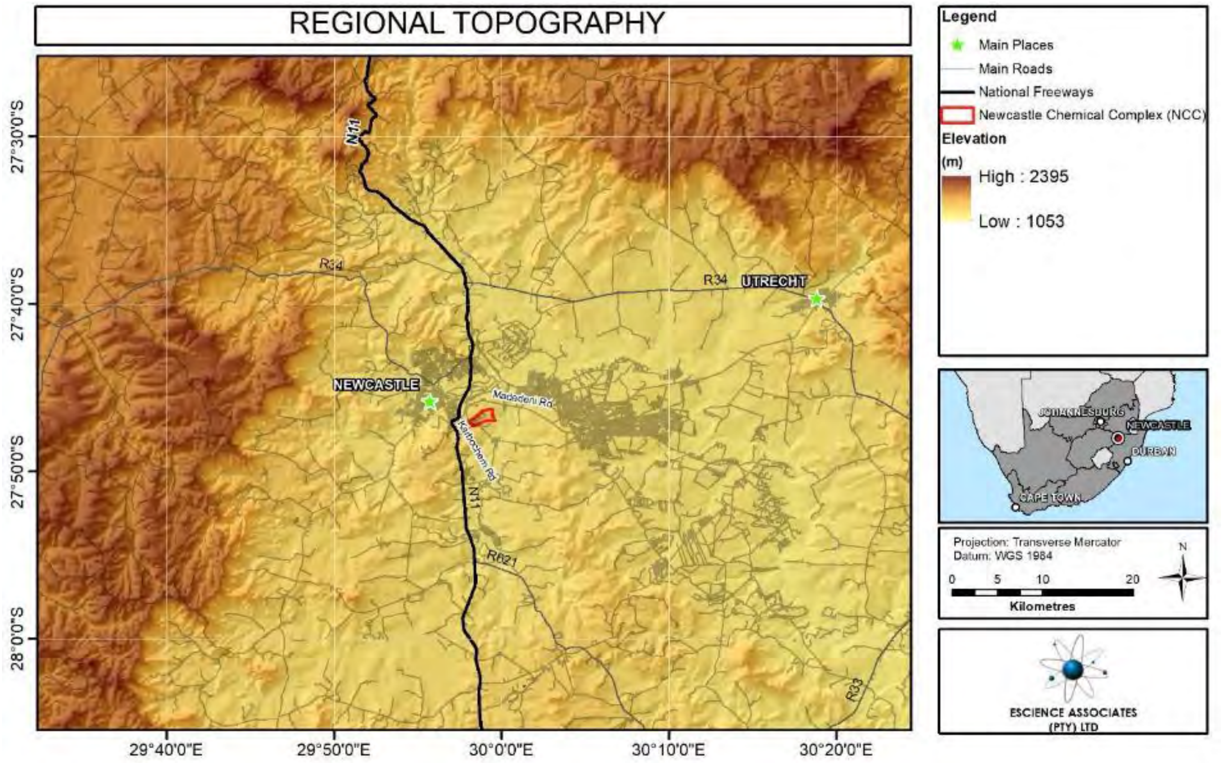


Figure 8-1: Topography map of the modelled area indicating complex terrain around the Brother CISA plant.

CALMET adjusts mesoscale wind speeds and direction to fine scale terrain features. Elevation data with a resolution of 50 m was aggregated to the 300 m CALMET grid resolution. The use of this high-resolution elevation data ensures that the complexity of the terrain is represented in the model. This aids in simulating terrain induced meteorological features like katabatic/anabatic flow and valley inversions.

8.3 LAND USE/ LAND COVER

Land use and land cover have two main effects on meteorology. The first is the reflective properties, or albedo, of the land cover. This determines how much radiation is reflected which has implications for determining diurnal heating patterns and atmospheric mixing levels. Mixing heights will determine the volume of air available in which air pollutants can vertically disperse. Secondly, land use types have an associated surface roughness which influences relative turbulent or laminar flow of wind. This in turn affect pollutant dispersion.

The site is largely surrounded by urban built-up area (refer to Figure 8-3). Although the area immediately adjacent to the site consists largely of open veld, new castle airport to the north, small holdings to the west, Roy Point cemetery to the south east and Karbochem cemetery to the north east. The nearest residential areas are Arbour Park, Vlam and Kwamathukuza. The Ngagane water purification facility lies to the south of the site. The nearest hospital is the Newcastle Provincial Hospital located with the Newcastle CBD.

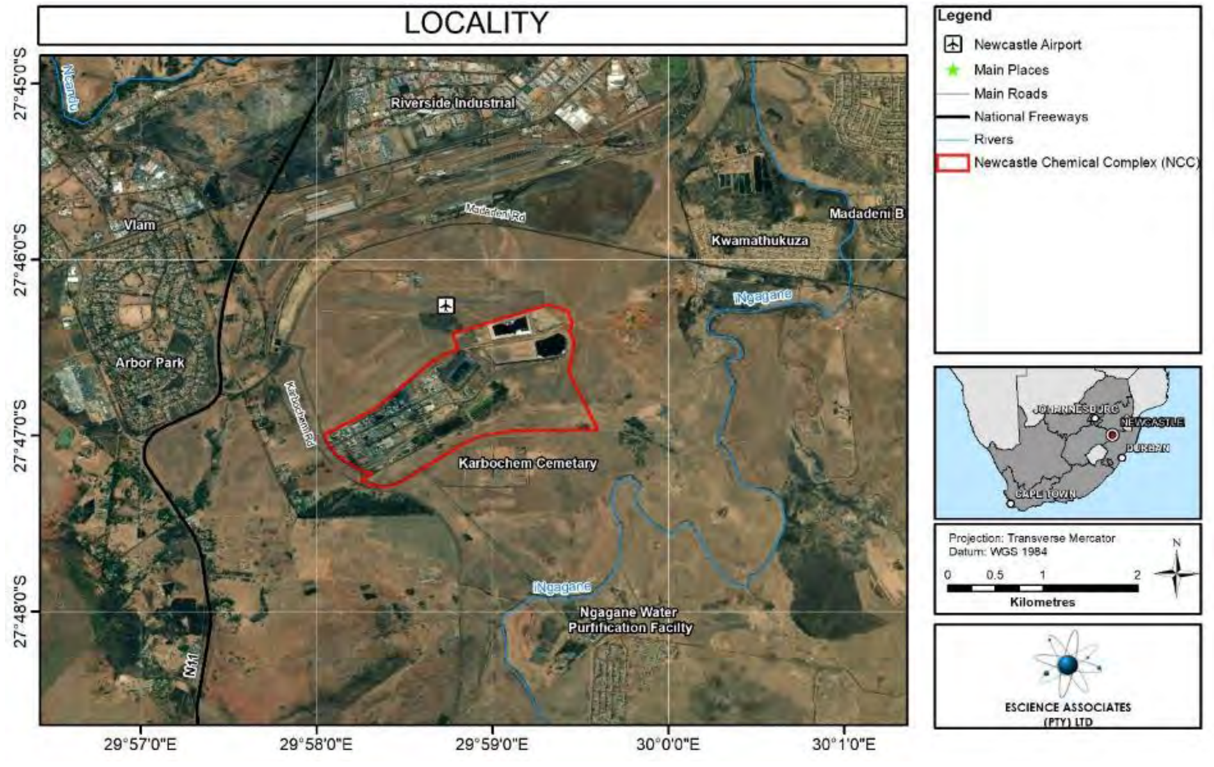


Figure 8-2: Satellite image –Surrounding land use

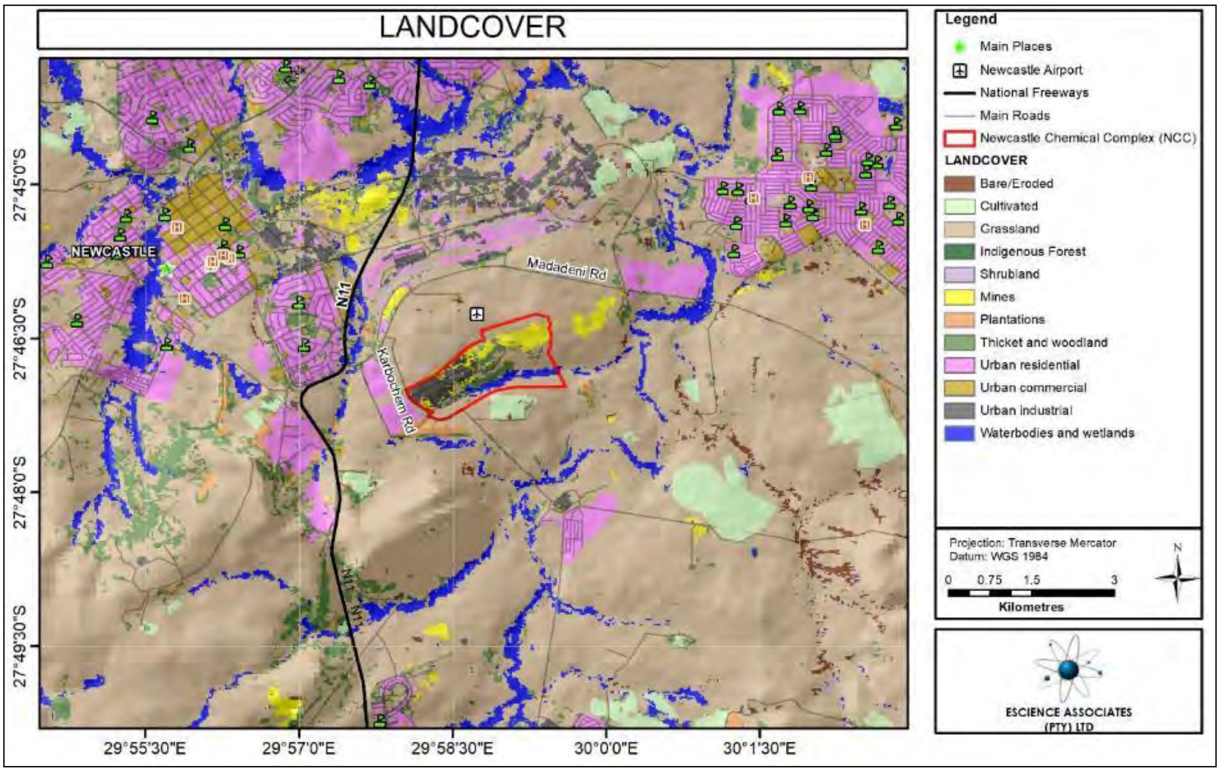


Figure 8-3: CALMET Land use types within the Brother CISA modelling domain

USGS global land cover characteristics data have been used to produce dominant land use categories and land-use weighted values of surface and vegetation properties for each CALMET grid cell. The land use data has been processed to produce a gridded field of fractional land use categories for the CALMET modelling domain.

The 37 Level I USGS land use categories are mapped into 14 CALMET land use categories as summarised in Table 8-1.

Table 8-1: Default CALMET Land Use Categories and Associated Geophysical Parameters.

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
10	Urban or Built-up Land	1	0.18	1.5	0.25	0.2	
20	Agricultural Land – Unirrigated	0.25	0.15	1	0.15	0	3
-20*	Agricultural Land - Irrigated	0.25	0.15	0.5	0.15	0	3
30	Rangeland	0.05	0.25	1	0.15	0	0.5
40	Forest Land	1	0.1	1	0.15	0	7
50	Water	0.001	0.1	0	1	0	0
51	Small Water Body	0.001	0.1	0	1	0	0
55	Large Water Body	0.001	0.1	0	1	0	0
60	Wetland	1	0.1	0.5	0.25	0	2
61	Forested Wetland	1	0.1	0.5	0.25	0	2
62	Non-forested Wetland	0.2	0.1	0.1	0.25	0	1
70	Barren Land	0.05	0.3	1	0.15	0	0.05
80	Tundra	0.2	0.3	0.5	0.15	0	0
90	Perennial Snow or Ice	0.2	0.7	0.5	0.15	0	0

* Negative values indicate irrigated" land use "

Based on the U.S. Geological Survey Land Use Classification System (14-Category System) (Scire et al, 2000)

Parameters relating to land use type applied in the modelling are given in Table 8-2. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index are computed proportionally to the fractional land use within each grid cell.

Table 8-2: Land use codes and categories used in the model

Land use code	Description	Surface roughness (m)	Albedo	Bowen ratio	Soil heat flux (w/m^2)	Leaf area index
10	Urban or built-up land	1.0	0.18	1.5	0.25	0.2
20	Agricultural land – not-irrigated	0.25	0.15	1.0	0.15	3.0
30	Rangeland	0.05	0.25	1.0	0.15	0.5
40	Forest land	1.0	0.10	1.0	0.15	7.0
51	Water body	0.001	0.10	0.0	1.0	0.0
70	Barren land	0.005	0.30	1.0	0.15	0.05

9 METEOROLOGY AND DISPERSION POTENTIAL

9.1 GENERAL DESCRIPTION OF CLIMATOLOGY AND METEOROLOGY

The climate and macro-scale air pollution dispersion potential of the Newcastle region is largely influenced by atmospheric conditions associated with the semi- permanent anticyclonic continental high-pressure cell located over the interior. Light variable winds occur over the region as a result of the anticyclone subsidence associated with the continental high pressure.

The tropical easterlies, and the occurrence of easterly waves and lows, affect the region throughout the year resulting in airflow with a north-easterly to north-westerly component, but their influence is generally weaker during winter months. During summer months, the anticyclonic belt weakens and shifts southwards, allowing the tropical easterly flow to resume its influence over the region.

In summer, unstable conditions result in mixing of air and rapid dispersion of pollutants in the atmosphere. Westerly waves and lows are largely responsible for the southerly wind component, which occurs over the interior. The winter months are characterized by atmospheric stability caused by a persistent high-pressure system. This high-pressure system results in subsidence, causing clear skies and pronounced temperature inversions at night. These inversions may be broken periodically by the passing of cold fronts. Cold fronts are typically followed by ridging highs which bring onshore flow and rain to the eastern half of the country.

The temperature inversion layer keeps the air pollutants trapped in the lower atmosphere, causing increasingly poor air quality. These inversions, which occur as a result of the anticyclone subsidence, suppress the diffusion and vertical dispersion of pollutants by reducing the depth of the mixing layer. Such inversions therefore play an important role in controlling the long-range transport, and recirculation of pollution. The lowest elevated inversion occurs at approximately the 700 hPa level (- 3 km above sea level) (Cosijn, 1995). Conditions in the winter months are highly unfavourable for the dispersion of atmospheric pollutants (Preston-Whyte and Tyson, 1988).

9.2 RAINFALL AND TEMPERATURE

Rainfall occurs predominantly in summer while the least amount of rain falls in the winter months. The rainfall data displayed is the average monthly rainfall over the period of 2010 – 2015 obtained from the World Weather Online website. The maximum mean-daily temperature occurred in December (23.5°C) whilst the minimum mean-daily temperature occurred in June (11.9°C). Summer temperatures are typically warmer, resulting in convection, with water vapour evaporation, and condensation completing the atmospheric water cycle processes. The maximum temperature occurred in December at 38.9°C and the minimum temperature occurred in June at -0.8°C. Precipitation in the form of showers and thundershowers are typical in this season.

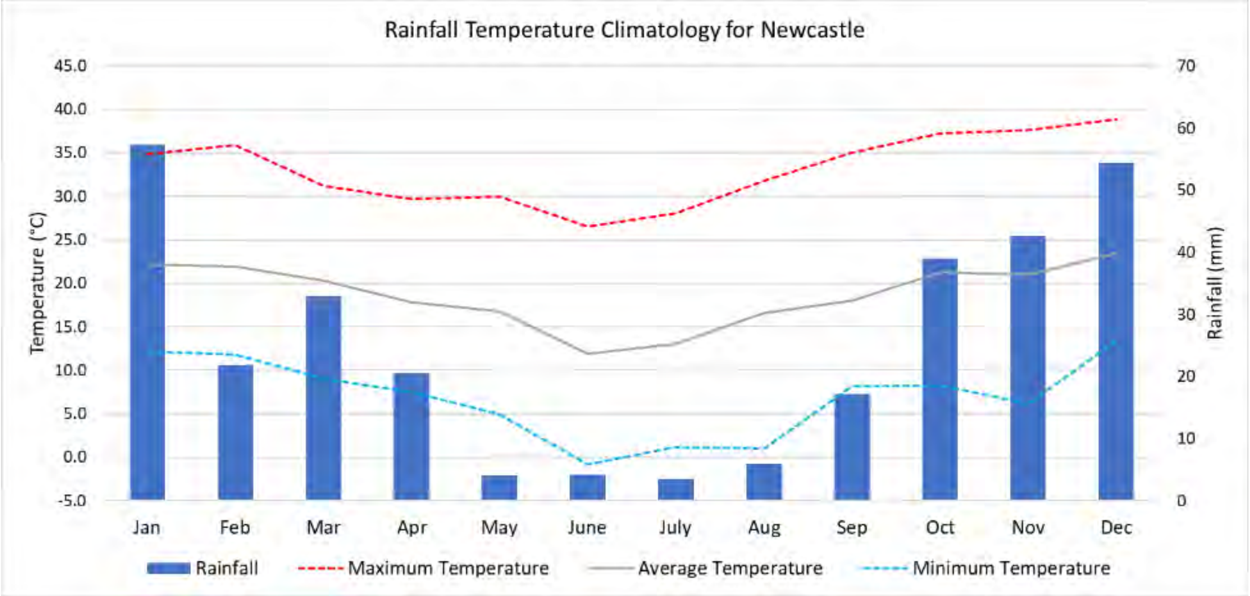


Figure 9-1: Average maximum and minimum temperatures at the Newcastle SAWS station for 2015 and average rainfall from World Weather Online website for 2010 - 2015.

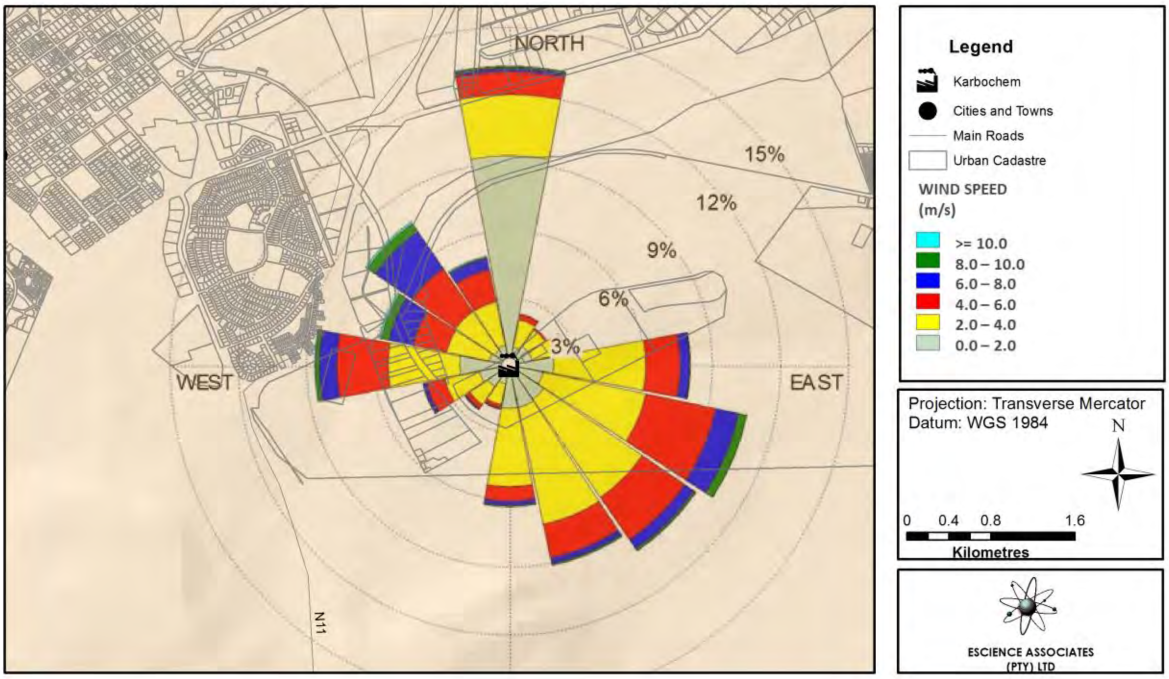
9.3 WIND

In general, calm, light wind speed conditions (0 – 3 m/s) are experienced in the lower lying valley regions of the modelling domain. Wind speed increases as terrain height increases. The Newcastle SAWS meteorological station is the nearest SAWS observation station to the Brother CISA plant location. The annual average wind speed measured at the Newcastle SAWS station in 2015 is 2.99 m/s.

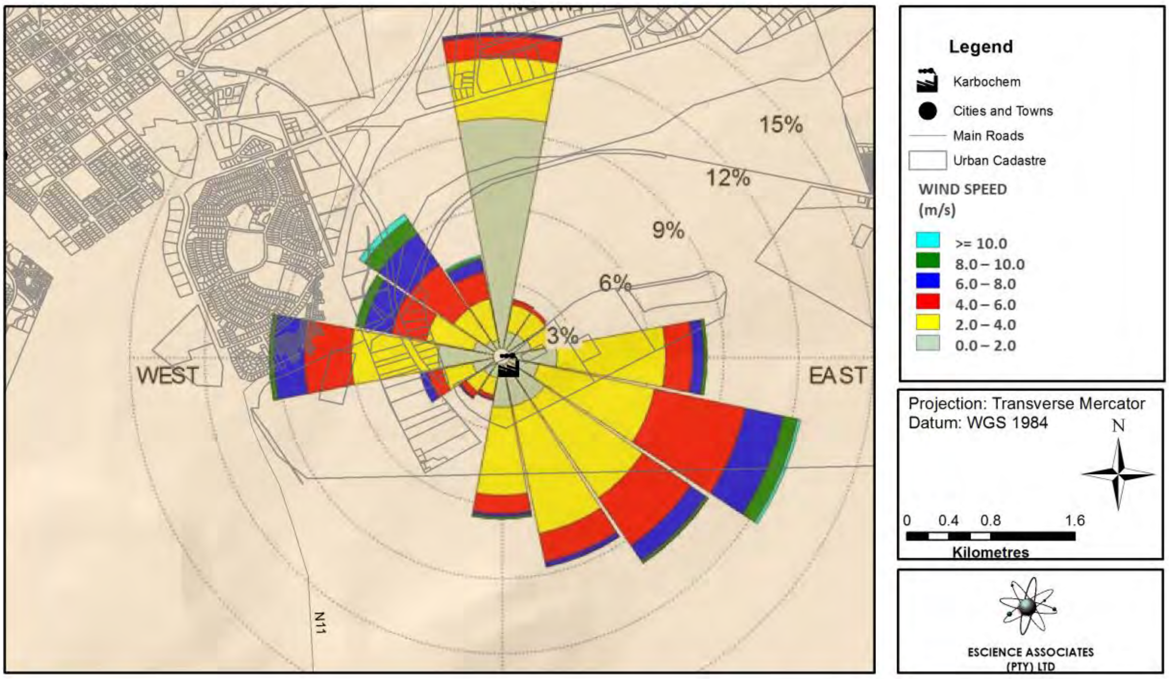
Wind roses have been developed from wind speed and wind direction data from the Newcastle SAWS meteorological stations in proximity to Brother CISA. These are presented in Figure 9-2. The data represents the full year of data collection for the years 2012 - 2015. The wind roses show the wind direction and distribution of wind speeds experienced in 2012 to 2015. The length of the colour-coded line is proportional to the frequency of occurrence of wind blowing from that direction. Wind speed classes are also colour coded and the length of each class/category is proportional to the frequency of occurrence of wind speed.

In general, wind speeds vary throughout the year, within each month and within each season, varying from calm 0.5 m/s – 1.4 m/s (25% frequency) to light 1 m/s – 2m/s to stronger gusts (>10 m/s). The resultant wind is predominantly east-west for the period of 2012 - 2015. The seasonal wind roses indicate the periods and wind patterns that contribute to this phenomenon and demonstrate the shifting wind pattern during the year (Figure 9-3).

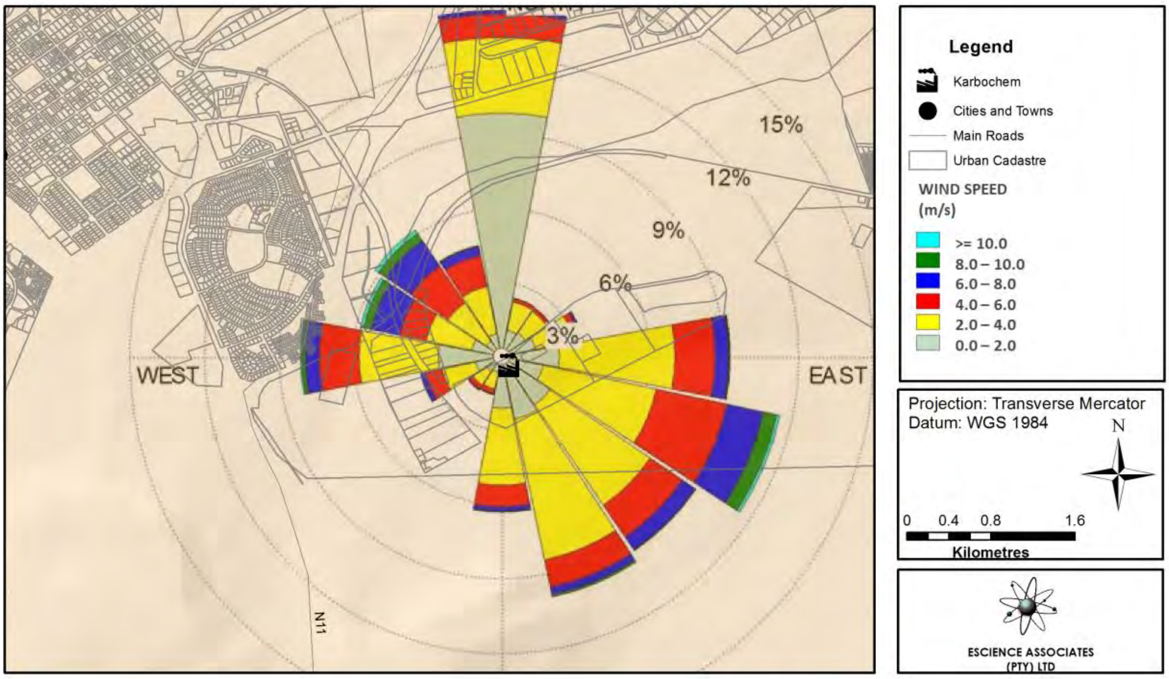
2012 Annual Windrose



2013 Annual Windrose



2014 Annual Windrose



2015 Annual Windrose

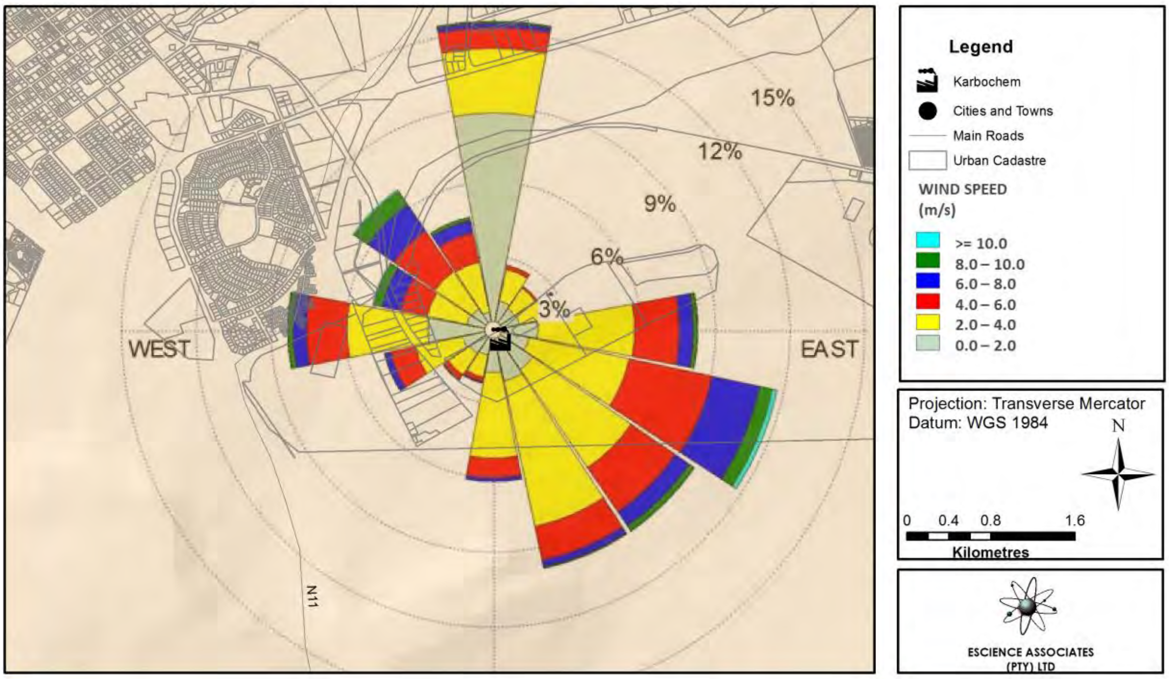
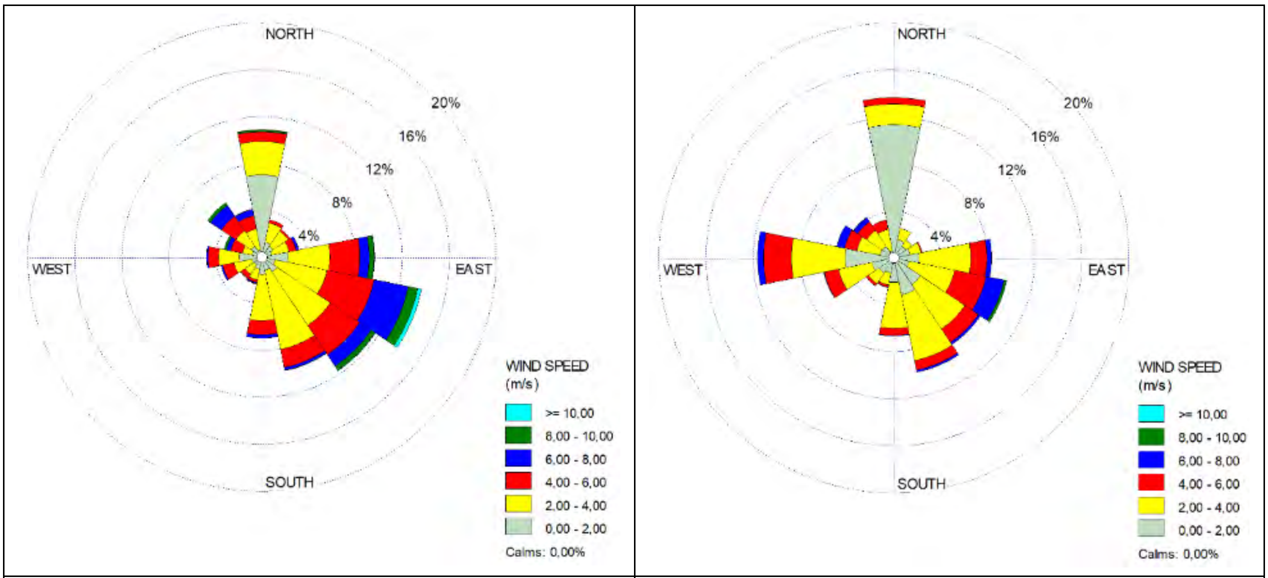
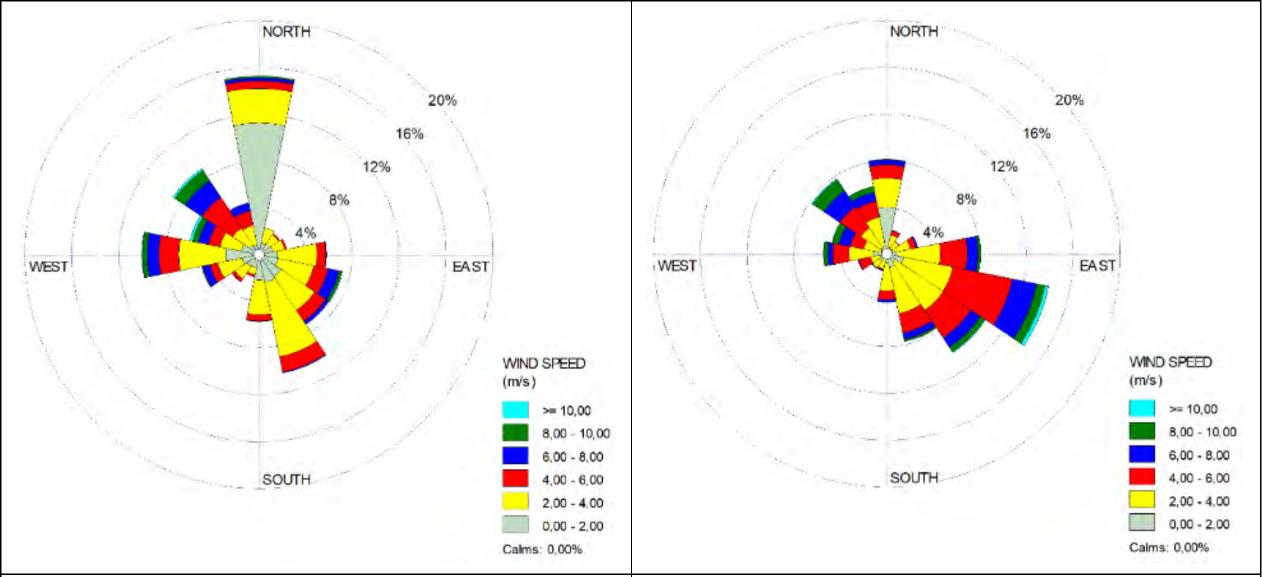


Figure 9-2: Wind roses from Newcastle SAWS station measured data for the years 2012-2015



Summer

Autumn



Winter

Spring

Figure 9-3: Seasonal Wind roses from Newcastle SAWS station measured data for 2015

9.4 DISPERSION POTENTIAL

The meteorological characteristics of a site, along with the characteristics of the source, govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The extent to which pollution accumulates or disperses in the atmosphere is dependent on various factors such as the degree of thermal (convective) turbulence and mechanical (friction and wind speed) turbulence within the earth's boundary layer as well as precipitation.

Dispersion occurs three dimensionally. The stability of the atmosphere and the height of the surface-mixing layer determine the vertical component of dispersion for non-buoyant sources. Horizontal dispersion in the boundary layer is influenced by the wind field characteristics, atmospheric stability, and topography. The wind speed and turbulence determine the rate of transport downwind and the rate of mixing. Mechanical turbulence is similarly a function of the wind speed and surface roughness.

Convective turbulence is determined by solar insolation, land cover, and wind speed (Turner, 1970).

9.4.1 ATMOSPHERIC STABILITY AND MIXING HEIGHTS

In the atmosphere, motion (air flow and turbulent eddies) occurs at all spatial scales (micro, meso and synoptic), simultaneously. Meteorological pressure relates to the weight of the atmosphere above a location, the weight decreases with an increase in altitude above sea level and varies for different weather conditions. Pressure gradient is a change in pressure measured across a given distance and is directed from a high to low pressure. Pressure gradient force is responsible for triggering the initial movement of air. Unequal heating of the atmosphere is responsible for creating pressure differences generating wind as air flows from areas of high to low pressure. This in turn influences atmospheric stability.

The degree of atmospheric stability influences the amount of plume rise that will occur from an emission source. Stable conditions or low mixing heights generally trap pollution plumes near the ground. These conditions are usually prominent in the early morning before sunrise where visible emissions can be seen at low altitude for long distances (where there is an appropriate emission source). Low mixing heights inhibit the dispersion of pollutants without sufficient buoyancy, and these are often trapped by an elevated inversion. Once the sun rises and heats the ground, convective heating occurs, and this increases turbulent flow in the lateral and vertical geophysical spheres. This results in surface inversion breakup or erosion of the capping layer and mixing heights increase. Figure 9-4 illustrates the mixing heights throughout the day for the period of 2017 – 2019, modelled at the Brother CISA site. The diurnal mixing height increases from 08h00am, a few hours after sunrise. Mixing heights are increased steadily until 15h00pm to a maximum of 2 000m above sea level. Mixing height then rapidly decreases with less direct solar radiation. From 19:00 pm, the mixing heights are generally below 100m until sunrise.

The boundary layer level or ground level turbulence plays a major role in pollutant dispersion. The random motion of a body or volume of air can act to dilute or diffuse a pollutant plume. Greater turbulence acts to increase the rate of dilution of diffusion of the plume whereas weak turbulence can limit diffusion and can cause high plume concentrations to occur downwind of a source. Periods of greater turbulence (which are driven by incoming solar radiation, surface heating, convection, thermal and pressure gradient induced wind flow) generally occur between 08h00am and 18h00pm, and mixing heights are generally higher during periods where the sun is still elevated.

Diurnal variations in the minimum, maximum, and average mixing heights, based on model CALMET generated meteorological data for the site are illustrated in Figure 9-4.

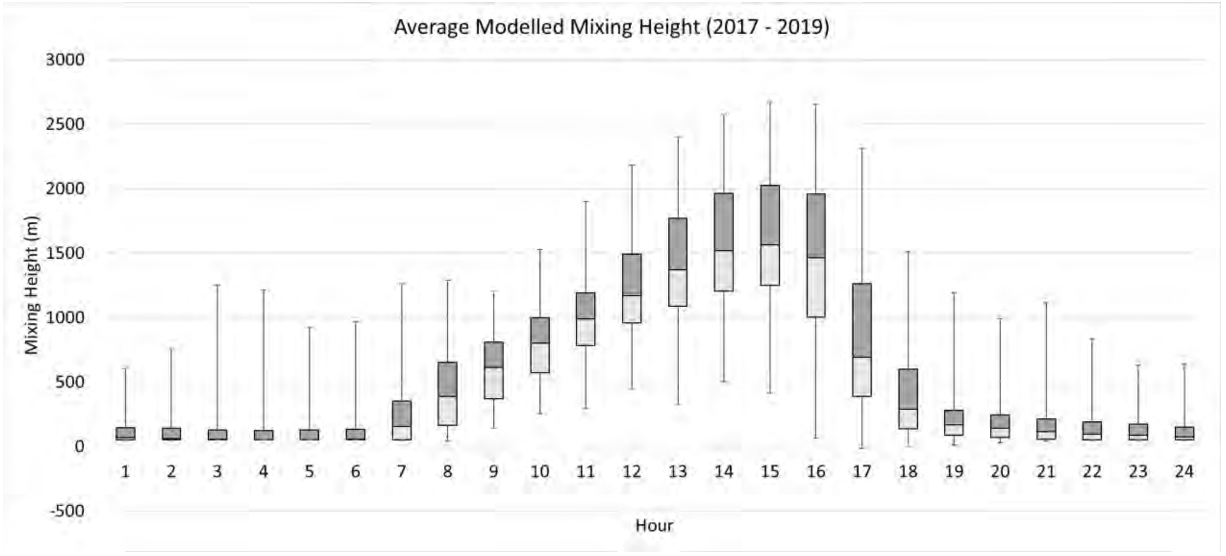


Figure 9-4: Average CALMET Modelled Mixing Heights at Brother CISA Site.

10 IMPACT ON THE RECEIVING ENVIRONMENT: DISPERSION MODELLING RESULTS AND DISCUSSION

10.1 PREAMBLE

10.1.1 ASSUMPTIONS AND LIMITATIONS

The following significant assumptions have been undertaken:

1. A tier 2 approach was undertaken for atmospheric conversion of NOx emissions to NO_2.

2. Chemical transformation of gaseous pollutants (NOx and SO_2) has otherwise not been accounted for. This is due to:
   a. Limitations in the availability of data on chemical and other parameters contributing to chemical transformation (e.g. ambient concentrations of ozone, reactive organic compounds etc.)
   b. The limitations of the modelling software. Although the CALPUFF suite is a tier 3 system, and one of the best in its class, the ability of such dispersion models in general to accurately account for chemical transformation is relatively limited.

   The predicted ambient concentrations of the gaseous pollutants are therefore typically expected to be over-estimations. This is in fitting with the precautionary principle.

3. All PM emitted from point source was assumed to be PM_{10}. This is potentially an over-estimation of actual PM_{10} emissions.

4. It has been assumed that all proposed stacks which may emit Cr(VI) are doing so at the emissions limits shown in Table 14-1, continuously for every hour of the full 3 years modelled. This is a significant exaggeration versus actual emissions. Notably:
   a. Measured data stack emissions tests show that the stacks are generally well within the permitted maximum concentrations at the time of measuring.
   b. Actual emissions vary in reality, and there are periods of no emissions due to planned and unplanned maintenance, as well as planned and unplanned production stoppages.

5. It has been assumed that all Cr(VI) remains in oxidised form and that there is no significant reduction in the atmosphere. Notably the presence of acidic gases such as SO_2 and NO_2 from industrial activities, motor vehicle emissions, and domestic fuel burning has not been taken into account. These may facilitate the atmospheric reduction of Cr(VI). It is notable from ambient measurements (refer to section 7 of this report) that actual ambient concentrations of Cr(VI) are below detectable levels and as such this is very conservative assumption.

6. Removal of potentially significant pollutants identified from ambient air through wet deposition has not been modelled and thus the modelled results are thus expected to be an over-estimation in this regard.

In general the predicted ambient concentrations are expected to be over-estimated. This is in fitting with the precautionary principle.

10.2 ANALYSIS OF EMISSIONS' IMPACT ON AIR QUALITY AND HUMAN HEALTH

It is important to note that NEMAQA defines ambient air as excluding air regulated by the Occupational Health and Safety Act (Act 85 of 1993). Thus, ground level exposure in the plant site is technically not regulated by the NAAQS. During working hours, working persons, persons exposed at the plant are expected to:

1) Primarily work normal shifts (i.e. 40 hours per week)
2) Be within the age range of the generally accepted working populace (18 years to 65 years)

In respect of the NAAQS, these receptors are not anticipated to be sensitive receptors by virtue of their limited exposure time and their age range. Occupational exposure limits apply within the industrial boundary, these limits are orders of magnitude higher than Ambient Air Quality Standards.

10.2.1 INTERPRETATION OF ISOPLETH MAPS

The spatial dispersion patterns and temporal distribution of predicted modelled ambient concentrations, for the potentially significant pollutants identified, are described for the proposed operations under normal operating conditions.

Predicted modelled ambient concentrations for pollutants are compared against NAAQS and applicable guidelines for the 1-hour, 24-hour, and annual maximums, where applicable. Note that, in respect of the NAAQS, for the hourly and 24-hour maxima, the numbers of exceedances per annum determine whether regulatory compliance is achieved. The maximum modelled values are mapped to demonstrate the spread and highest predicted outcomes for the impact from the operations. Where there are exceedances of the NAAQS, the frequency of exceedance (FoE) is plotted to illustrate compliance status.

The data is presented in the form of colour coded isopleth maps. The colour coding follows the general format described in Table 10-1 and Table 10-2.

Table 10-1: Predicted Maximum Ambient Concentrations – Colour Coding

	White/Grey	Less than 5% limit value.
🟦	Shades of Blue	Significantly lower than ambient limit value (typically from 5% to 60% of the limit value). Note: In instances where all/most of the modelled values are less than 20% of the limit value, shades of blue may still be used to demonstrate the impact spread.
🟩	Shades of Green	Relatively close to the limit value (60% - 100% of the limit value).
🟥	Shades of Red	Exceeds the limit value.

Table 10-2: Predicted Frequency of Exceedance – Colour Coding

	White/Grey	No exceedances of the limit value.

Table 10-2: Predicted Frequency of Exceedance – Colour Coding

🟦	Shades of Blue	Significantly lower than the allowable FoE (typically < 60% maximum allowable FoE).
🟩	Shades of Green	Relatively close to the maximum allowable FoE (60% - 100% of the maximum allowable FoE).
🟥	Shades of Red	Exceeds the maximum allowable FoE.

Predicted incremental cancer risk from lifetime exposure to carcinogenic pollutants (Cr(VI) from the current operations at the plant are presented here. The data is presented in the form of colour coded contour maps. The colour coding follows the general format described in Table 10-3.

Table 10-3: Predicted Chromium (VI) Lifetime Carcinogenic Risk – Colour Coding

🟥	Shades of Red	Less than 1 in 10 000
🟧	Shades of Orange	Between 1:10 001 and 1 in 100 000
🟩	Shades Green	Above 1 in 100 000

- Note that results are presented for a modelled period spanning 3 calendar years.
- In order to prevent proliferation of maps, only those associated with significant predicted ambient concentrations are presented.

10.2.1.1 PRESENTATION OF RESULTS

In general, the variance of hourly concentrations in comparison to the relative stratification of the hourly, 24 hourly and annual standards are such that if there are no exceedances of the hourly standard then there are generally no exceedances of the 24 hour and annual standards. The same applies to 24-hour averages, if there are no exceedances of the 24-hour standard then there typically are no exceedances of the annual standard.

Where there are no exceedances of the hourly standard (and subsequently the 24 hour and annual standards), only the maximum hourly results are presented in order to keep the report concise. The maximum hourly results typically demonstrate the worst-case prediction. Should the above not be the case then the relevant results are presented accordingly.

In accordance with the Regulations Regarding Air Dispersion Modelling (GN.R 533 of 2014), three consecutive meteorological years, of the last five years were modelled (2017 to 2019).

Three scenarios were modelled:

i. Scenario 1: Proposed Sources - All proposed sources modelled at the minimum emission standards for the applicable regulated emissions per source as stipulated by Subcategory 7.2 and Subcategory 7.4 in GN893:2013, as amended. Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, the Cr(VI) emissions limits as shown in Table 14-1 were applied to stacks where Cr(VI) emissions are anticipated.

ii. Scenario 2: Baseline - All current sources modelled at the measured emission rates as per the stack test reports.
iii. Scenario 3: Cumulative = Baseline + Proposed Sources - All proposed sources modelled at the minimum emission standards and all current sources modelled at the measured emission rates as per the stack test reports.

10.2.2 SCENARIO 1: PROPOSED EMISSIONS

All proposed sources modelled at the minimum emission standards for the applicable regulated emissions per source as stipulated by Subcategory 7.2 and Subcategory 7.4 in GN893:2013, as amended. Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, the Cr(VI) emissions limits as shown in Table 14-1 were applied to stacks where Cr(VI) emissions are anticipated. Measured Cr(VI) emissions from the plant show that this emission concentration is achievable with the abatement technologies currently in use.

10.2.2.1 PREDICTED CONCENTRATIONS FOR PM_{10}

Modelled particulate emissions have not been fractioned to indicate the percentage of PM_{10} in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are PM_{10}.

10.2.2.1.1 PREDICTED 24 HOUR CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is well within the NAAQS limit of 75 $\mu g/m^3$ for the 24-hour averaging interval. For the three years assessed (2017 through to 2019) the maximum PM_{10} concentration occurring over the area for the 24-hour averaging period is 4.55 $\mu g/m^3$.

10.2.2.1.2 PREDICTED ANNUAL CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is well within the NAAQS limit of 40 $\mu g/m^3$ for the annual averaging interval as well. For the three years assessed (2017 through to 2019) the maximum PM_{10} concentration occurring over the area for the annual averaging period is 0.83 $\mu g/m^3$.

10.2.2.2 PREDICTED CONCENTRATIONS FOR PM2.5

Modelled particulate emissions have not been fractioned to indicate the percentage of $PM_{2.5}$ in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are $PM_{2.5}$.

10.2.2.2.1 PREDICTED 24 HOUR CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is well within the NAAQS limit of 40 $\mu g/m^3$ for the 24-hour averaging interval (Figure 10-1).

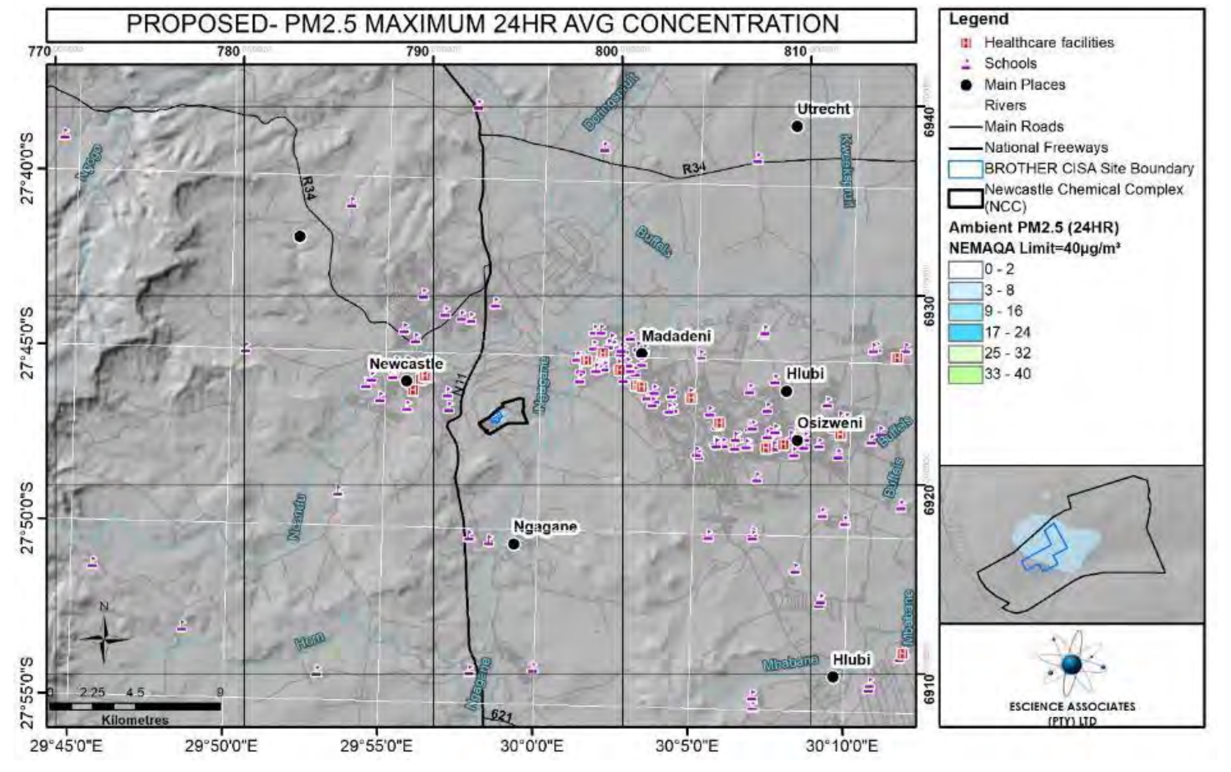


Figure 10-1: Scenario 1 Predicted $PM_{2.5}$ 24-Hour maximum modelled ambient concentration.

10.2.2.2.2 PREDICTED ANNUAL CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is well within the NAAQS limit of 20 µg/m^3 for the annual averaging interval as well. For the three years assessed (2017 through to 2019) the maximum $PM_{2.5}$ concentration occurring over the area for the annual averaging period is 0.83 µg/m^3.

10.2.2.3 PREDICTED CONCENTRATIONS FOR SO_2

10.2.2.3.1 PREDICTED 1 HOUR CONCENTRATIONS FOR SO_2

There are predicted exceedances of the NAAQS limit of 350 µg/m^3 for the 1-hour averaging interval, however the predicted exceedance are all within the industrial boundary (Figure 10-2). The predicted number of exceedances is within the permissible number of exceedances over the period (88 exceedances allowed per annum), over the modelling period (Figure 10-3).

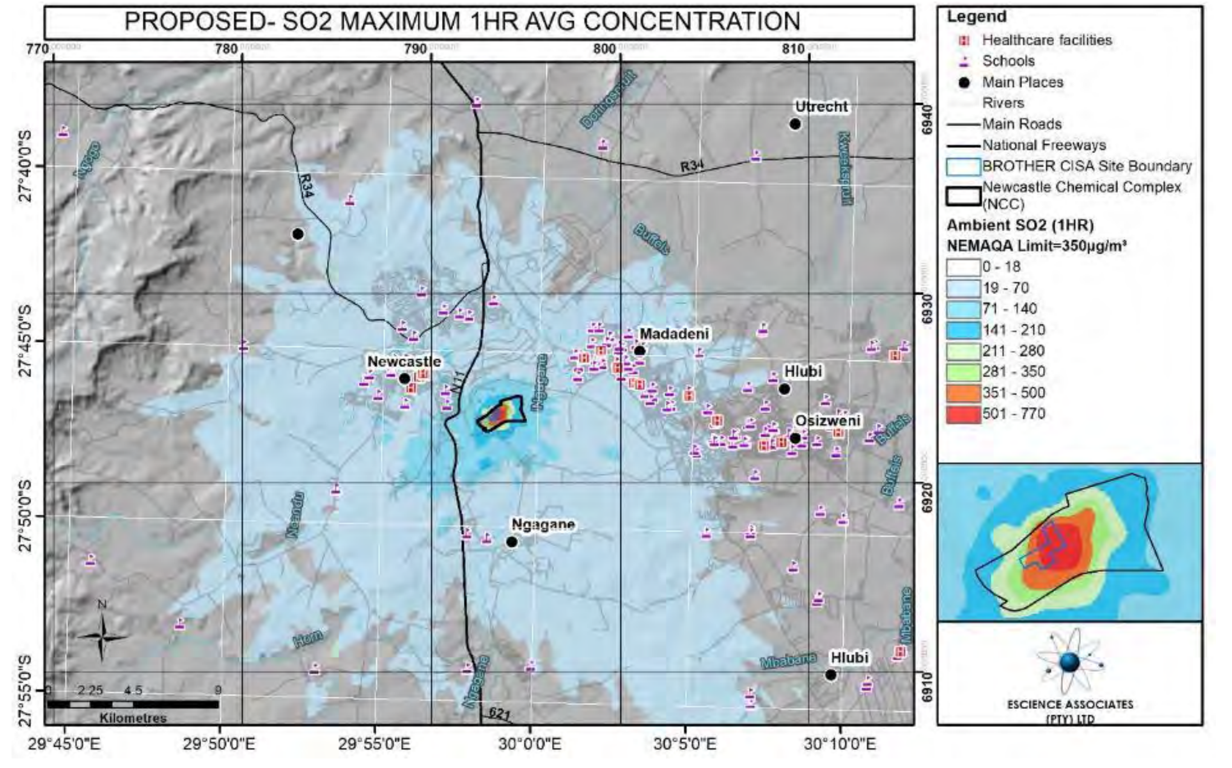


Figure 10-2: Scenario 1 Predicted SO_2 1-Hour maximum modelled ambient concentration.

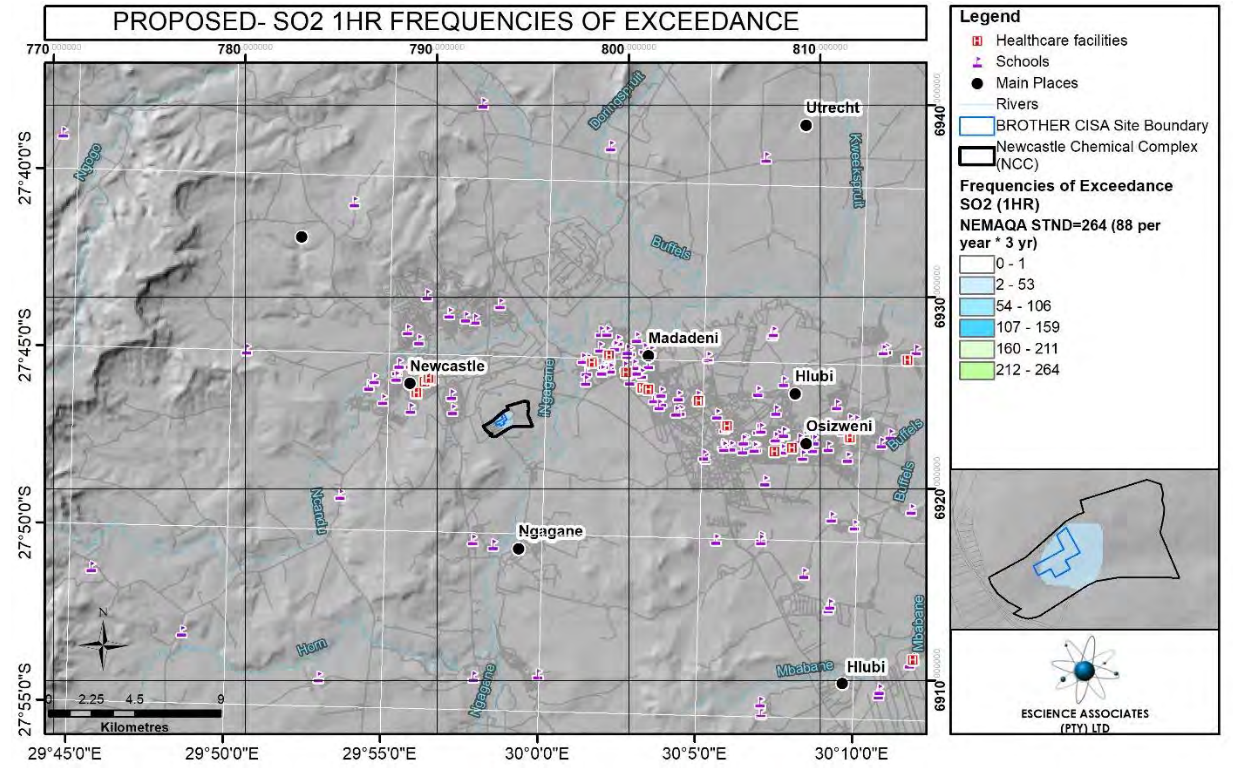


Figure 10-3: Scenario 1 Predicted SO_2 1-Hour maximum modelled ambient number of exceedances.

10.2.2.3.2 PREDICTED 24 HOUR CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is well within the NAAQS limit of 125 µg/m³ for the 24-hour averaging interval (Figure 10-4).

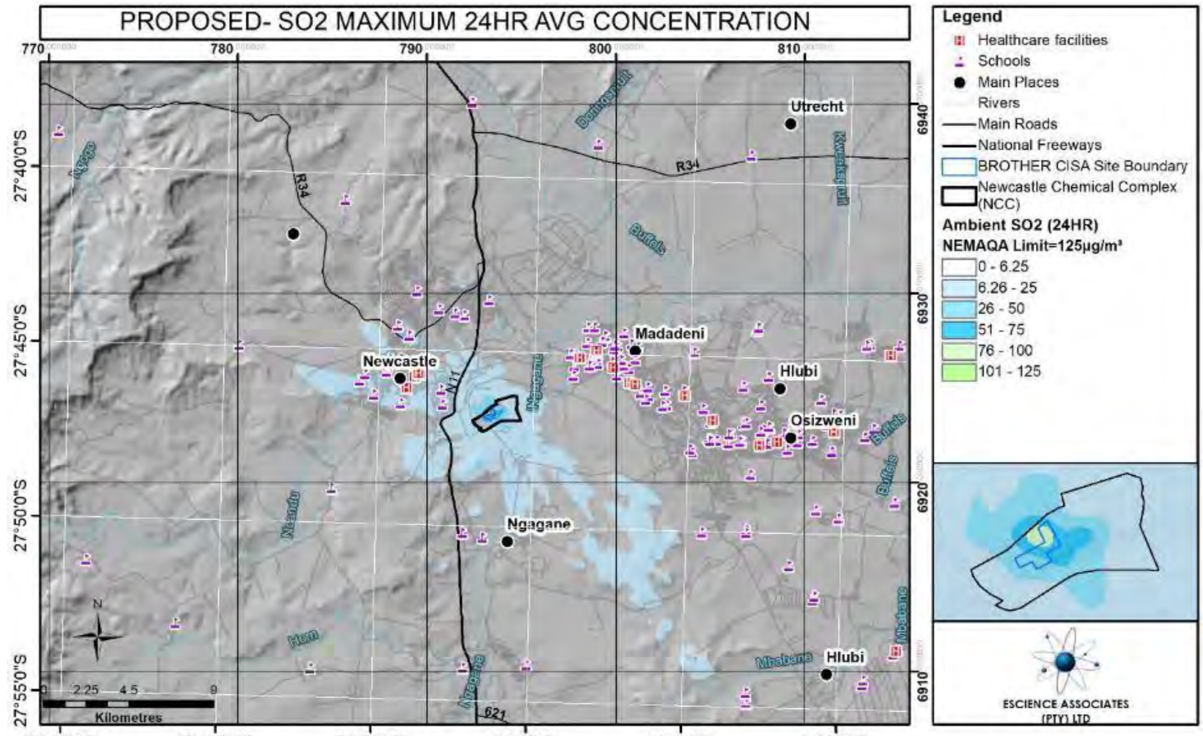


Figure 10-4: Scenario 1 Predicted SO_2 24-Hour maximum modelled ambient concentration.

10.2.2.3.3 PREDICTED ANNUAL CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is well within the NAAQS limit of 50 µg/m³ for the annual averaging interval as well (Figure 10-5).

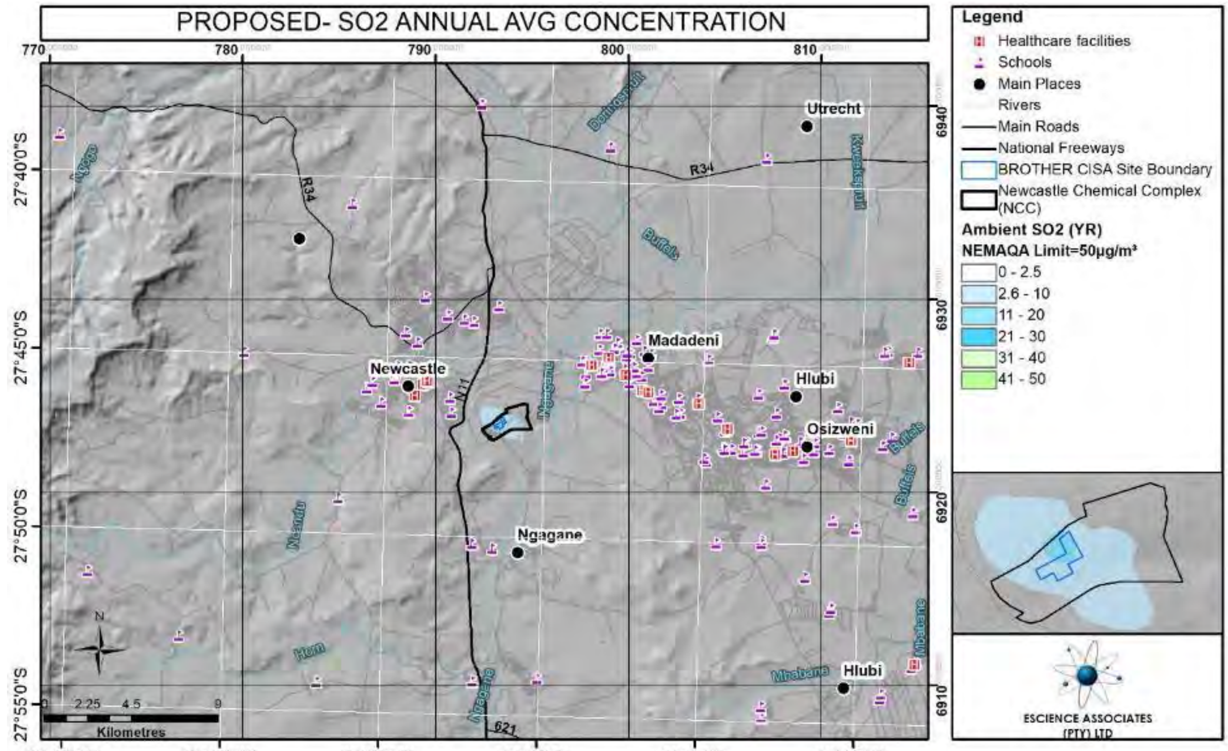


Figure 10-5: Scenario 1 Predicted SO_2 annual maximum modelled ambient concentration.

10.2.2.4 PREDICTED CONCENTRATIONS FOR NO_2

10.2.2.5 PRE-AMBLE NITROUS OXIDES

The national ambient air quality standards regulate ambient concentrations of NO_2. It must be noted that NO_x represents all oxides of nitrogen species. NO_x gases are composed of chemical species other than NO_2 which is typically in the order of only 5 to10% of NO_x emitted from combustion sources. The primary NO_x constituent of these off-gases is typically NO (approximately 90% to 95%). NO will eventually be oxidised to NO_2 in the atmosphere, and the rate of conversion is dictated by the kinetics of reaction in the atmosphere. The downwind concentration of NO_2 from the source is thus generally over-estimated by assuming that all NO_x emissions are NO_2 (various sources – Cooper et al, Yu et al, Hori et al). The implication is that the modelled results have over predicted the NO_2 ambient concentration and the true ambient concentration of NO_2 is significantly less.

In terms of the Regulations Regarding Air Dispersion Modelling (GN. R 533 of 2014), the dispersion model used for this air quality impact assessment, and in general all of those recommended, do not have sufficiently detailed descriptions of atmospheric chemistry to robustly account for NO to NO_2 conversion and thus the predicted NO_x concentration must be equated to NO_2, using a conversion factor. A tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources as stipulated by the US EPA and other guidelines:

Tier 1: Total Conversion Method – Assume that all NO_x is converted to NO_2.
Tier 2: Ambient Ratio Method – Assume a national ratio of NO_2/NO_x of 0.80.

In the absence of reliable and complete measured ambient data for NO and NO_2, the tier 2 conversion has been applied in this assessment.

10.2.2.5.1 PREDICTED 1 HOUR CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 200 µg/m³ for the 1-hour averaging interval. For the three years assessed (2017 through to 2019) the maximum NO_2 concentration occurring over the area for the 1-hour averaging period is 2.01 µg/m³.

10.2.2.5.2 PREDICTED ANNUAL CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 40 µg/m³ for the annual averaging interval as well. For the three years assessed (2017 through to 2019) the maximum NO_2 concentration occurring over the area for the annual averaging period is 0.06 µg/m³.

10.2.2.6 PREDICTED CONCENTRATIONS FOR CR(VI)

10.2.2.6.1 PREDICTED 1 HOUR CONCENTRATIONS FOR Cr(VI)

The predicted ambient concentration from the operations is within the Alberta, Canada Ambient Air Quality limit of 1 µg/m³ for the 1-hour averaging interval (Figure 10-6).

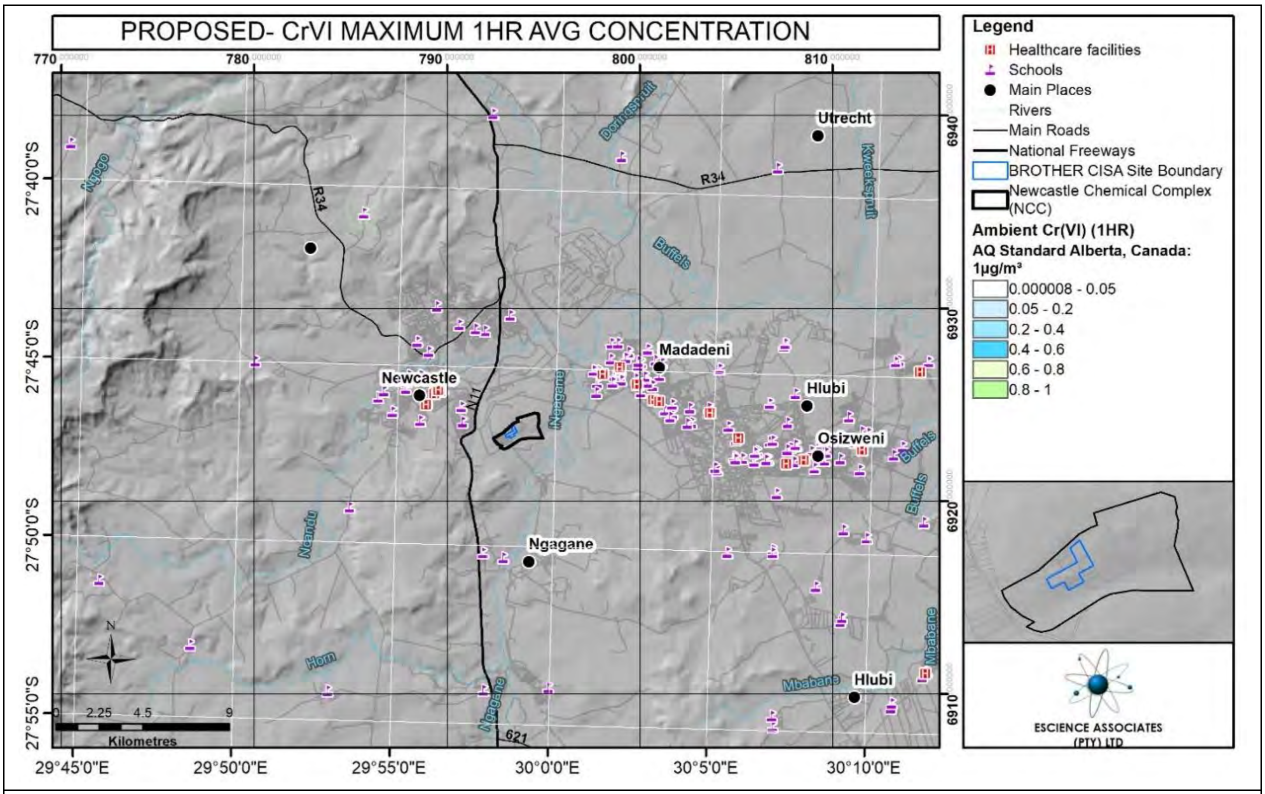


Figure 10-6: Scenario 1 Predicted Cr(VI) 1-Hour maximum modelled ambient concentration.

10.2.2.6.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

Figure 10-7 shows the predicted excess lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer.

As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed to be within the de minimis range.

The predicted lifetime excess carcinogenic risk factor for a small area within the Newcastle Chemicals Complex is 1 in 100 000. Extending over the immediate surrounds of the site there is a lifetime carcinogenic risk in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

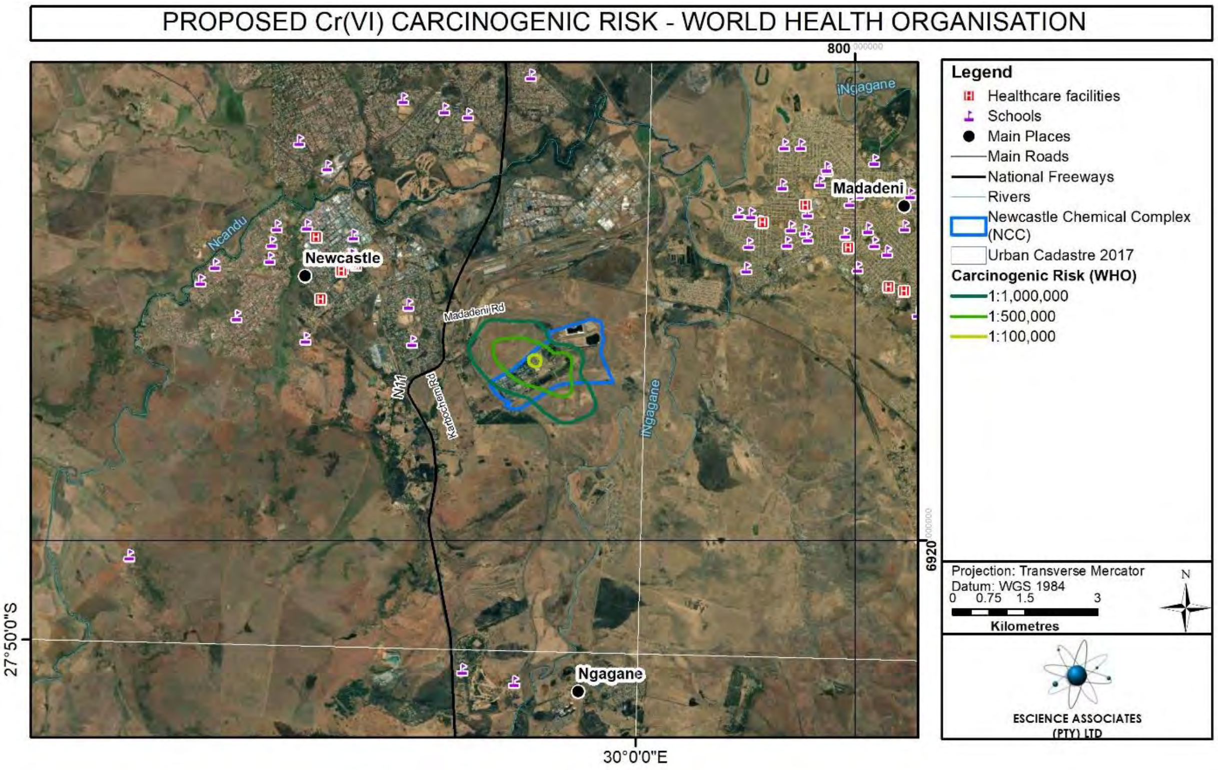


Figure 10-7: Scenario 1 Predicted Cr(VI) lifetime carcinogenic risk with WHO IUR.

10.2.2.6.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

Figure 10-8 shows the predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer. As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed within the de minimis range

The predicted excess lifetime carcinogenic risk factor within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

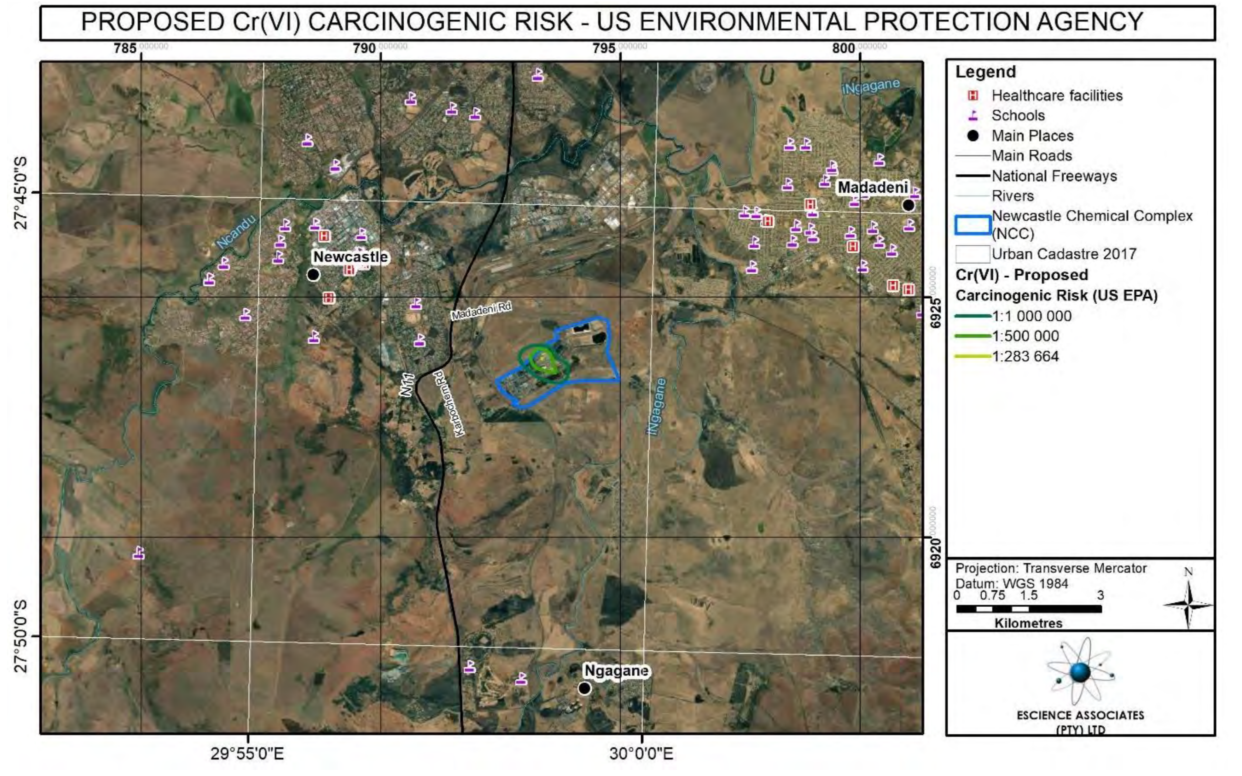


Figure 10-8: Scenario 1 Predicted Cr(VI) lifetime carcinogenic risk with US EPA IUR.

10.2.2.7 PREDICTED CONCENTRATIONS FOR H_2SO_4

10.2.2.7.1 PREDICTED 1 HOUR CONCENTRATIONS FOR H_2SO_4

The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m³ and 120 µg/m³ respectively. (Figure 10-9).

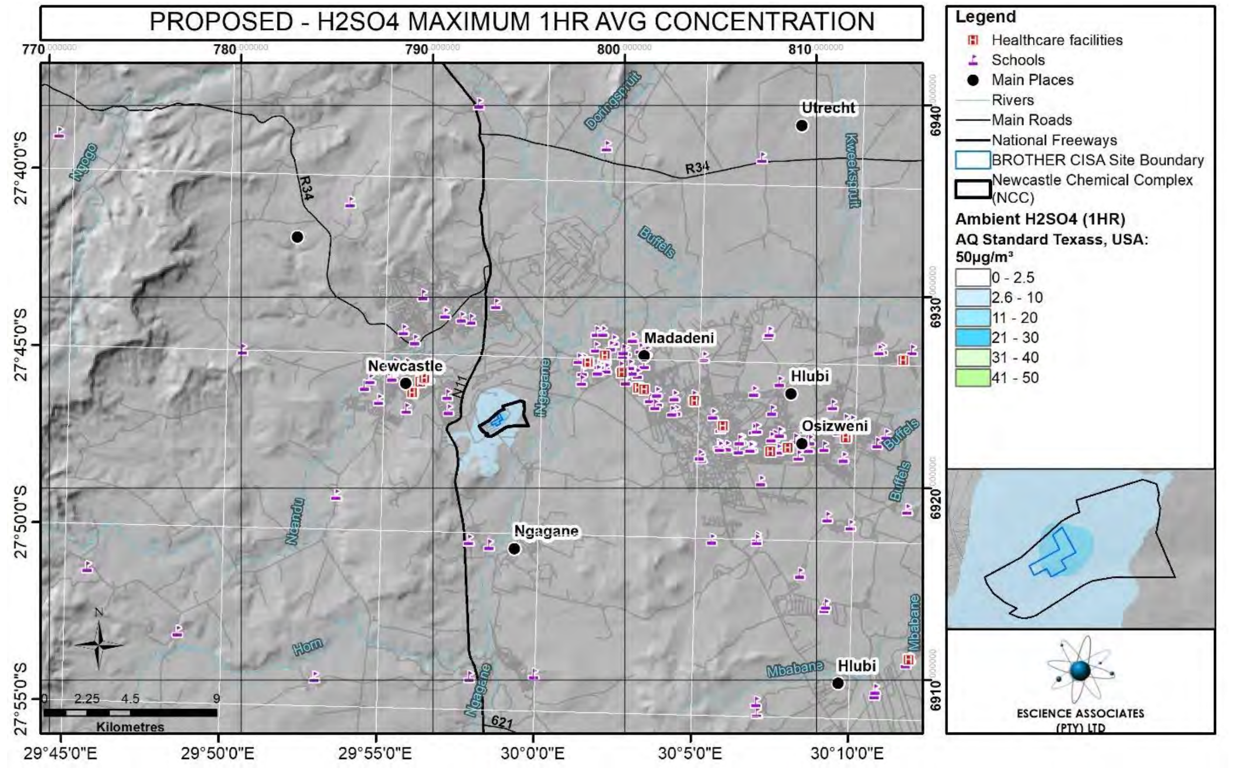


Figure 10-9: Scenario 1 Predicted H_2SO_4 1-Hour maximum modelled ambient concentration.

10.2.2.7.2 PREDICTED 24 HOUR CONCENTRATIONS FOR H_2SO_4

The predicted ambient concentration from the operations is within the Ontario, Canada Ambient Air Quality limit of 5 µg/m³, for the 24-hour averaging interval (Figure 10-10).

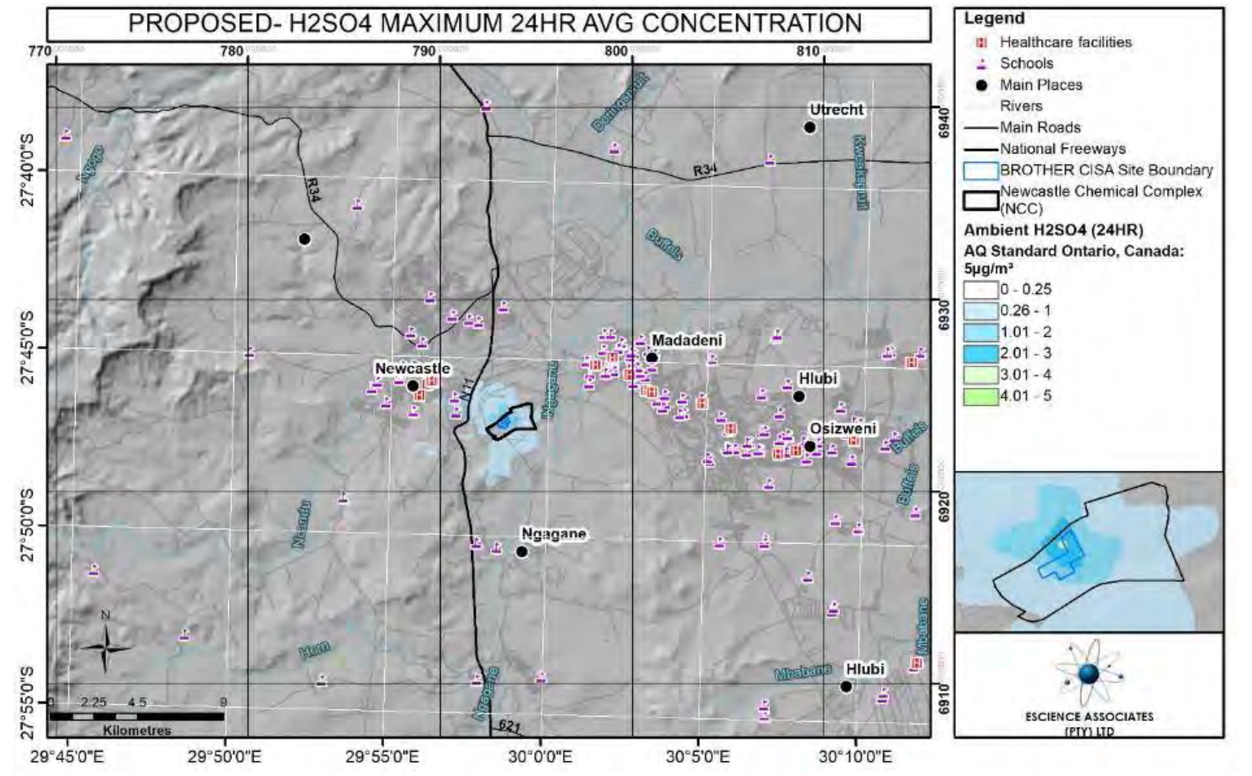


Figure 10-10: Scenario 1 Predicted H_2SO_4 24-Hour maximum modelled ambient concentration.

10.2.2.7.3 PREDICTED ANNUAL CONCENTRATIONS FOR H_2SO_4

The predicted ambient concentration from the operations is within the Michigan, USA Ambient Air Quality limit of 1 µg/m³ for the annual averaging interval (Figure 10-11).

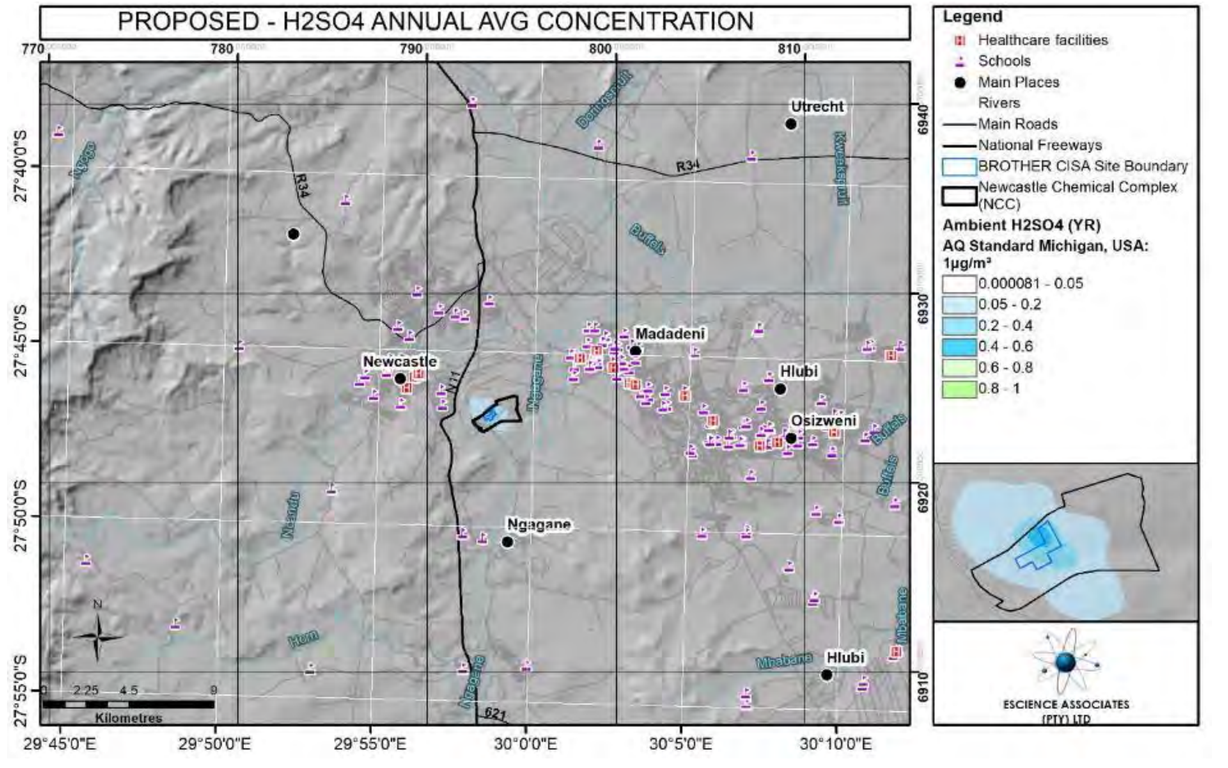


Figure 10-11: Scenario 1 Predicted H_2SO_4 Annual maximum modelled ambient concentration.

10.2.3 SCENARIO 2: BASELINE EMISSIONS

All existing significant point sources modelled at the measured emission rates as per the stack test reports.

10.2.3.1 PREDICTED CONCENTRATIONS FOR PM_{10}

Measured particulate emissions have not been fractioned to indicate the percentage of PM_{10} in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are PM_{10}.

10.2.3.1.1 PREDICTED 24 HOUR CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is well within the NAAQS limit of 75 µg/m^3 for the 24-hour averaging interval (Figure 10-12).

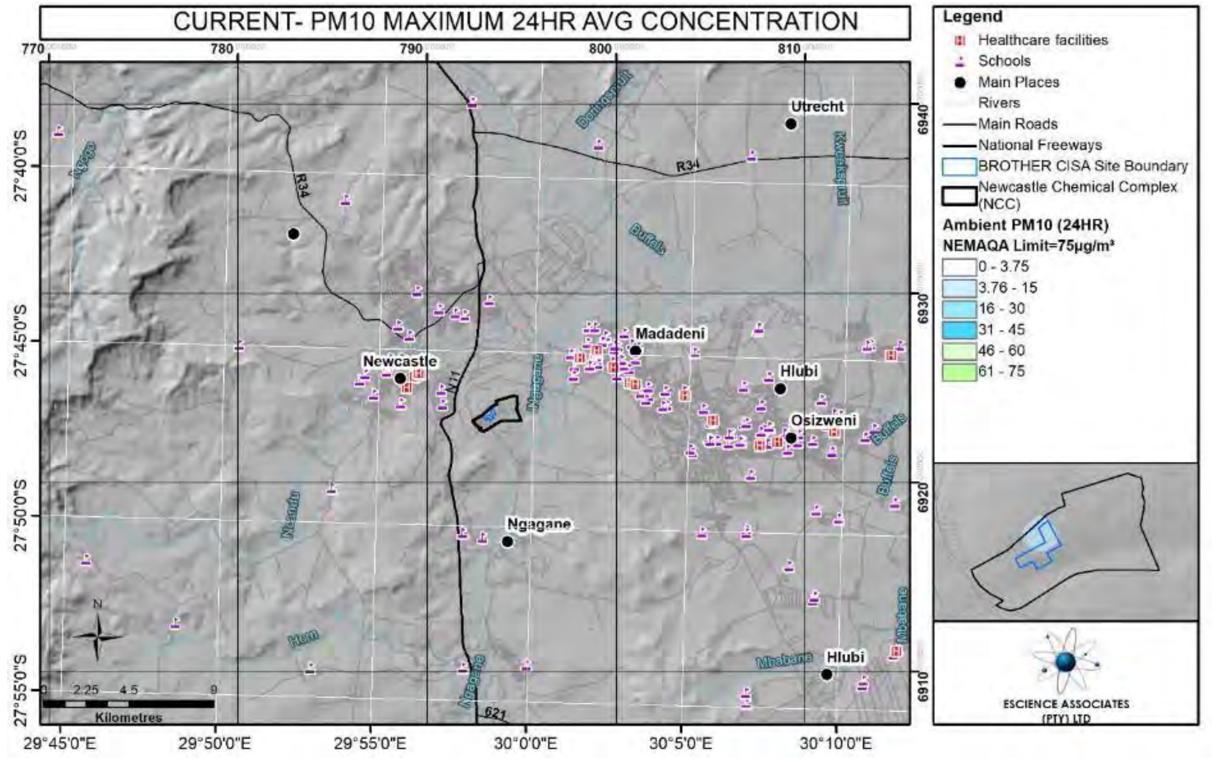


Figure 10-12: Scenario 2 Predicted PM_{10} 24-Hour maximum modelled ambient concentration.

10.2.3.1.2 PREDICTED ANNUAL CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is well within the NAAQS limit of 40 µg/m³ for the annual averaging interval. For the three years assessed (2017 through to 2019) the maximum PM_{10} concentration occurring over the area for the annual averaging period is 1.42 µg/m³.

10.2.3.2 PREDICTED CONCENTRATIONS FOR PM2.5

Measured particulate emissions have not been fractioned to indicate the percentage of $PM_{2.5}$ in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are $PM_{2.5}$.

10.2.3.2.1 PREDICTED 24 HOUR CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is well within the NAAQS limit of 40 µg/m³ for the 24-hour averaging interval (Figure 10-13).

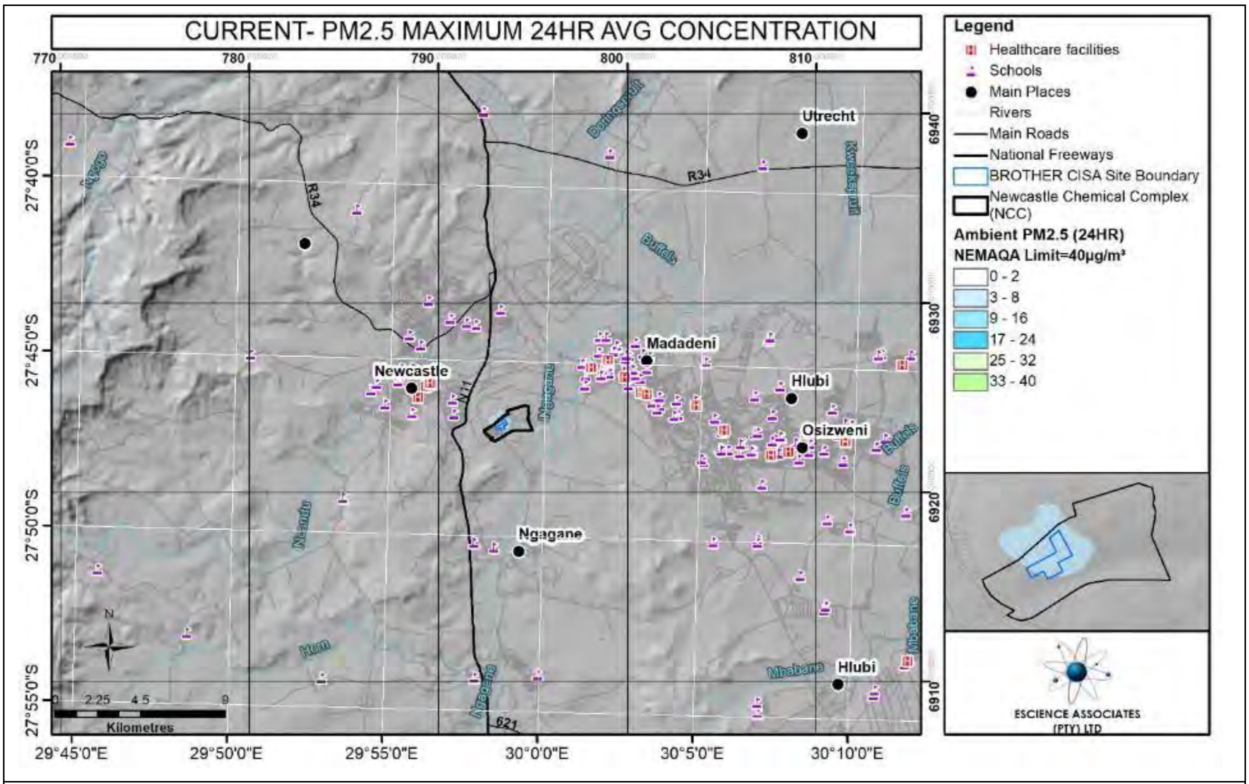


Figure 10-13: Scenario 2 Predicted $PM_{2.5}$ 24-Hour maximum modelled ambient concentration.

10.2.3.2.2 PREDICTED ANNUAL CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is well within the NAAQS limit of 20 µg/m³ for the annual averaging interval as well (Figure 10-14).

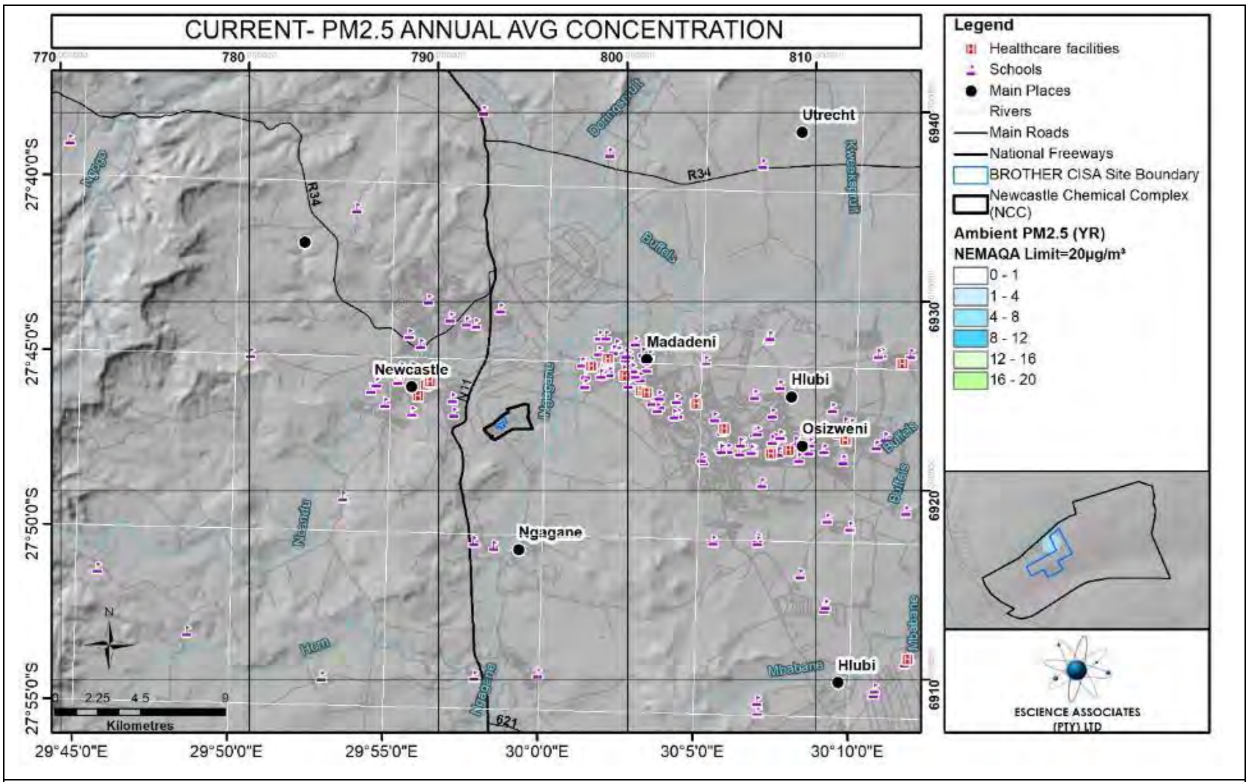


Figure 10-14: Scenario 2 Predicted $PM_{2.5}$ annual maximum modelled ambient concentration.

10.2.3.3 PREDICTED CONCENTRATIONS FOR SO_2

10.2.3.3.1 PREDICTED 1 HOUR CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is well within the NAAQS limit of 350 µg/m³ for the 1-hour averaging interval (Figure 10-15).

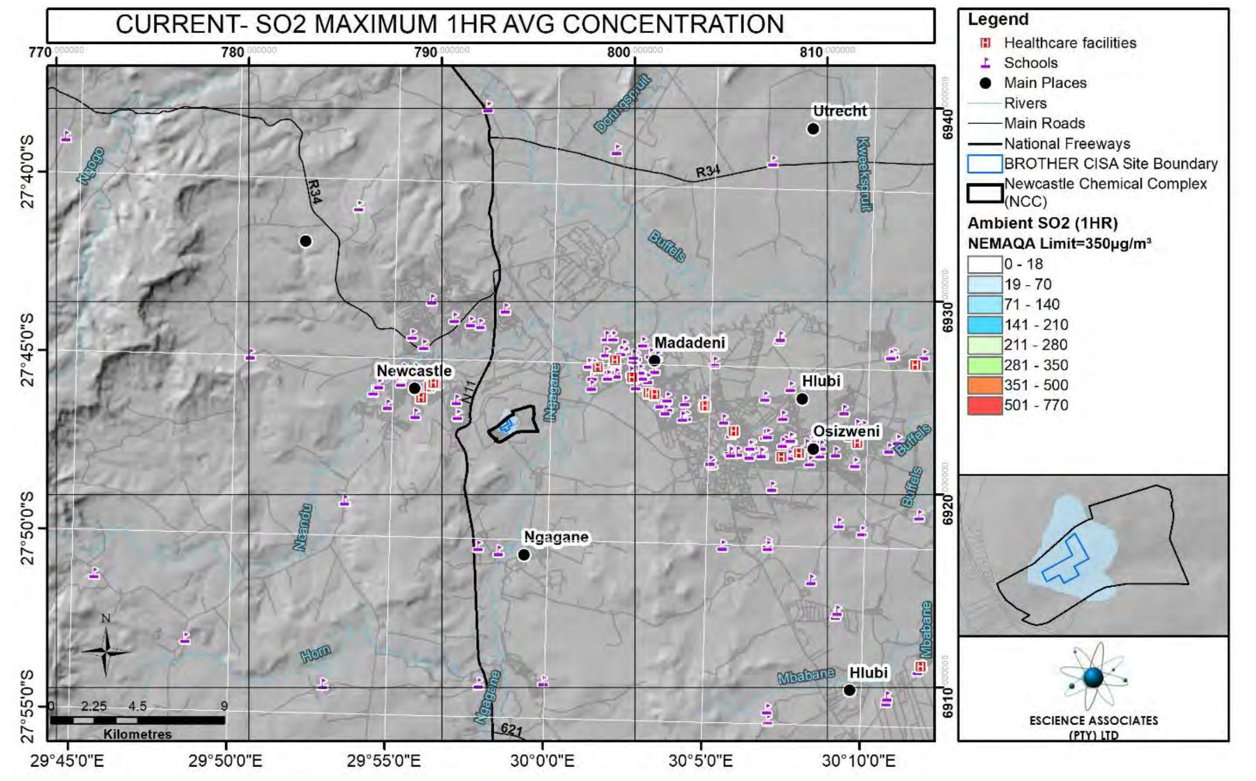


Figure 10-15: Scenario 2 Predicted SO_2 1-Hour maximum modelled ambient concentration.

10.2.3.3.2 PREDICTED 24 HOUR CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is well within the NAAQS limit of 125 µg/m³ for the 24-hour averaging interval (Figure 10-16).

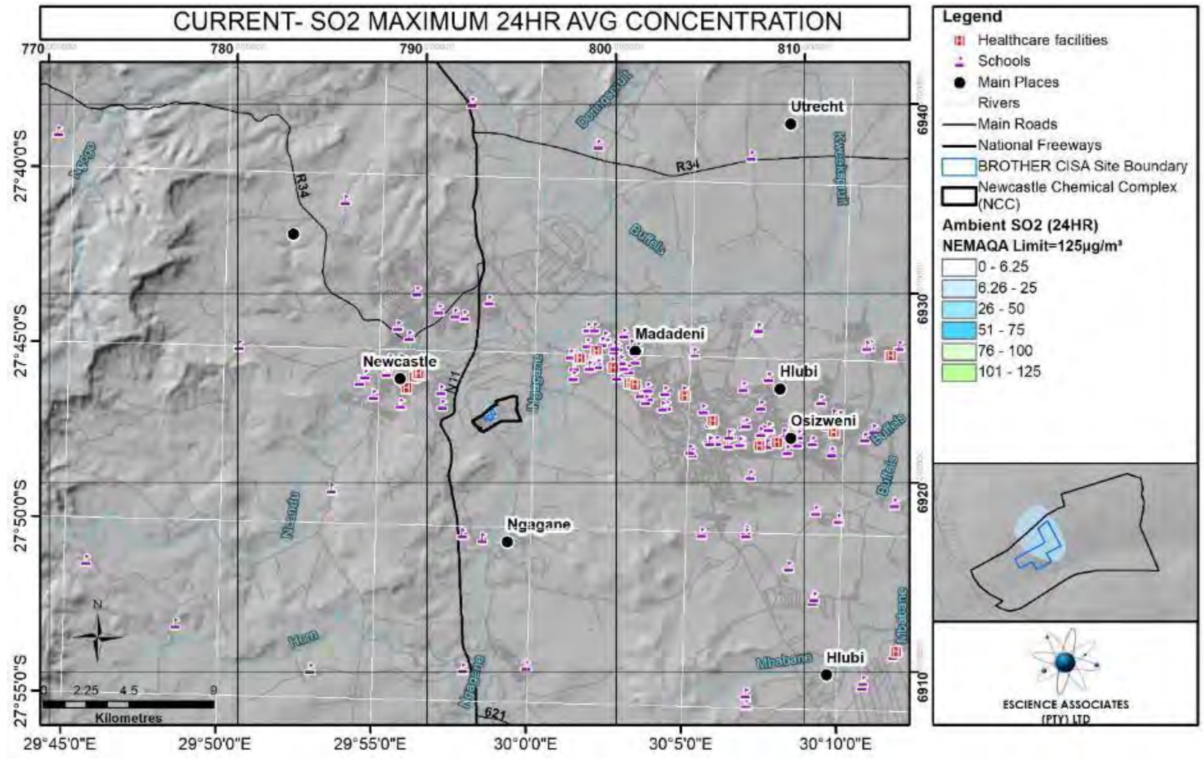


Figure 10-16: Scenario 2 Predicted SO_2 24-Hour maximum modelled ambient concentration.

10.2.3.3.3 PREDICTED ANNUAL CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is well within the NAAQS limit of 50 µg/m³ for the annual averaging interval as well (Figure 10-17).

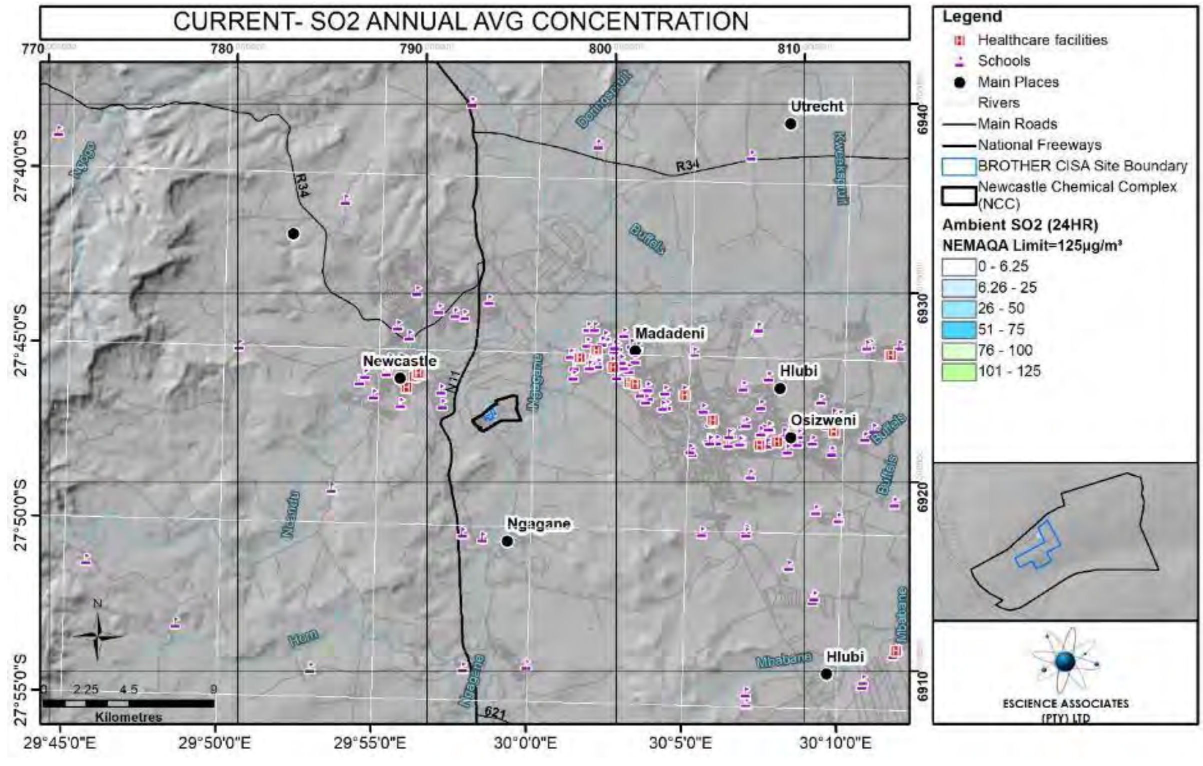


Figure 10-17: Scenario 2 Predicted SO_2 annual maximum modelled ambient concentration.

10.2.3.4 PREDICTED CONCENTRATIONS FOR NO_2

10.2.3.5 PRE-AMBLE NITROUS OXIDES

The national ambient air quality standards regulate ambient concentrations of NO_2. It must be noted that NO_x represents all oxides of nitrogen species. NO_x gases are composed of chemical species other than NO_2 which is typically in the order of only 5 to10% of NO_x emitted from combustion sources. The primary NO_x constituent of these off-gases is typically NO (approximately 90% to 95%). NO will eventually be oxidised to NO_2 in the atmosphere, and the rate of conversion is dictated by the kinetics of reaction in the atmosphere. The downwind concentration of NO_2 from the source is thus generally over-estimated by assuming that all NO_x emissions are NO_2 (various sources – Cooper et al, Yu et al, Hori et al). The implication is that the modelled results have over predicted the NO_2 ambient concentration and the true ambient concentration of NO_2 is significantly less.

In terms of the Regulations Regarding Air Dispersion Modelling (GN. R 533 of 2014), the dispersion model used for this air quality impact assessment, and in general all of those recommended, do not have sufficiently detailed descriptions of atmospheric chemistry to robustly account for NO to NO_2 conversion and thus the predicted NO_x concentration must be equated to NO_2, using a conversion factor. A tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources as stipulated by the US EPA and other guidelines:

Tier 1: Total Conversion Method – Assume that all NO_x is converted to NO_2.
Tier 2: Ambient Ratio Method – Assume a national ratio of NO_2/NO_x of 0.80.

In the absence of reliable and complete measured ambient data for NO and NO_2, the tier 2 conversion has been applied in this assessment.

10.2.3.5.1 PREDICTED 1 HOUR CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 200 $\mu g/m^3$ for the 1-hour averaging interval (Figure 10-18).

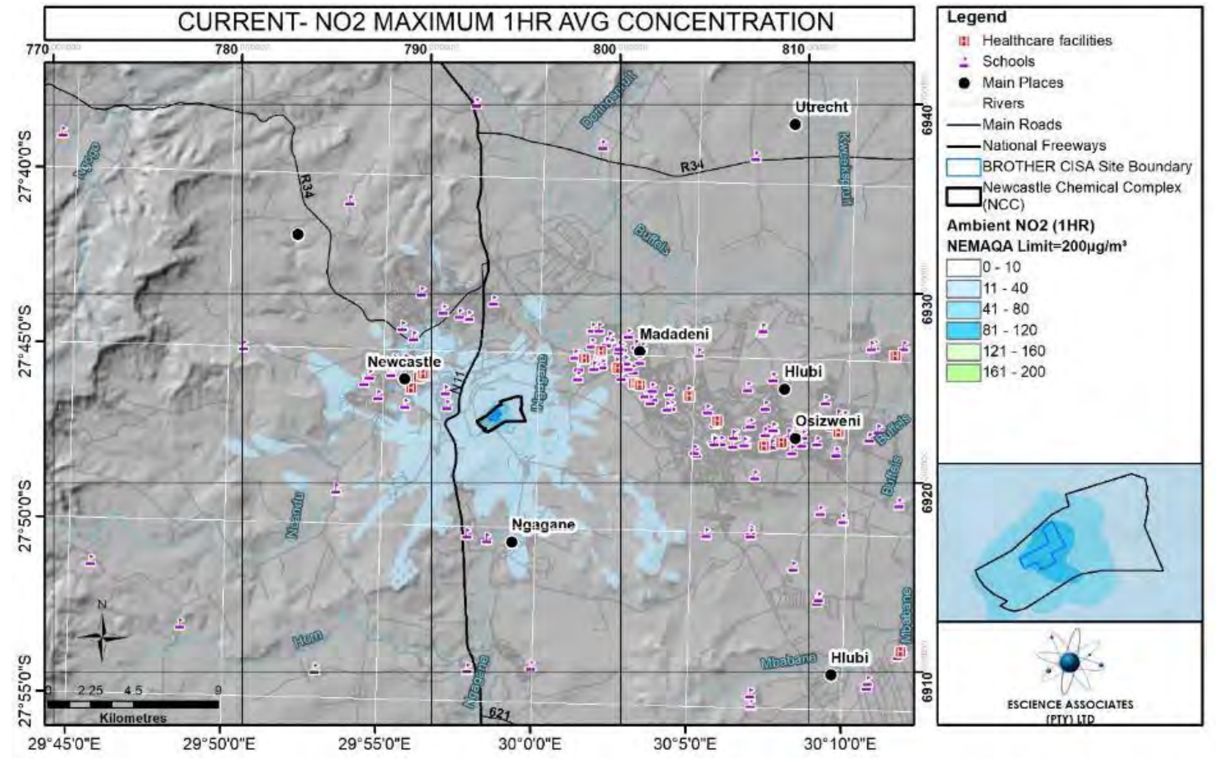


Figure 10-18: Scenario 2 Predicted NO_2 1-Hour maximum modelled ambient concentration.

10.2.3.5.2 PREDICTED ANNUAL CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 40 µg/m^3 for the annual averaging interval as well (Figure 10-19).

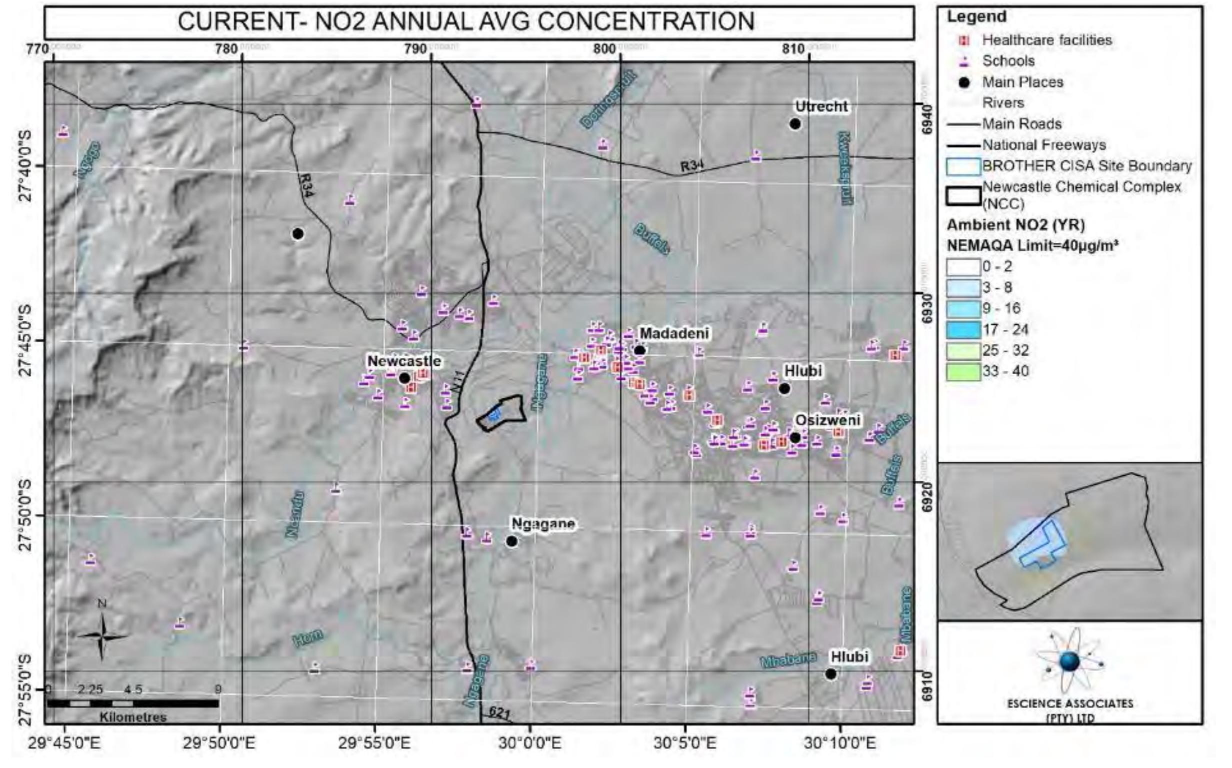


Figure 10-19: Scenario 2 Predicted NO_2 annual maximum modelled ambient concentration.

10.2.3.6 PREDICTED CONCENTRATIONS FOR CR(VI)

10.2.3.6.1 PREDICTED 1 HOUR CONCENTRATIONS FOR Cr(VI)

The predicted ambient concentration from the operations is within the Alberta, Canada Ambient Air Quality limit of 1 µg/m^3 for the 1-hour averaging interval (Figure 10-20).

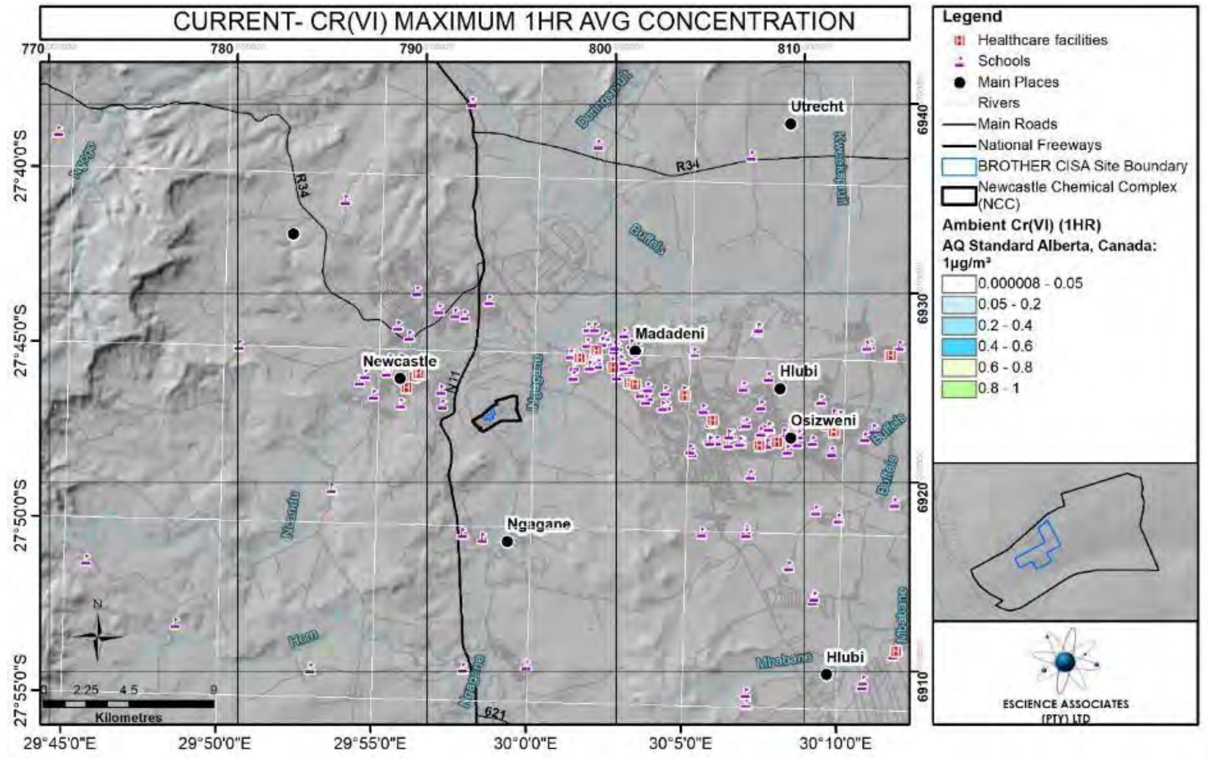


Figure 10-20: Scenario 2 Predicted Cr(VI) 1-Hour maximum modelled ambient concentration.

10.2.3.6.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

Figure 10-21 shows the predicted lifetime carcinogenic risk resulting from the maximum emissions from the existing plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer. As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed within the de minimis range

The predicted excess lifetime carcinogenic risk factor for a small area within site is 1:50 000. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. A small part of the Arbour Park residential area is exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk in the order of 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

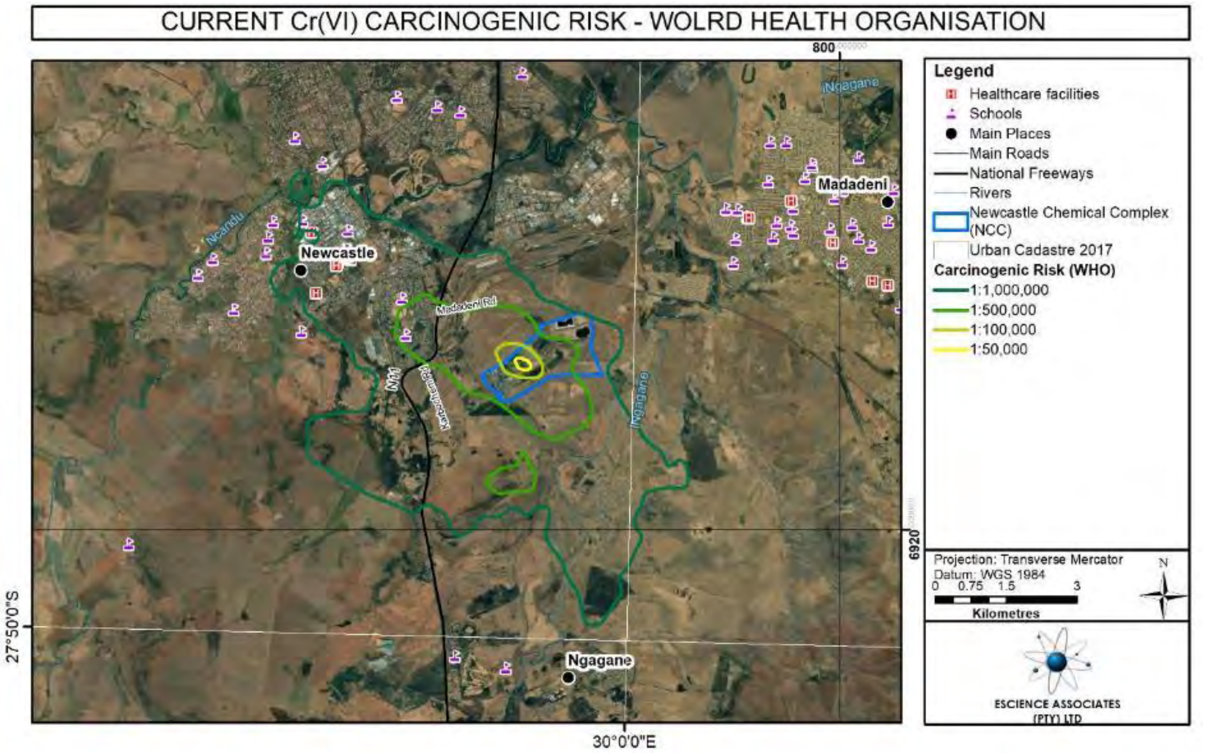


Figure 10-21: Scenario 2 Predicted Cr(VI) lifetime carcinogenic risk with WHO IUR.

10.2.3.6.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

Figure 10-22 shows the Predicted lifetime carcinogenic risk resulting from the emissions from the existing plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer. As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed within the de minimis range

The maximum predicted lifetime excess carcinogenic risk factor for a small area within the Newcastle Chemicals Complex is 1 in 150 453. The predicted excess lifetime carcinogenic risk factor within part of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

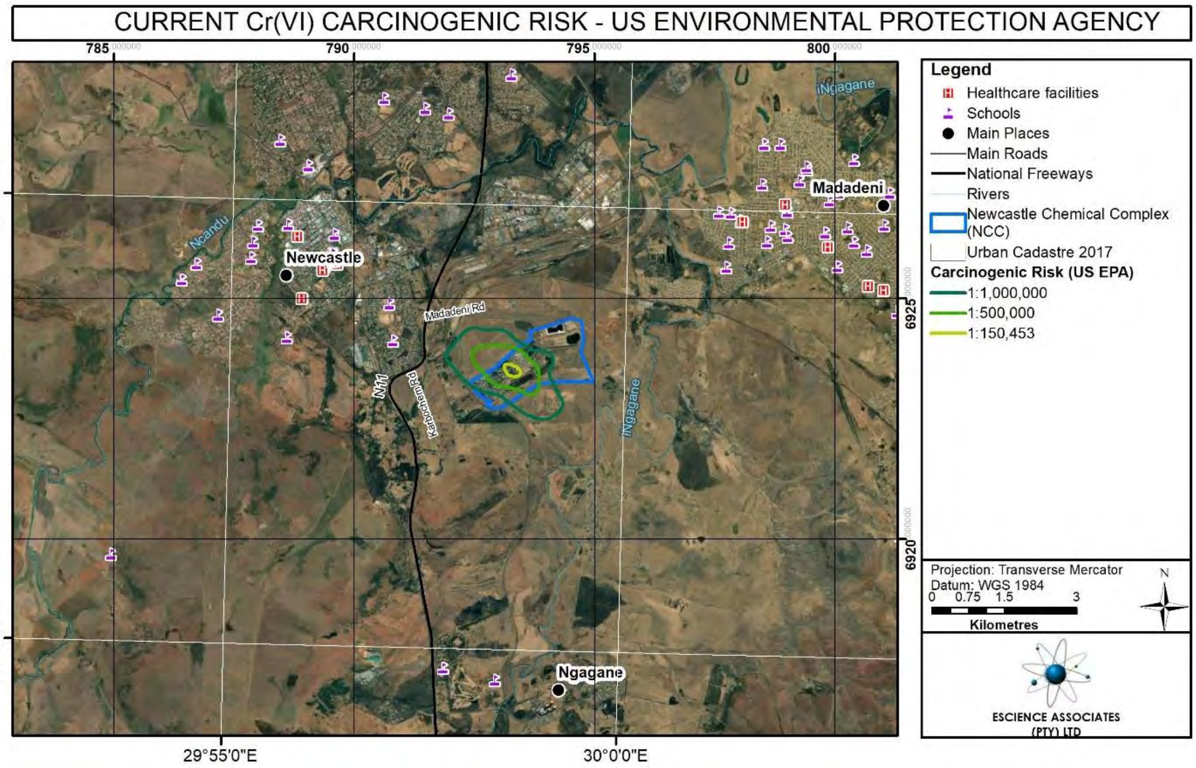


Figure 10-22: Scenario 2 Predicted Cr(VI) lifetime carcinogenic risk with US EPA IUR.

10.2.3.6.4 COMPARISON OF MODELLED AND MEASURED CR(VI)

As shown in Figure 7-3, in 2017 – 2019 the measured Cr(VI) has been below detectable limit of 0.0001 µg/m³ at all stations, expect for 1 reading of 0.0002 µg/m³ at station B Arbor Park School

The modelled maximum 3 week average ambient concentrations extracted at the locations of the monitoring stations are shown in Table 10-4.

Table 10-4: Modelled maximum 3 week average ambient Cr(VI) concentrations at CSIR ambient monitoring locations

Monitoring location		2017	2018	2019	Max 2017- 2019
		µg/m³			
Station A	Effluent Plant	0.000360	0.000325	0.000248	0.000360
Station B	Arbor Park School	0.000083	0.000080	0.000059	0.000083
Station C	Keyway Motors	0.000030	0.000021	0.000025	0.000030
Station D	Airport	0.000072	0.000046	0.000036	0.000072

Station A - Effluent Plant is the closest monitoring station to the Brother CISA facility. The Modelled maximum 3 week average ambient Cr(VI) concentration extracted for this location was 0.00036 µg/m³. This is 3.6 times higher than the analytical detection limit of 0.0001 µg/m³.

The modelled maximum 3 week average ambient Cr(VI) concentration for each year, 2017, 2018 and 2019 were all above the analytical detection limit of 0.0001 µg/m³. and thus, it can be concluded that for Location A the modelled Cr(VI) concentrations are above the actual Cr(VI) concentrations.

At the other stations the modelled maximum 3 week average ambient Cr(VI) concentrations are all below the analytical detection limit of 0.0001 µg/m³, thus no meaningful comparison of modelled and measured results can be made for locations B, C and D.

10.2.4 SCENARIO 3: CUMULATIVE EMISSIONS IMPACT

A cumulative impact assessment of proposed and current sources modelled as per the scenarios discussed in the previous sections.

10.2.4.1 PREDICTED CONCENTRATIONS FOR PM_{10}

Particulate emissions have not been fractioned to indicate the percentage of PM_{10} in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are PM_{10}.

10.2.4.1.1 PREDICTED 24 HOUR CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is within the NAAQS limit of 75 µg/m³ for the 24-hour averaging interval.

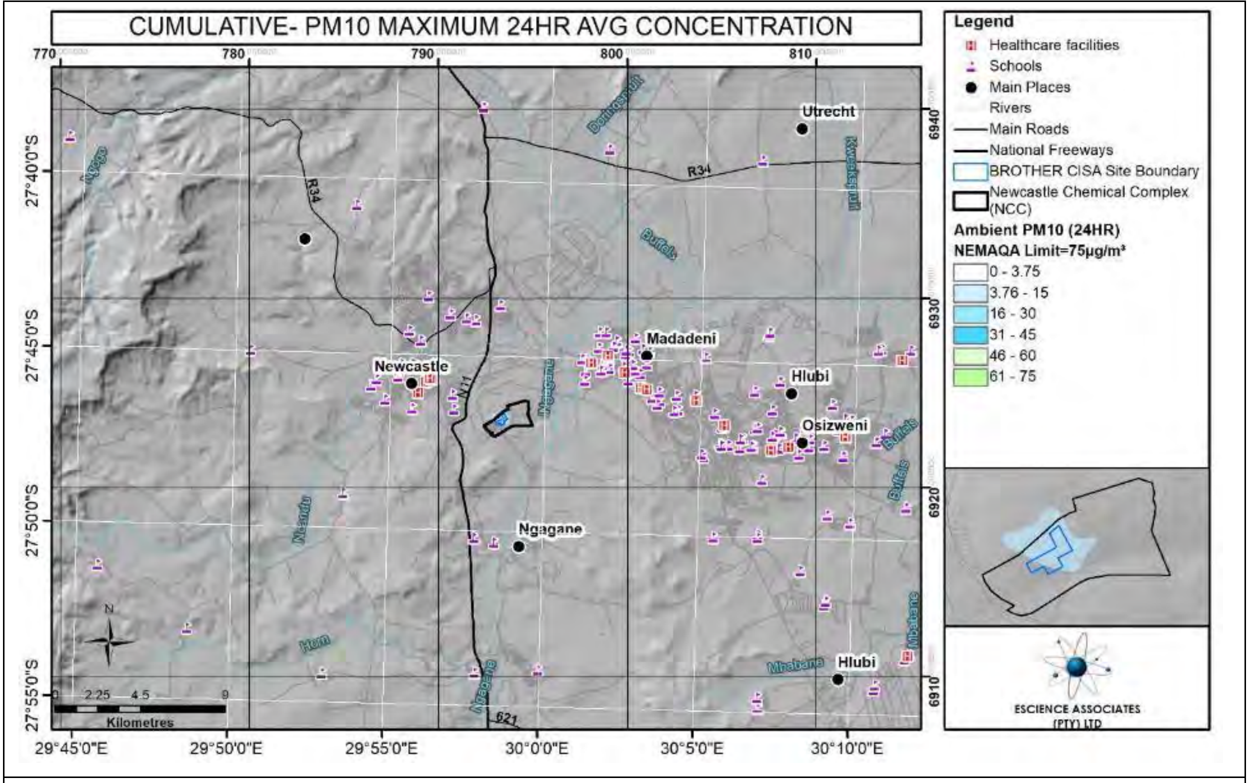


Figure 10-23: Scenario 3 Predicted PM_{10} 24-hour maximum modelled ambient concentration.

10.2.4.1.2 PREDICTED ANNUAL CONCENTRATIONS FOR PM_{10}

The predicted ambient concentration from the operations is within the NAAQS limit of 40 µg/m³ for the annual averaging interval. For the three years assessed (2017 through to 2019) the maximum PM_{10} concentration occurring over the area for the annual averaging period is 1.72 µg/m³.

10.2.4.2 PREDICTED CONCENTRATIONS FOR PM2.5

Particulate emissions have not been fractioned to indicate the percentage of $PM_{2.5}$ in the total particulates measured. For the purposes of this assessment it was conservatively assumed that all particulates measured are $PM_{2.5}$.

10.2.4.2.1 PREDICTED 24 HOUR CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is within the NAAQS limit of 40 µg/m³ for the 24-hour averaging interval.

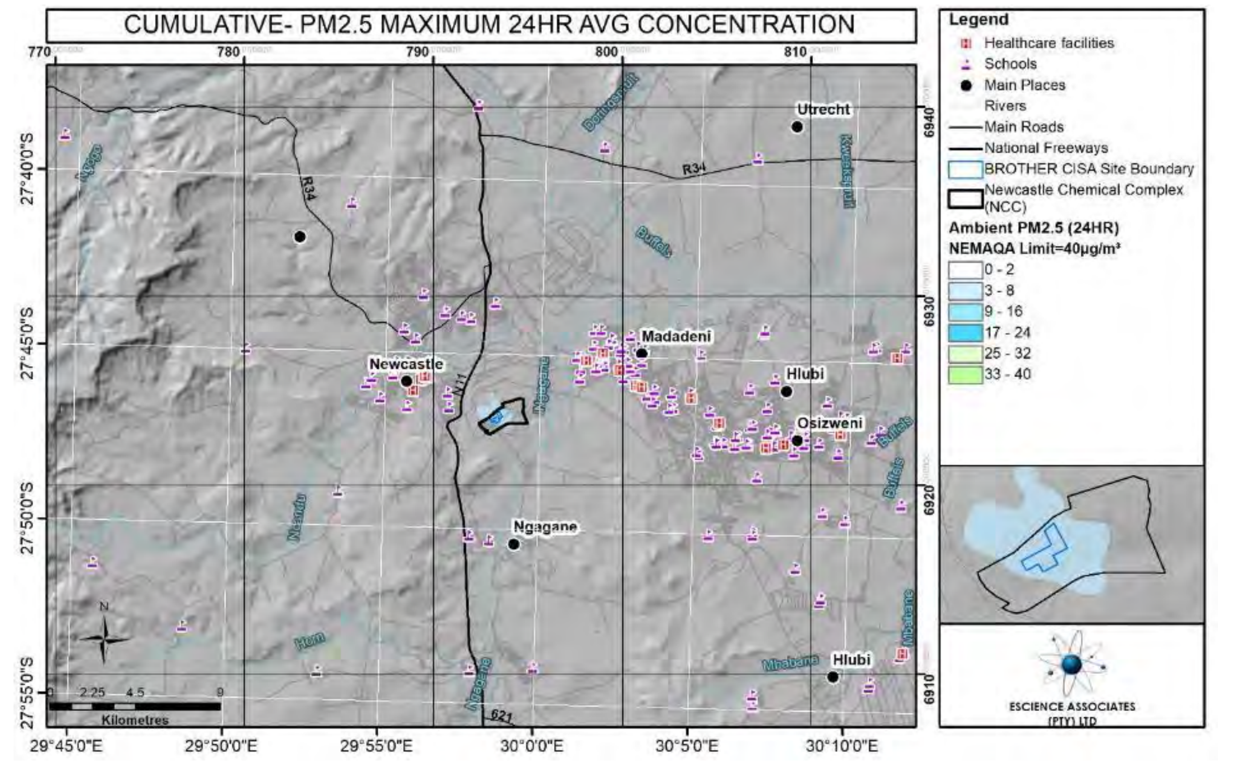


Figure 10-24: Scenario 3 Predicted $PM_{2.5}$ 24-hour maximum modelled ambient concentration.

10.2.4.2.2 PREDICTED ANNUAL CONCENTRATIONS FOR $PM_{2.5}$

The predicted ambient concentration from the operations is within the NAAQS limit of 20 µg/m³ for the annual averaging interval. For the three years assessed (2017 through to 2019) the maximum $PM_{2.5}$ concentration occurring over the area for the annual averaging period is 1.72 µg/m³.

10.2.4.3 PREDICTED CONCENTRATIONS FOR SO_2

10.2.4.3.1 PREDICTED 1 HOUR CONCENTRATIONS FOR SO_2

There are predicted exceedances the NAAQS limit of 350 µg/m³ for the 1-hour averaging interval, however the predicted exceedances are all within the industrial boundary (Figure 10-25). The predicted number of exceedances is within the permissible number of exceedances over the period (88 exceedances allowed per annum), over the modelling period (Figure 10-26).

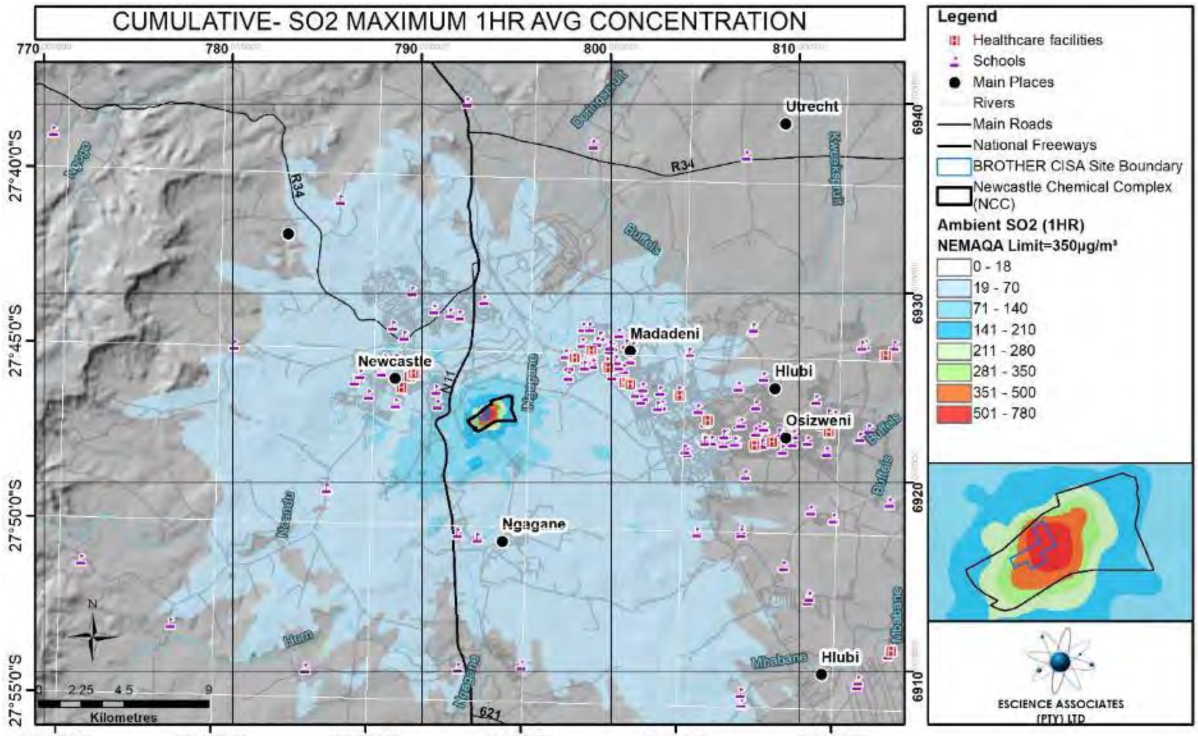


Figure 10-25: Scenario 3 Predicted SO_2 1-Hour maximum modelled ambient concentration.

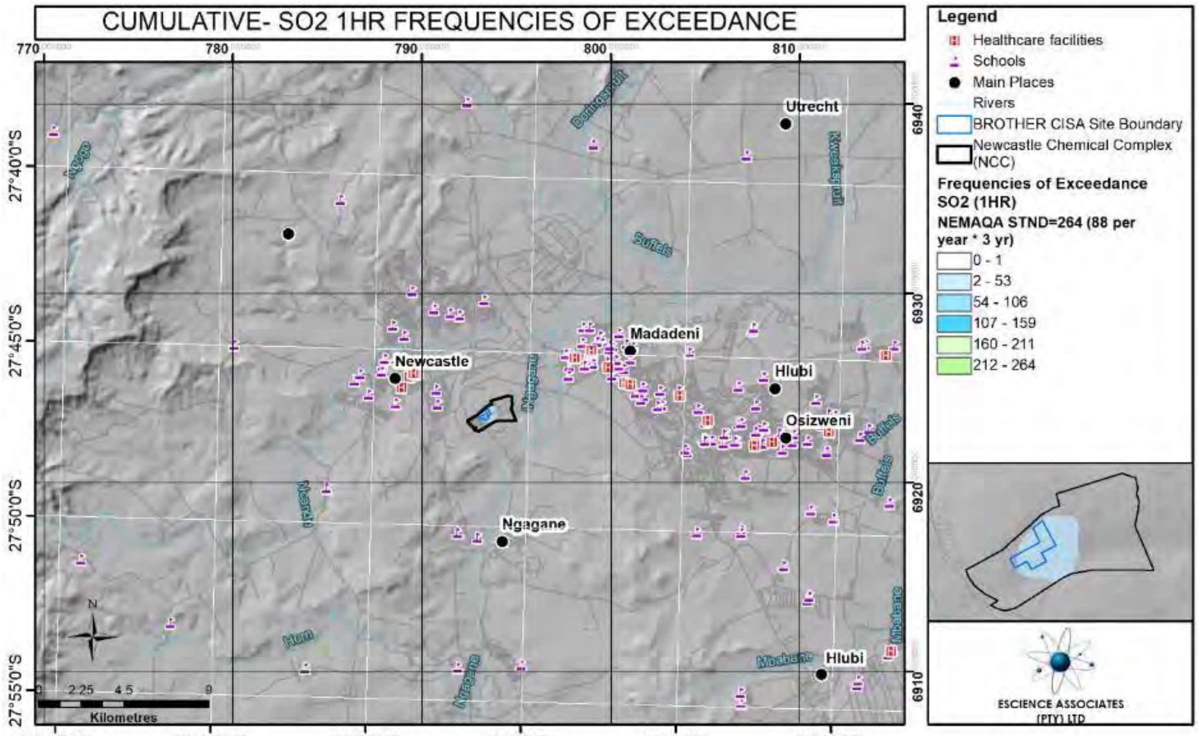


Figure 10-26: Scenario 3 Predicted SO_2 1-Hour maximum modelled ambient number of exceedances.

10.2.4.3.2 PREDICTED 24 HOUR CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 125 µg/m³ for the 24-hour averaging interval (Figure 10-27).

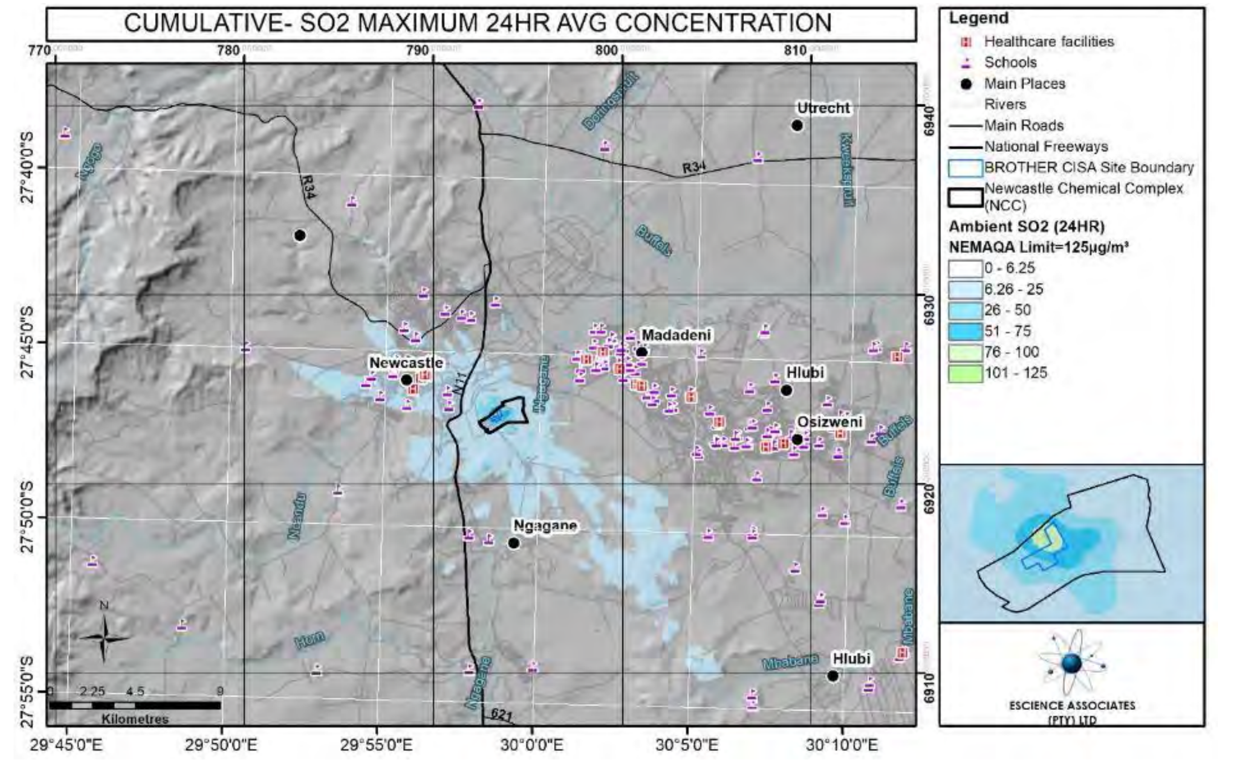


Figure 10-27: Scenario 3 Predicted SO_2 24-Hour maximum modelled ambient concentration.

10.2.4.3.3 PREDICTED ANNUAL CONCENTRATIONS FOR SO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 50 µg/m³ for the annual averaging interval as well (Figure 10-28).

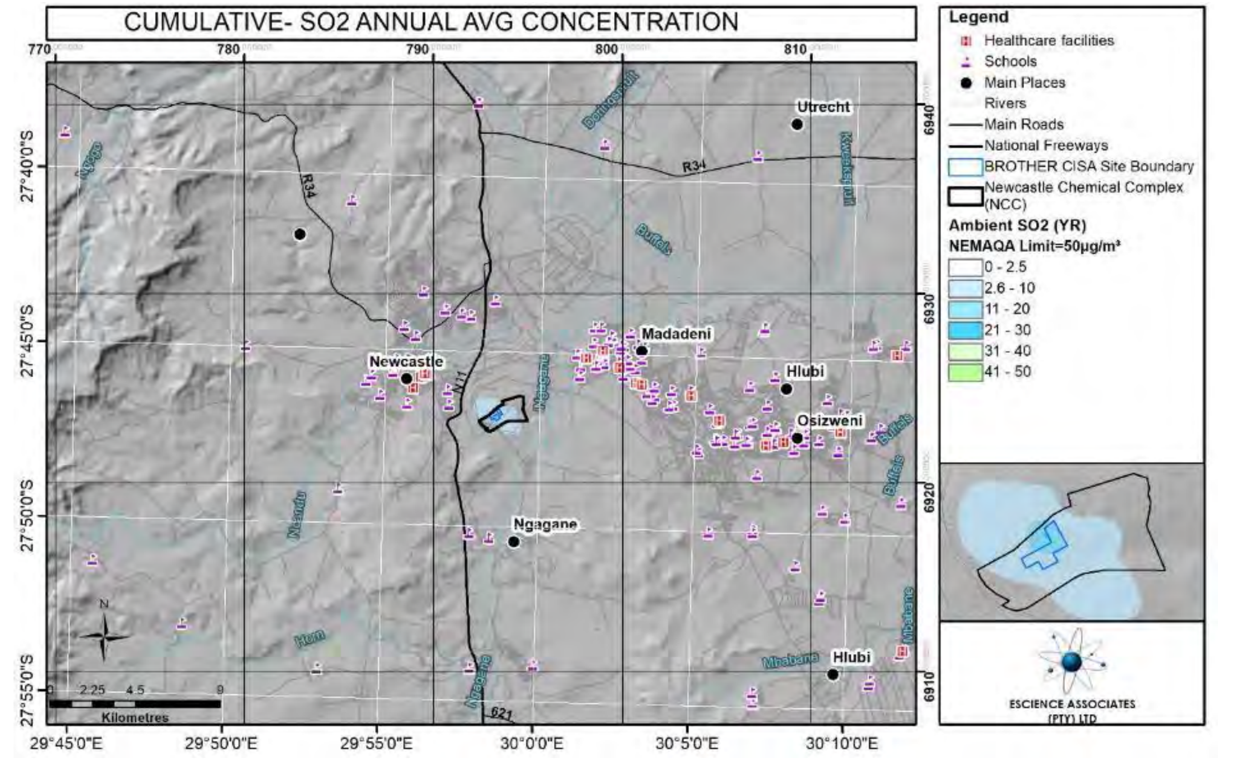


Figure 10-28: Scenario 3 Predicted SO_2 annual maximum modelled ambient concentration.

10.2.4.4 PREDICTED CONCENTRATIONS FOR NO_2

10.2.4.5 PRE-AMBLE NITROUS OXIDES

The national ambient air quality standards regulate ambient concentrations of NO_2. It must be noted that NO_x represents all oxides of nitrogen species. NO_x gases are composed of chemical species other than NO_2 which is typically in the order of only 5 to10% of NO_x emitted from combustion sources. The primary NO_x constituent of these off-gases is typically NO (approximately 90% to 95%). NO will eventually be oxidised to NO_2 in the atmosphere, and the rate of conversion is dictated by the kinetics of reaction in the atmosphere. The downwind concentration of NO_2 from the source is thus generally over-estimated by assuming that all NO_x emissions are NO_2 (various sources – Cooper et al, Yu et al, Hori et al). The implication is that the modelled results have over predicted the NO_2 ambient concentration and the true ambient concentration of NO_2 is significantly less.

In terms of the Regulations Regarding Air Dispersion Modelling (GN. R 533 of 2014), the dispersion model used for this air quality impact assessment, and in general all of those recommended, do not have sufficiently detailed descriptions of atmospheric chemistry to robustly account for NO to NO_2 conversion and thus the predicted NO_x concentration must be equated to NO_2, using a conversion factor. A tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources as stipulated by the US EPA and other guidelines:

Tier 1: Total Conversion Method – Assume that all NO_x is converted to NO_2.
Tier 2: Ambient Ratio Method – Assume a national ratio of NO_2/NO_x of 0.80.

In the absence of reliable and complete measured ambient data for NO and NO_2, the tier 2 conversion has been applied in this assessment.

10.2.4.5.1 PREDICTED 1 HOUR CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 200 $\mu g/m^3$ for the 1-hour averaging interval (Figure 10-29).

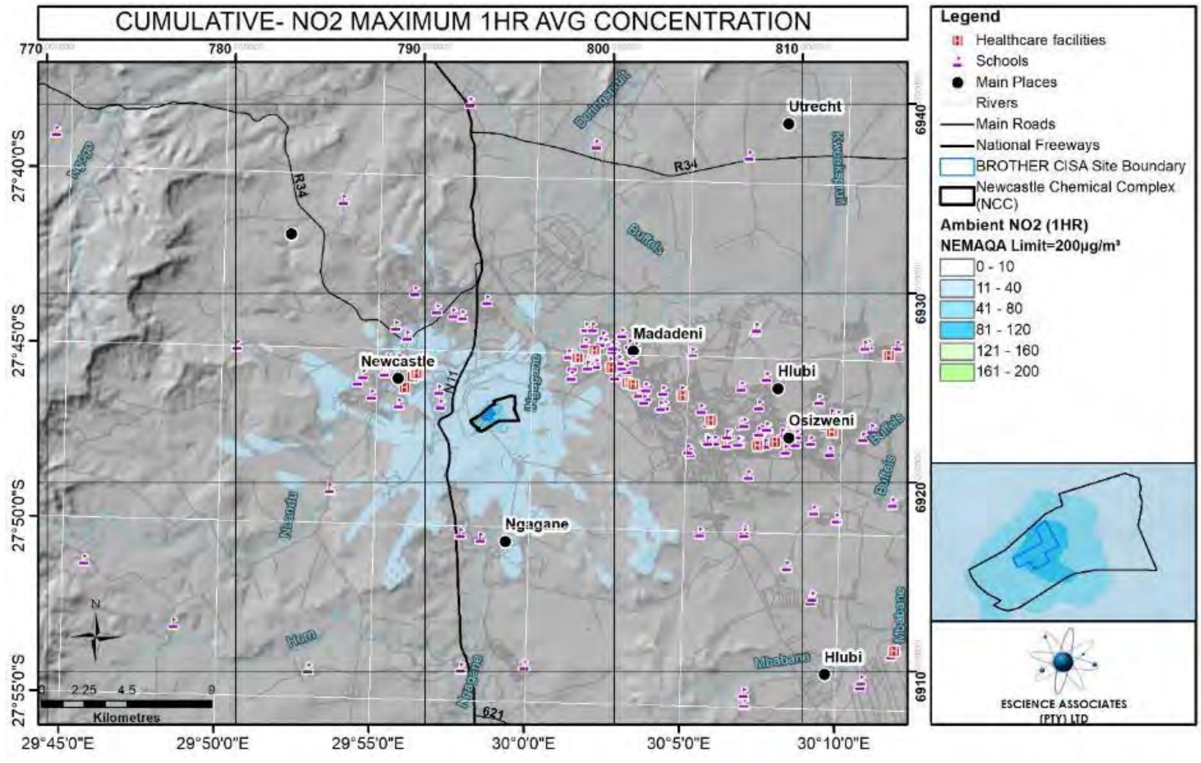


Figure 10-29: Scenario 3 Predicted NO_2 1-Hour maximum modelled ambient concentration.

10.2.4.5.2 PREDICTED ANNUAL CONCENTRATIONS FOR NO_2

The predicted ambient concentration from the operations is within the NAAQS limit of 40 µg/m³ for the annual averaging interval as well (Figure 10-30).

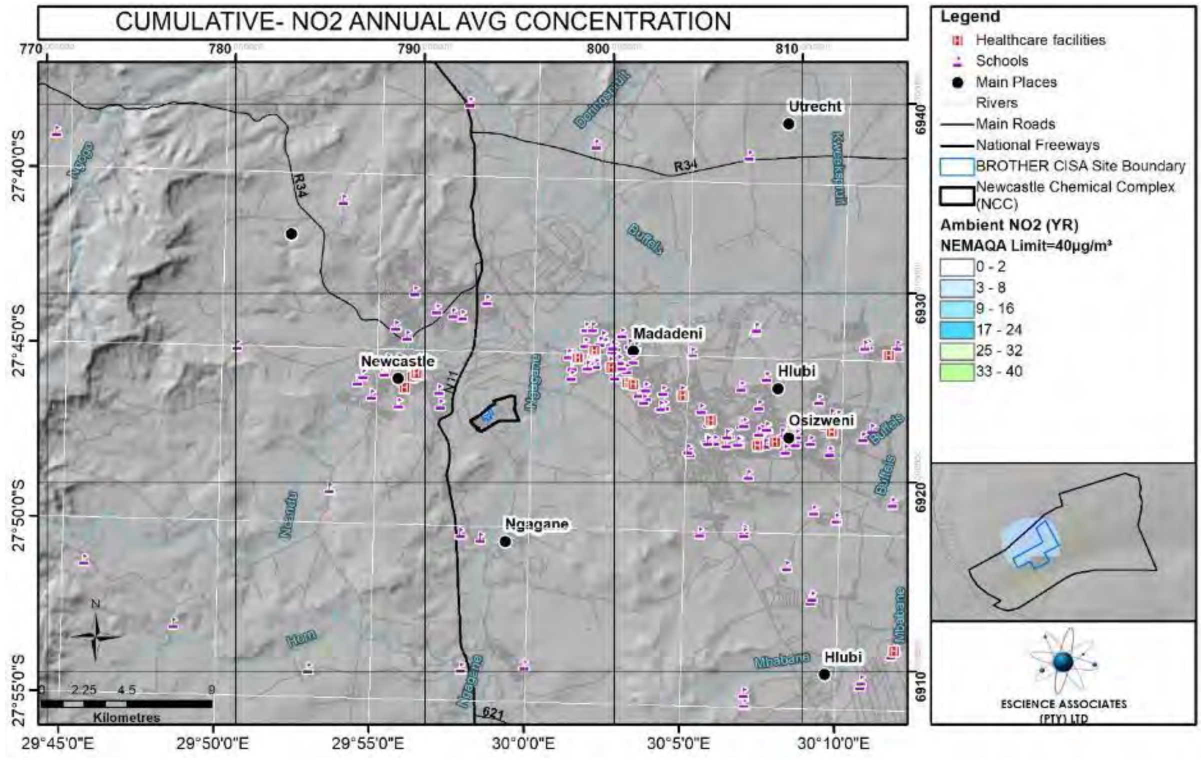


Figure 10-30: Scenario 3 Predicted NO_2 annual maximum modelled ambient concentration.

10.2.4.6 PREDICTED CONCENTRATIONS FOR CR(VI)

10.2.4.6.1 PREDICTED 1 HOUR CONCENTRATIONS FOR Cr(VI)

The predicted ambient concentration from the operations is within the Alberta, Canada Ambient Air Quality limit of 1 µg/m^3 for the 1-hour averaging interval (Figure 10-31).

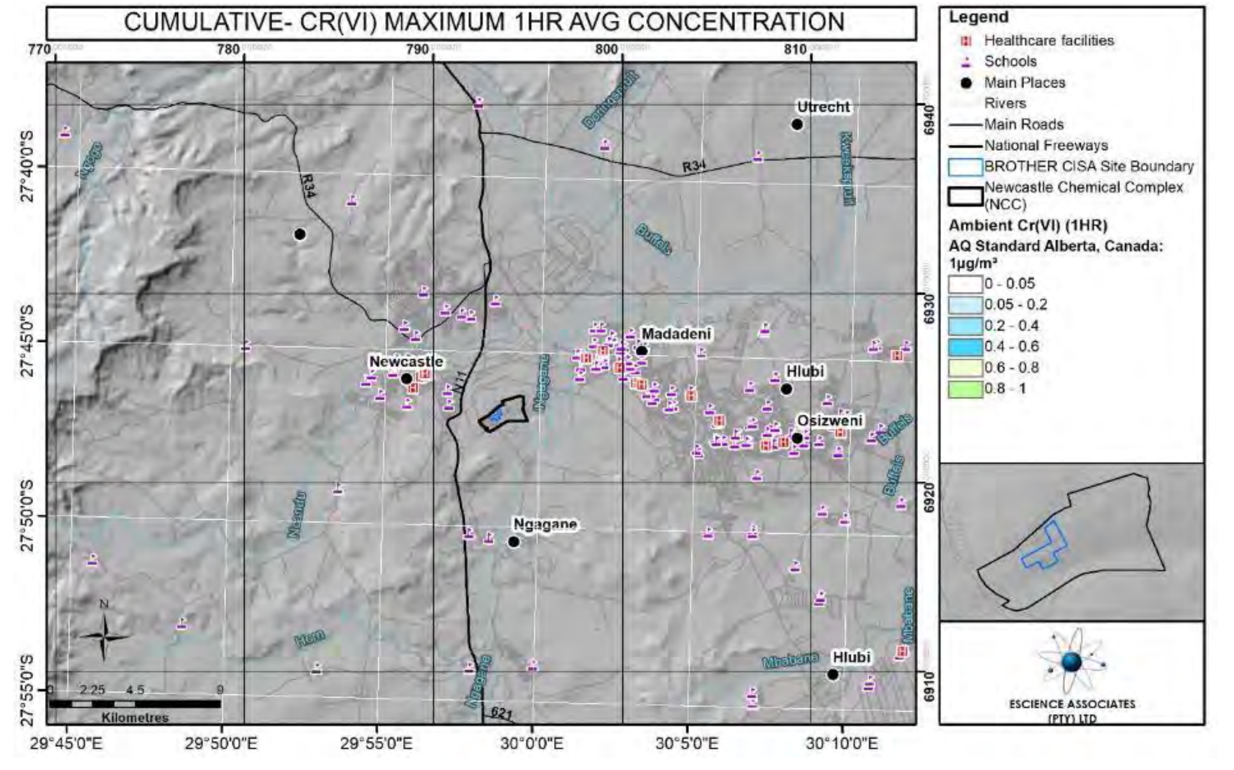


Figure 10-31: Scenario 3 Predicted Cr(VI) 1-Hour maximum modelled ambient concentration.

10.2.4.6.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

Figure 10-32 shows the predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer. As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed within the de minimis range

The predicted excess lifetime carcinogenic risk factor for a small area within the site is 1:36 550. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. The Arbour Park residential area is predicted to be exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk of 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

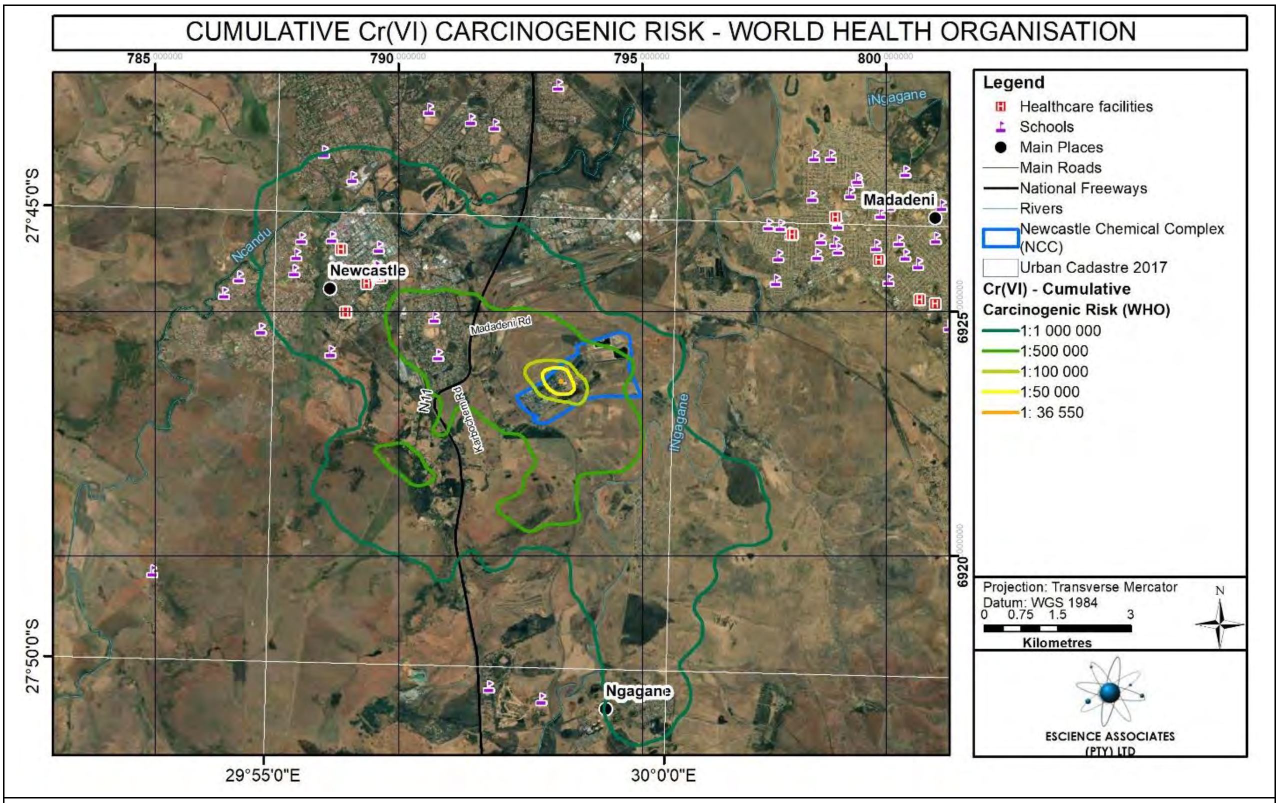


Figure 10-32: Scenario 3 Predicted Cr(VI) lifetime carcinogenic risk with WHO IUR.

10.2.4.6.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

Figure 10-33 shows the predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer. As noted in section 6.4.13.4 of this report life time exposure risk ratings have been adopted in this study with 1 in 10 000 as the maximum tolerable risk to the public and any lesser risk being deemed within the de minimis range

The predicted excess lifetime carcinogenic risk factor within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

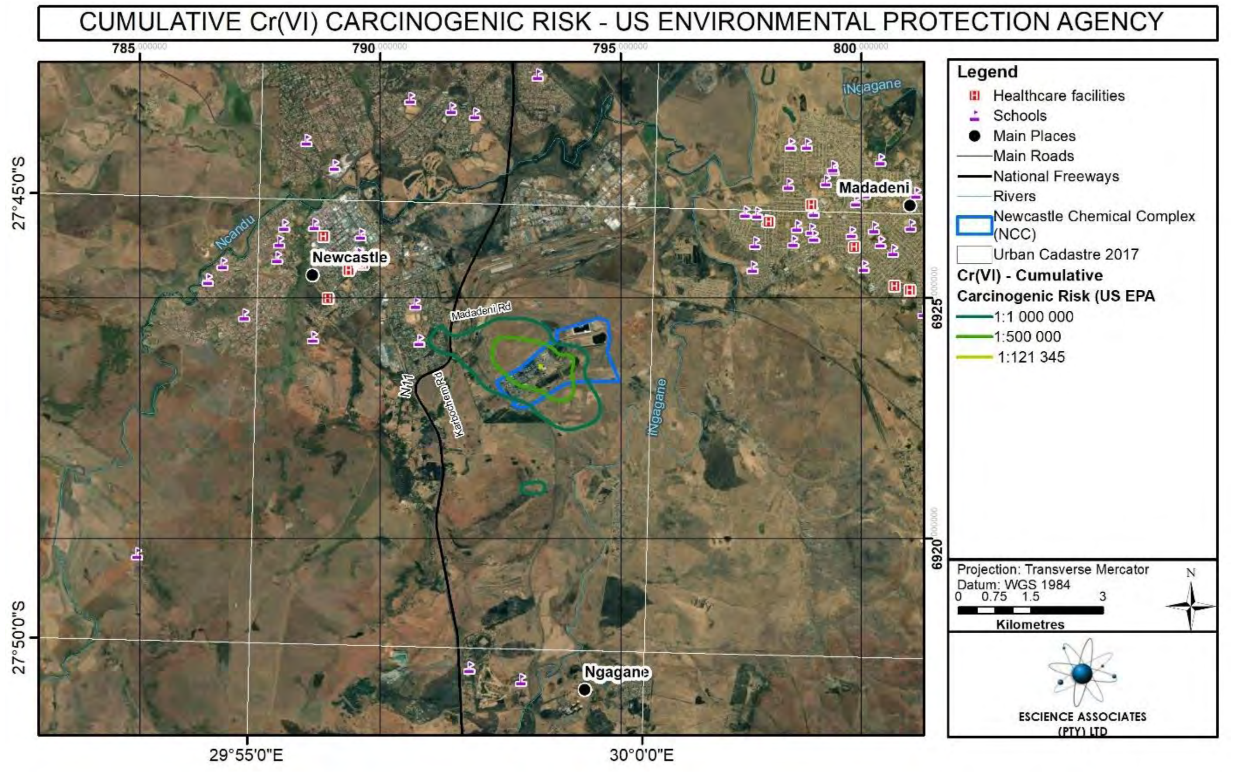


Figure 10-33: Scenario 3 Predicted Cr(VI) lifetime carcinogenic risk with US EPA IUR.

10.2.4.7 PREDICTED CONCENTRATIONS FOR H_2SO_4

10.2.4.7.1 PREDICTED 1 HOUR CONCENTRATIONS FOR H_2SO_4

The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m³ and 120 µg/m³ respectively. (Figure 10-34).

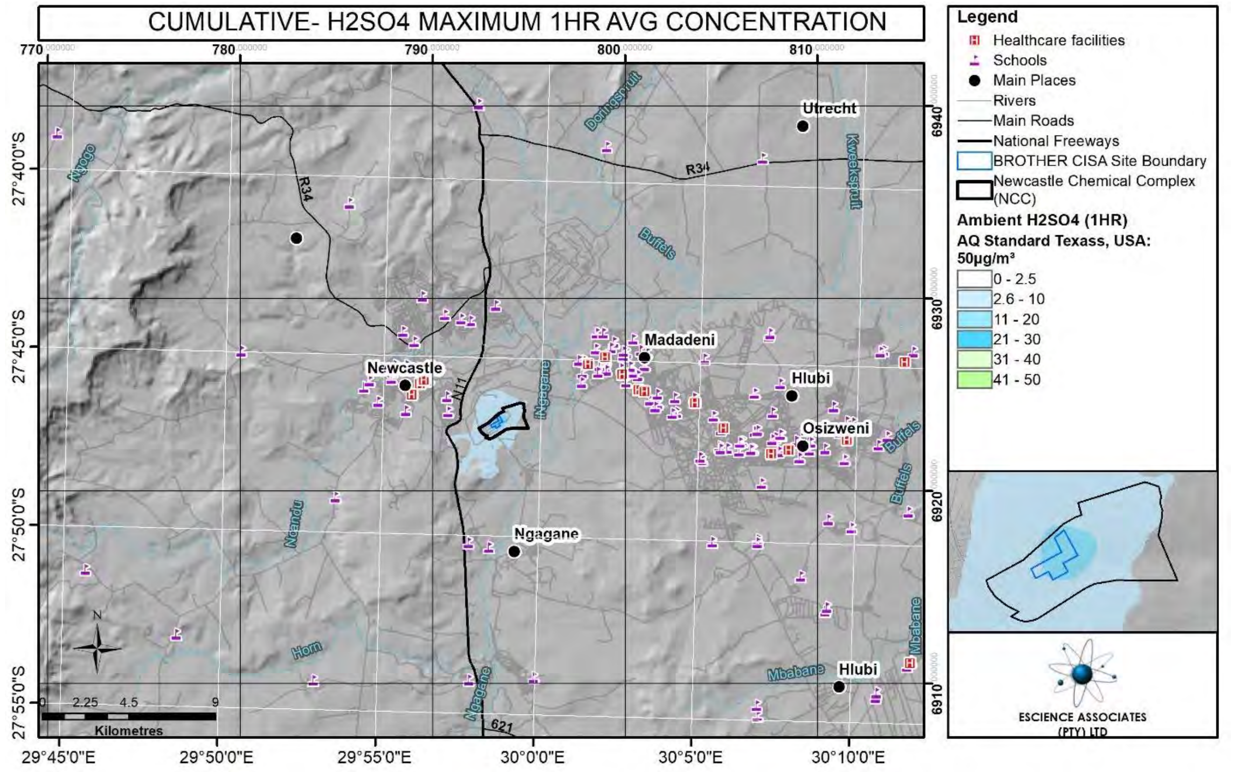


Figure 10-34: Scenario 3 Predicted H_2SO_4 1-Hour maximum modelled ambient concentration.

10.2.4.7.2 PREDICTED 24 HOUR CONCENTRATIONS FOR H_2SO_4

The predicted ambient concentration from the operations is within the Ontario, Canada Ambient Air Quality limit of 5 µg/m^3, for the 24-hour averaging interval (Figure 10-35).

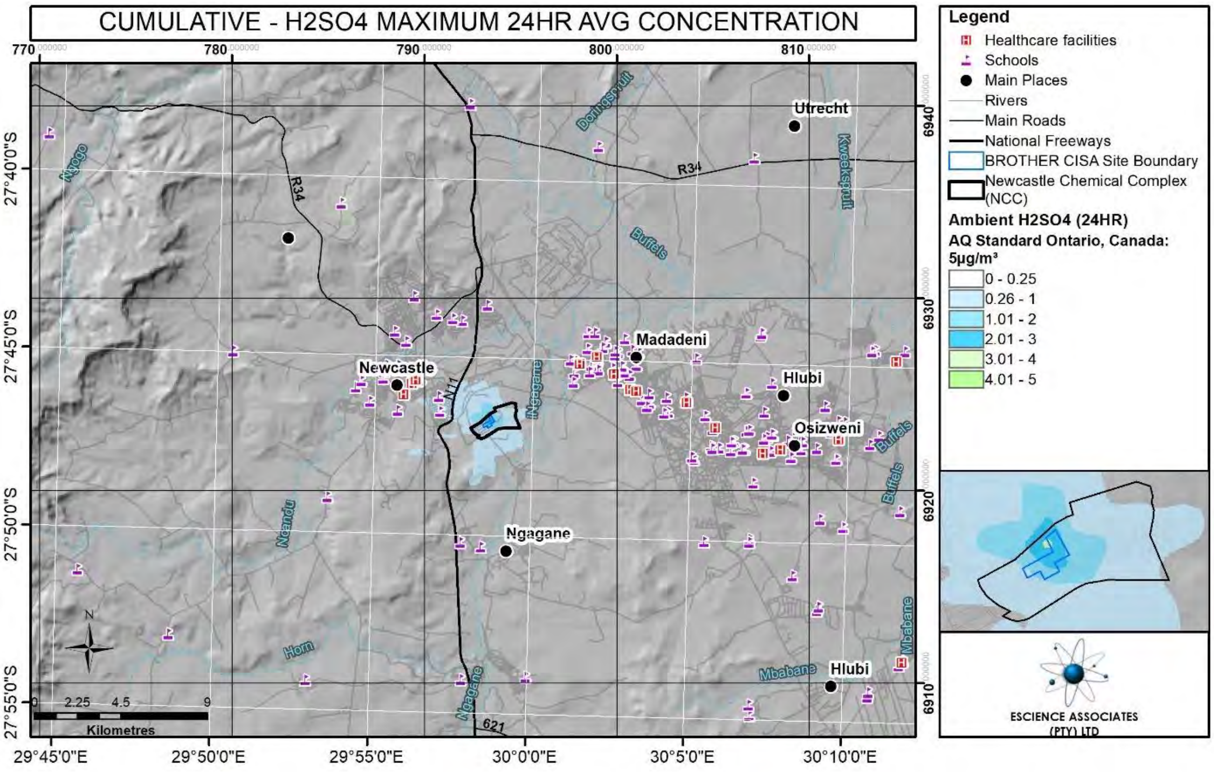


Figure 10-35: Scenario 3 Predicted H_2SO_4 24-Hour maximum modelled ambient concentration.

10.2.4.7.3 PREDICTED ANNUAL CONCENTRATIONS FOR H_2SO_4

The predicted ambient concentration from the operations is within the Michigan, USA Ambient Air Quality limit of 1 µg/m^3 for the annual averaging interval (Figure 10-36).

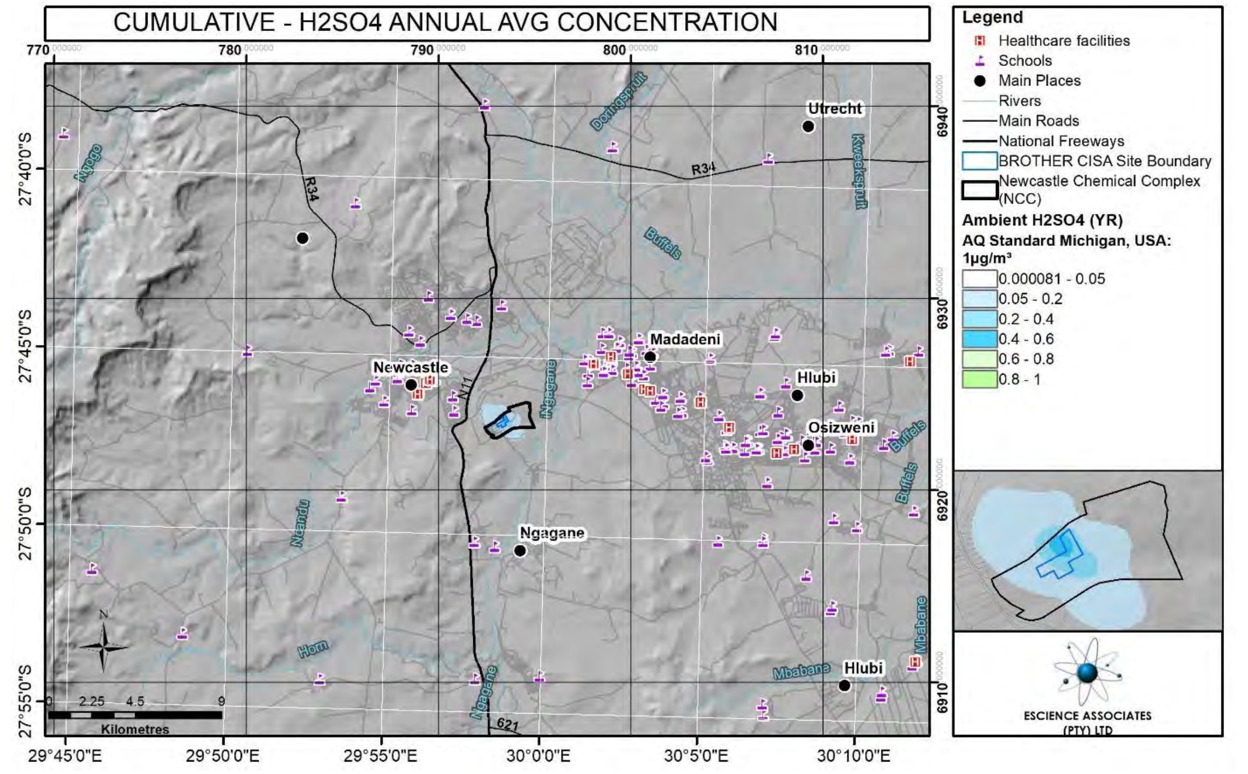


Figure 10-36: Scenario 3 Predicted H_2SO_4 Annual maximum modelled ambient concentration.

10.3 ANALYSIS OF EMISSIONS' IMPACT ON THE ENVIRONMENT

The pollutants of concern pose a variety of potential non-health impacts. The most significant impacts are considered to be dry and wet acid depositions but there are also concerns around potential impact on vegetation and fauna. The lack of defined acceptable ambient limits is the most challenging aspect of assessing the impacts of these pollutants to the environment. Thus, this report assumes that if there is compliance with the NAAQS and relevant international standards, the damage risk to the environment would be considered acceptable.

Although there are predicted exceedances of the SO_2 1-hour ambient limit (when modelled at the minimum emission rate of 350 mg/Nm^3 for the proposed activities), however the allowable number of exceedances is not exceeded. The exceedances are all within the site boundary.

11 COMPLAINTS

No complaints with respect to emissions to atmosphere from Brother CISA's operations have been received in the past 5 years.

12 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

12.1 CURRENT AIR QUALITY MANAGEMENT INTERVENTIONS

No Air Quality Management Interventions are in place as none are necessary. Abatement equipment is in place on the existing emission sources and will be installed on the proposed sources as air quality management measures.

13 COMPLIANCE AND ENFORCEMENT ACTIONS

No compliance and enforcement actions relevant to air quality management have been reported.

14 CONCLUSIONS AND RECOMMENDATIONS

14.1 RESULTS AND CONCLUSIONS

The emissions quantification and subsequent prediction of ambient impact have been undertaken with conservativeness, with the effect that the modelled outcomes relating to emissions from the site are expected to be over-predictions. The modelling further does not account for wet deposition of the pollutants, thus further over-predicting atmospheric concentrations.

Three scenarios were modelled:

- iv. Scenario 1 – All proposed sources modelled at the minimum emission standards for the applicable regulated emissions per source as stipulated by Subcategory 7.2 and Subcategory 7.4 in GN893:2013, as amended. Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, the Cr(VI) emissions limits as shown in Table 14-1 were applied to stacks where Cr(VI) emissions are anticipated;
- v. Scenario 2 - All current sources modelled at the measured emission rates as per the stack test reports.
- vi. Scenario 3 - All proposed sources modelled at the minimum emission standards and all current sources modelled at the measured emission rates as per the stack test reports

14.2 SCENARIO 1: PROPOSED EMISSIONS

It is important to note that this scenario evaluates the potential impact of Brother CISA operating all its' proposed sources at the maximum allowable emissions rates on a continuous basis of 24h a day for 365 a year. This is in fact an exaggeration of the actual impact of operating at the maximum allowable emission rates the sources do not have 100% uptime, and actual emissions vary. However, it demonstrates the worst case permitted emissions scenario and gives insight into the worst case impact that would occur if the site operated at the very limit of compliance with the emissions regulations.

14.2.1 PARTICULATE MATTER

14.2.1.1 PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the proposed operations are well within the 24-hour limit, 75 µg/m³.

14.2.1.2 PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the proposed operations are well within the annual ambient air quality limit, 40 µg/m³.

14.2.1.3 $PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the proposed operations are well within the 24-hour limit, 40 µg/m³.

14.2.1.4 $PM_{2.5}$ - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the proposed operations are well within the annual ambient air quality limit, 20 µg/m³.

14.2.2 SULPHUR DIOXIDE

14.2.2.1 1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations exceed the 1-hour limit, 350 µg/m³. The frequency of exceedance is however well within the maximum allowable number of exceedances per year.

14.2.2.2 24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m³.

14.2.2.3 ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

14.2.3 NITROGEN DIOXIDE

14.2.3.1 1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

14.2.3.2 ANNUAL

Predicted maximum ambient concentrations of NO_2 from the proposed operations are within the annual limit, 40 µg/m³.

14.2.4 HEXAVALENT CHROMIUM

14.2.4.1 1-HOUR

The maximum predicted ambient concentrations from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m³ and 4.5 µg/m³, respectively.

14.2.4.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer for a small area within the Newcastle Chemicals Complex is 1 in 100 000. Extending over the immediate surrounds of the site there is a lifetime carcinogenic risk in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

14.2.4.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

14.2.5 SULPHURIC ACID

14.2.5.1 1-HOUR

The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m³ and 120 µg/m³ respectively.

14.2.5.2 24-HOUR

Predicted maximum 24-h ambient concentrations from the operations are within the Ontario state limit of 5 µg/m³.

14.2.5.3 ANNUAL

Predicted maximum ambient concentrations of H_2SO_4 from the operations are within the Michigan state limit of 1 µg/m³ and the Massachusetts state limit of 2.72 µg/m³.

14.3 SCENARIO 2: BASELINE EMISSIONS

14.3.1 PARTICULATE MATTER

14.3.1.1 PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the 24-hour limit, 75 µg/m³.

14.3.1.2 PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the annual ambient air quality limit, 40 µg/m³.

14.3.1.3 $PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the 24-hour limit, 40 µg/m³.

14.3.1.4 $PM_{2.5}$ - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the annual ambient air quality limit, 20 µg/m³.

14.3.2 SULPHUR DIOXIDE

14.3.2.1 1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 1-hour limit, 350 µg/m³.

14.3.2.2 24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m³.

14.3.2.3 ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

14.3.3 NITROGEN DIOXIDE

14.3.3.1 1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

14.3.3.2 ANNUAL

Predicted maximum ambient concentrations of NO_2 from the operations are within the annual limit, 40 µg/m³.

14.3.4 HEXAVALENT CHROMIUM

14.3.4.1 1-HOUR

The maximum predicted ambient concentration from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m³ and 4.5 µg/m³, respectively.

14.3.4.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum emissions from the existing plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, for a small area within site is 1:50 000. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. A small part of the Arbour Park residential area is exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk in the order of 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

14.3.4.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The Predicted lifetime carcinogenic risk resulting from the maximum emissions from the existing plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, for a small area within the Newcastle Chemicals Complex is 1 in 150 453. The predicted excess lifetime carcinogenic risk factor within part of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015).

14.4 SCENARIO 3: CUMULATIVE EMISSIONS

14.4.1 PARTICULATE MATTER

14.4.1.1 PM_{10} - 24 HOUR

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the 24-hour limit, 75 µg/m³.

14.4.1.2 PM_{10} - ANNUAL

Predicted maximum ambient concentrations of PM_{10} from the operations are well within the annual ambient air quality limit, 40 µg/m³.

14.4.1.3 $PM_{2.5}$ - 24 HOUR

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the 24-hour limit, 40 µg/m³.

14.4.1.4 $PM_{2.5}$ - ANNUAL

Predicted maximum ambient concentrations of $PM_{2.5}$ from the operations are well within the annual ambient air quality limit, 20 µg/m³.

14.4.2 SULPHUR DIOXIDE

14.4.2.1 1-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations exceed the 1-hour limit, 350 µg/m³, however the predicted exceedances are all within the industrial boundary. The frequency of exceedance is well within the maximum allowable number of exceedances per year.

14.4.2.2 24-HOUR

Predicted maximum ambient concentrations of SO_2 from the operations are within the 24-hour limit, 125 µg/m³.

14.4.2.3 ANNUAL

Predicted maximum ambient concentrations of SO_2 from the operations are within the annual limit, 50 µg/m³.

14.4.3 NITROGEN DIOXIDE

14.4.3.1 1-HOUR

Predicted maximum ambient concentrations of NO_2 are within the 1-hour limit of 200 µg/m³.

14.4.3.2 ANNUAL

Predicted maximum ambient concentrations of NO_2 from the operations are within the annual limit, 40 µg/m³.

14.4.4 HEXAVALENT CHROMIUM

14.4.4.1 1-HOUR

The maximum predicted ambient concentration from the operations are within the Alberta state and Manitoba state 1-hour limits of 1 µg/m^3 and 4.5 µg/m^3, respectively.

14.4.4.2 PREDICTED LIFETIME CARCINOGENIC RISK USING THE WHO IUR

The predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the WHO recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, for a small area within the site is 1:36 550. Immediately outside the boundary, but not covering any receptors is an area exposed to a lifetime carcinogenic risk of 1 in 100 000. The Arbour Park residential area is predicted to be exposed to a lifetime carcinogenic risk in the order of 1 in 500 000. Further residential areas and part of the Newcastle CBD are exposed to a lifetime carcinogenic risk of 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015). Considering that no receptors beyond the boundaries of the Newcastle Chemicals Complex are predicted to experience lifetime carcinogenic risk greater than 1 in 500 000, the risk is considered acceptable.

14.4.4.3 PREDICTED LIFETIME CARCINOGENIC RISK USING THE US EPA IUR

The Predicted lifetime carcinogenic risk resulting from the maximum anticipated emissions from the plant, based on the US EPA recommendations for linear dose-response relationships between exposure to Cr(VI) compounds and lung cancer, within the proximity of the Newcastle Chemicals Complex and the immediate surrounds of the site is in the order of 1 in 500 000. No residential areas are predicted to be exposed to a risk greater than 1 in 1000 000. To put this into context for South Africa, it must be noted that the overall (background) cancer risk for South Africans in 2009 was 1 in 8 for men and 1 in 9 for women (Herbst, 2015). Considering that no receptors beyond the boundaries of the Newcastle Chemicals Complex are predicted to experience lifetime carcinogenic risk greater than 1 in 500 000, the risk is considered acceptable.

14.4.5 SULPHURIC ACID

14.4.5.1 1-HOUR

The maximum predicted ambient concentration from the operations is within the Texas and Michigan state limits of 50 µg/m^3 and 120 µg/m^3 respectively.

14.4.5.2 24-HOUR

Predicted maximum 24-h ambient concentrations from the operations are within the Ontario state limit of 5 µg/m^3.

14.4.5.3 ANNUAL

Predicted maximum ambient concentrations of H_2SO_4 from the operations are within the Michigan state limit of 1 µg/m^3 and the Massachusetts state limit of 2.72 µg/m^3.

14.5 RECOMMENDATIONS

In cognisance of the findings of the assessment, and provided that the proposed plant will meet the emissions limits stipulated, it is recommended that the proposed activities be authorised.

Due to the fact that no maximum allowable emission concentration is provided for Cr(VI) in GN 893 of 2015 as amended, It is recommended that Cr(VI) emissions limits as shown in Table 14-1 be applied to stacks where Cr(VI) emissions are anticipated.

Table 14-1: Recommended Cr(VI) emissions limits

Point Source	Proposed Cr(VI) emissions limit (mg/Nm^3)
CTS1 - CTS Organic Stack 1	0.035
CTS2 - CTS Organic Stack 2	0.035
CTS13 - CTS Organic Stack 13	0.035
CTS14 - CTS Organic Stack 14	0.035
CTS17 – CTS Inorganic Stack 1	0.01

These recommended limits are based on the following factors:

- These emissions limits result in acceptable Cr(VI) ambient concentrations as shown in sections 10.2.4.6 and 14.4.4
- These concentrations are considered achievable through the use of proposed emissions abatement technology;
- The recommended limits are more stringent than the German Technical Instructions on Air Quality Control (TA Luft) limit of 0.05 mg/Nm^3 which may be considered for reference purposes in the absence of a legislated South African emission limit.

It is recommended that the listed point source emissions be monitored in accordance with the stipulations of GN 893 of 2015 as amended, at least once per annum.

15 DETAILS OF THE SPECIALIST

15.1 SPECIALISTS COMPILING THE REPORT

The Air Quality Impact Assessment was undertaken by EScience Associates (Pty) Ltd. A summary of the consultants who undertook the specialist work is noted in Table 15-1.

Table 15-1: Details of the Specialists

Name	Qualification	Role/Responsibility
Abdul Ebrahim (Certified EAP, Registered ECSA)	BEng (Hons) Env Eng. BEng (Hons) Mech Eng.	Principle Specialist
Sam Leyde	BSc (Hons) Mechanical Engineering	Emissions inventory construction and Integrative report writing
Tiffany Seema	BSc (Hons) Geology	Junior Consultant – Emissions inventory construction
Zayd Ebrahim	BSc Geology and Environmental & Geographical Sciences	Meteorological and atmospheric dispersion modelling, integrative report writing
James Pugin	MSc Archaeology	Geographical information systems specialist - Geophysical data file formulation, and mapping.

For further details on experience of the specialists refer to the Appendix 2.

16 FORMAL DECLARATION

16.1 DECLARATION OF ACCURACY OF INFORMATION-APPLICANT

Name of Enterprise: Brother CISA (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, ____________________________________, [duly authorised], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at: ______________________ on this ____ Day of ________________

____

SIGNATURE

____

CAPACITY OF SIGNATORY

16.2 DECLARATION OF INDEPENDENCE – PRACTITIONER

Name of Practitioner:	Abdul Ebrahim
Name of Registration Body:	Engineering Council of South Africa
Registration No:	20075012

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act.

I, Abdul Ebrahim, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer, the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1) (g) of this Act.

Signed at: Oaklands (Johannesburg) on this ____ Day of ________________________

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SIGNATURE

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CAPACITY OF SIGNATORY

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18 RECLASSIFICATION OF SA LULC CODES INTO CALMET LULC CODES

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
1	40	Forest (indigenous)	All wooded areas with a tree canopy > 70 %. A multi-strata community, with interlocking canopies, composed of canopy, sub-canopy, shrub and herb layers. The canopy is composed mainly of self-supporting, single stemmed, woody plants > 5 metres in height. Essentially indigenous species, growing under natural or semi-natural conditions (although it may include some areas of self-seeded exotic species). Excludes planted forests (and woodlots)
2	40	Woodland	All wooded areas with a tree canopy between 10 - 70%. A broad sparse - open – closed canopy community, typically consisting of a single tree canopy layer and a herb (grass) layer. The canopy is composed mainly of self-supporting, single stemmed, woody plants > 5 metres in height. Essentially indigenous species, growing under natural or semi-natural conditions (although it may include some areas of self-seeded exotic species). Excludes planted forests (and woodlots)
		(previously termed *Forest & Woodland*)	Canopy cover density classes may be mapped if desired, based on sparse (< 40%), open (40 – 70 %), and closed (> 70 %).
3	30	Thicket, Bush land, Bush Clumps, High Fynbos	Communities typically composed of tall, woody, self-supporting, single or multi-stemmed plants (branching at or near the ground), with, in most cases no clearly definable structure. Total canopy cover is greater than 10%, with canopy heights between 2 – 5 metres. Essentially indigenous species, growing under natural or semi-natural conditions (although it may include some areas of self-seeded exotic species, especially along riparian zones). Presence of alien exotic species can be modelled spatially using broad principles of unlikely structural / temporal occurrences within a given vegetation biome or region. Dense bush encroachment would be included in this category.

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
			Canopy cover density classes may be mapped if desired, based on sparse (< 40%), open (40 – 70 %), and closed (> 70 %).
4	30	Shrub land and Low Fynbos	Communities dominated by low, woody, self-supporting, multi-5stemmed plants, branching at or near the ground, between 0.2 and 2 m in height. Total tree cover < 0.1 Typical examples are low Fynbos, Karoo and Lesotho (alpine) communities.
5	30	Herb land	Communities dominated by low, non-woody, non-grass like plants, between 0.2 and 2 m in height. Total tree cover < 0.1 Typical examples are found in Namaqualand or "weed" dominated degraded areas.
6	30	Natural Grassland (previously termed *Unimproved Grassland*)	All areas of grassland with < 10% tree and/or shrub canopy cover, and >0.1% total vegetation cover. Dominated by grass-like, non-woody, rooted herbaceous plants. *Essentially indigenous species growing under natural or semi-natural conditions*.
7	30	Planted Grassland (previously termed *Improved Grassland*)	As above, except …. Planted grassland, containing either indigenous or exotic species, growing under man-managed (including irrigated) conditions for grazing, hay or turf production, recreation (i.e. golf) etc.
8	40	Forest Plantations (Eucalyptus spp)	All areas of systematically planted, man-managed tree resources, composed of primarily exotic species (including hybrids). Category includes both young and mature plantations that have been established for commercial timber production, seedling trials and woodlot / windbreaks of sufficient size to be identifiable on satellite imagery. Excludes all non-timber based
9	40	Forest Plantations (Pine spp)	

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes			
SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
10	40	Forest Plantations (Acacia spp)	plantations such as tea, sisal, citrus, nut crops etc.
11	40	Forest Plantations (Other / mixed spp)	
12	40	Forest Plantations (clear-felled)	
13	50	Water bodies	Areas of (generally permanent) open water. The category includes both natural and man-made water bodies, which are either static or flowing, and fresh, brackish and salt-water conditions. This category includes features such as rivers, major reservoirs, farm-level irrigation dams, permanent pans, lakes and lagoons.
14	60	Wetlands	Natural or artificial areas where the water level is permanently or temporarily at (or very near) the land surface, typically covered in either herbaceous or woody vegetation cover. The category includes fresh, brackish and salt-water conditions. Examples include pans (with non-permanent water cover), and reed-marsh or papyrus-swamp. Dry pans are included in this category unless they are *permanently* dry.
15	70	Bare Rock and Soil (natural)	Natural areas of exposed sand, soil or rock with no, or very little vegetation cover during any time of the year, (excluding agricultural fields with no crop cover, and open cast mines and quarries). Examples would include rock outcrops, beach sand, and dry riverbed material.
16	70	Bare Rock and Soil (erosion: dongas / gullies)	Non-vegetated areas (or areas of very little vegetation cover *in comparison to the surrounding natural vegetation)*, that are primarily the result of active gully erosion processes. Typically located in association with areas of poor grassland cover along existing streamlines and / or on slightly steeper slopes than sheet erosion areas (i.e. greater than 6 degree slope). In some areas the full extent of donga activity may be obscured by either overhanging adjacent bushes, encroaching thorn bush, or, in the case of more stable dongas, by bush or grass cover along the actual streamline.

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
17	70	Bare Rock and Soil (erosion: sheet)	Non-vegetated areas (or areas of very little vegetation cover *in comparison to the surrounding natural vegetation*), that are primarily the result of active sheet erosion processes. Typically located in association with areas of severe donga erosion and / or poor grassland cover (i.e. low image NDVI rating). In some areas the full extent of this process may be obscured by encroaching bush. Typically located on slopes less than or equal to 6 degrees.
18	70	Degraded Forest & Woodland	
19	70	Degraded Thicket, Bush land, etc.	Permanent or near-permanent, man-induced areas of very low vegetation cover (i.e. removal of tree, bush, or herbaceous cover) *in comparison to the surrounding natural vegetation cover*. Typically associated with subsistence level agriculture and rural population centres, where overgrazing of livestock and / or wood-resource removal has been locally excessive. Often associated with severe soil erosion problems.
20	70	Degraded Shrub land and Low Fynbos	
21	70	Degraded Herb land	
22	70	Degraded Unimproved (natural) Grassland	
23	-20		

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
		Cultivated, permanent, commercial, irrigated	Land which has been ploughed and / or prepared for the raising of crops (excluding timber production). Unless otherwise stated, includes areas currently under crop, fallow land, and land being prepared for planting. Class boundaries are broadly defined to encompass the main areas of agricultural activity and are not defined on exact field boundaries. As such all sub-classes may include small inter-field cover types (e.g. hedges, grass strips, small windbreaks), as well as farm infrastructure
			Several sub-classes are defined, based on the following parameters:
			Commercial: characterised by large, uniform, well managed field units (i.e. ± 50 ha), with the aim of supplying both regional, national and export markets. Often highly mechanised.
			Semi-Commercial: characterised by small – medium sized field units (i.e. ± 10 ha), within an intensively cultivated site, often in close proximity to rural population centres. Typically based on multi-cropping activities where annual (i.e. temporary crops) are produced for local markets. Can be irrigated by either mechanical means or gravity-fed channels and furrows. Medium - low levels of mechanisation.
24	20		Subsistence: characterised by numerous small field units (less than ±10 ha) in close proximity to rural population centres. Field units can either be grouped either intensive or widely spaced, depending on the extent of the area under cultivation and the proximity to rural dwellings and grazing areas. Includes both rain fed and irrigated (i.e. mechanical or gravity-fed), multi-cropping of annuals, for either individual or local (i.e. village) markets. May include fallow and 'old fields', and some inter-field grazing areas (which are often classified as degraded).

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
		Cultivated, permanent, commercial, dry land	Permanent Crops: lands cultivated with crops that occupy the area for long periods and are not re-planted after harvest. Examples would include sugar cane and citrus orchards. Note in the case of sugar can, the growing season is typically 15 – 18 months per ratoon (i.e. harvest), with 2 – 3 ratoons possible before re-planting. Sugar cane is mapped as a separate crop type, and includes both large and small-scale commercial activities, as well as fallow (i.e. burnt / cleared) areas.
25	-20		Temporary Crops: land under temporary crops (i.e. annuals) that are harvested at the completion of the growing season, and that will remain idle until re-planted. In general, this refers to maize and soya bean cultivation within the Pongola catchment, although cotton is locally dominant amongst the larger commercial sugar cane plantation areas.
		Cultivated, permanent, commercial, sugarcane	
			Irrigated / Non-Irrigated: major irrigation schemes (i.e. areas supplied with water for agricultural purposes by means of pipes, overhead sprinklers, ditches or streams), and are often characterised
26	-20		
		Cultivated, temporary, commercial, irrigated	
27	20		

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
		Cultivated, temporary, commercial, dry land	
28	20		
		Cultivated, temporary, subsistence, dry land	
29	-20		
		Cultivated, temporary, subsistence, irrigated	
30x	10	Urban / Built-up	A *generic urban class*, essentially comprising all formal built-up areas, in which people reside on a permanent or near-permanent basis, identifiable by the high density of residential and associated infrastructure. Includes both towns, villages, and where applicable, the central nucleus of more open, rural clusters. This class should be used if it is not possible to identify more industrial and transportation land-uses.

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
			Low-density smallholdings frequently located on the urban / peri-urban fringe should be mapped as a separate smallholding sub-classes, subdivided by the appropriate (level I) background vegetation type. If visible, individual farm units are to be mapped as isolated urban / built-up units (if no other class is applicable). Specific urban / built-up sub-classes as listed below – in such cases it could include residential, commercial,
31x	10	Urban / Built-up (rural cluster)	Areas of clustered rural dwellings (i.e. kraals) whose structural density is too low to be classified as a formal village but are of sufficient level to be easily identifiable as such on satellite imagery. Small scale cultivation / garden plots often form a major spatial component and are located amongst the residential structures.
32	10	Urban / Built-up (residential, formal suburbs)	Permanent residential structures, either single or multi-level, located within new or well-established residential areas, i.e. '*garden-suburbs*', (often refers to 'middle-class' and 'upper class' residential areas). Includes both low and high building densities.
33	10	Urban / Built-up (residential, flatland)	Permanent residential structures, consisting mainly of 3 or more levels (often up to 10), resulting in a concentration of mid-to-high rise building, for example Hillbrow (Jhb) or Sunnyside (Pta).
34	10	Urban / Built-up (residential, mixed)	mixture …
35	10	Urban / Built-up (residential, hostels)	Permanent residential structures, typically located in formal township districts, consisting mainly of 1 or 2 levels in concentrated block-like structures.
36	10	Urban / Built-up (residential, formal township)	Permanent (i.e. brick etc.) structures (predominately single level), usually located on serviced sites within former black residential areas, laid out in an organised, pre-planned manner. Includes both low and high building densities.

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
37	10	Urban / Built-up (residential, informal township	Permanent / semi-permanent shack type dwellings (i.e. corrugated tin structures) laid out and established in an organised, pre-planned manner on both serviced and non-serviced sites. Includes both low and high building densities
38	10	Urban / Built-up (residential, informal squatter camp)	Non-permanent shack type dwellings (i.e. tin, cardboard, wood etc.) typically established on an informal, ad hoc basis, on non-serviced sites. Typically, high building densities
39	10	Urban / Built-up (smallholdings, forest & woodland …)	see “residential’ definition above ...
40	10	Urban / Built-up (smallholdings, thicket, bush land)	see “residential’ definition above ...
41	10	Urban / Built-up (smallholdings, shrub land …)	see “residential’ definition above ...
42	10	Urban / Built-up (smallholdings, grassland …)	see “residential’ definition above ...
43	10	Urban / Built-up, (commercial, mercantile)	Non-residential areas used primarily for the conduct of commerce and other mercantile business, typically located in the central business district (CBD). Often consisting of a concentration of multi-level buildings, but also includes small commercial zones (i.e. spaza shops) within high density townships.

Table 18-1: South African Land Use Land Cover (LULC) codes reclassified according to CALMET LULC codes

SA LULC code	USGS code equivalent	USGS class definition	SA LULC class definition
44	10	Urban / Built-up, (commercial, education, health, IT)	Non-residential, non-industrial sites or complexes associated with educational (i.e. schools, universities), business development centres such as industrial 'techno-parks', and / or social services (i.e. hospitals), often consisting of a concentration of multi-level buildings (Note: only mapped if clearly identifiable, otherwise included within '*commercial / mercantile*' or '*suburban*' categories.
45	10	Urban / Built-up, (industrial / transport: heavy)	Non-residential areas with major industrial (i.e. manufacture and/or processing of goods and products) or transport related infrastructure. Examples would include power stations, steel mills, dockyards, train stations and airports (i.e. Johannesburg).
46	10	Urban / Built-up, (industrial / transport: light	Non-residential areas with major technology, manufacturing or transport related infrastructure. Examples would include light manufacturing units, warehouse dominated business development centres, and small airports (i.e. Lanseria). Also includes similar structures such as farm-based pig and battery hen breeding units.
47	70	Mines & Quarries (underground / subsurface mining)	Active or non-active underground or sub-surface based mining activities. Category includes all associated surface infrastructure etc.
48	70	Mines & Quarries (surface-based mining)	Active or non-active surface-based mining activities. Includes both hard rock or sand quarry extraction sites, and opencast mining sites i.e. coal. Category includes all associated surface infrastructure.
49	70	Mines & Quarries (mine tailings, waste dumps)	Primarily non-vegetated, exposed mining (and heavy industry) extraction or waste material. *Major areas* of managed vegetation rehabilitation on these sites can be mapped according to the appropriate vegetation category.

APPENDIX 1: **CV'S OF TEAM MEMBERS**

EScience Associates
9 Victoria Road, Oaklands
Johannesburg, 2192
Tel: +27 (0)11 718 6380

Curriculum Vitae:

Abdul Ebrahim

Surname: Abdul Ebrahim
Date of birth: 07 December 1977
Country of Residency: Republic of South Africa
Position: Director
Key Qualifications: BEng (Hons) Environmental, BEng (Hons) Mechanical
Registrations: ECSA, EAPASA

Contact details

☎: 011 7186380
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✉: abdul@escience.co.za

Abstract

Abdul Ebrahim is a director of EScience Associates, an environmental consultancy specialising in waste and waste recovery, effluent, atmospheric emissions and air quality, as well as cleaner and renewable energy. EScience Associates caters for a diversity of industries and economic sectors and has forged strong relationships with other specialists, and specialist agencies, allowing the company to deal with complex and contentious environmental problems.

Abdul Ebrahim holds a BEng (Hons) in both Mechanical and Environmental Engineering disciplines. He specialises in air quality management, hazardous waste management and cleaner production, as well as their related environmental authorisation and licensing processes. His work experience includes numerous environmental impact assessments, cleaner production, waste recover-recuse-recycling, hazardous waste management assessments, and air quality impact management projects in power generation, manufacturing, minerals processing, and mining industries. His interests range from atmospheric modelling and wind energy, to the beneficial use of industrial wastes and effluents.

He is a certified Environmental Assessment Practioner (EAP) and member of amongst other professional organisations: Engineering Council of South Africa (ECSA), and the National Association of Clean Air (NACA).

Abdul has provided Honours level lecturing at the University of Pretoria, UNISA, Cape Town University of Technology and various private training institutions in the fields of Environmental Compliance Enforcement, Environmental Impact Assessment, Cleaner Production and Air Quality Management since 2005.

His work experience includes:

- Environmental strategic, legal, and technical compliance advisory services
- Environmental Permitting - Environmental Authorisation, Waste Management Licensing, Atmospheric Emissions Licensing, Mine Environmental Management Programme development, and their relating environmental impact assessment and stakeholder engagement processes.
- Air quality management and Air Quality Management Plan development – Emissions quantification; meteorological and air quality modelling and impact assessment; development of emissions abatement and management strategies;
- Waste management consulting - classification, landfill assessment, mine residue liner risk assessments, development of waste minimisation treatment & recycling strategies;
- Development of specialist training courses (including EIA Administration and Review, Environmental Enforcement, Environmental Compliance Achievement for Industry).
- Environmental Due Diligence – due diligence assessment to inform purchase or ownership transfer of existing going concerns or proposed new establishments.

Abdul has 20 years post graduate experience of which four years are in industry, and the remainder in consulting.

Education

BEng (Hons) Mechanical Engineering
BEng (Hons) Environmental Engineering

Languages

English (excellent speaking and writing)	Limited French and Portuguese

EScience Associates
9 Victoria Road, Oaklands
Johannesburg, 2192
Tel: +27 (0)11 718 6380

Curriculum Vitae:

Abdul Ebrahim

Experience

Personal work experience includes:

- Cleaner and renewable energy strategy development, plan and project development;
- Technical and environmental due diligence – industrial and energy projects
- Waste management (classification, handling, storage, and disposal requirements;
- Development of waste minimisation treatment & recycling strategies);
- Air quality management and emissions inventorying¸ development of abatement and management strategies;
- Environmental Impact Assessment and Permitting
- Development and dissemination of specialist training for government and the private sector at NQF level 7 (honours degree).

Abdul's work experience in a wide diversity of economic sectors and industries and provides him with a good understanding of both small scale and large scale impacts of waste and pollution, as well as keeping up to date with various management alternatives available and their individual advantages and disadvantages, both locally and internationally implemented and pilot scale. Various waste streams have been dealt with to determine the most applicable disposal methods and impacts on the environment, from various industries:

- Metallurgical processes
- Power generation
- Food processing
- Waste recovery, reuse, and recycling and waste to energy
- Mining
- Cement manufacturing
- General Commercial – General waste management from various industries

Professional Registration

Environmental Assessment Practioner (EAP)
Engineering Council of South Africa (ECSA

Hourly Rate

Nature of expertise offered

- Ability to interpret and analyse technical material on wide range of subjects
- Engineering expertise in energy, waste, air quality and multi-disciplinary subjects
- Ability to undertake technology feasibility studies, technical and financial due diligence
- Understanding of the green economy and technologies, ICT and agricultural and agro-processing sectors
- Ability to undertake a market research and investigation into the industry
- Proposal evaluation expertise

Experience and relevant projects

1. **AIR QUALITY MANAGEMENT:**

1.1 Government & Regulatory

- o Vaal Triangle Air-shed Priority Area - Air Quality Management Plan review, development of emissions inventory and Ambient Air Quality Impact Assessment.
- o Highveld Priority Area Air Quality Management Plan – development of emissions inventory, and mitigation strategies.
    - ▪ Reference: Dr Thulile Mdluli

  - Tel: 012 310 3436
  - Email : tmdluli@environment.gov.za
- Ekurhuleni Metropolitan Municipality - Development of an Air Quality Management Plan (AQMP)
  - Reference: Mr Edmund van Wyk
  - Tel: 011 999 2470
  - Email: Edmund.vWyk@ekurhuleni.gov.za
- Nkangala District Municipality - Development of an Air Quality Management Plan (AQMP)
  - Reference: Mr Vusi Mahlangu
  - Tel: 013 249 2164
  - Email: Mahlangumv@nkangaladm.gov.za
- North West Province - development of provincial emissions inventory (PM, NOx, SO_2 etc)
- Development of National Air Quality Officers Companion Guide for the Republic of South Africa
- Development of the atmospheric emissions licensing department for Nkangala District Municipality
- EThekwini Municipality (Durban) - Greenhouse gas emissions quantification
- Newcastle Local Municipality - Development of an Air Quality Management Plan (AQMP)
  - Reference: Mr Phelelani Ntshingila
  - Tel: 034 328 3300
  - Phelelani.Ntshingila@newcastle.gov.za

1.2 Industrial and Mining

- A large variety of major industrial and mining operation across the Highveld and Vaal Triangle as part of Highveld Priority Area and Vaal Triangle Air-shed Priority Area AQMP projects.
- Lanxess CISA Chrome Chemicals Plant Expansion, CO_2 generation, Power Generation and hazardous waste treatment and recovery
- Samancor Chrome Proposed Chrome Chemicals plant
- Karbochem (Synthetic Rubber Manufacture) proposed Power Generation Plant
- PPC Cement Slurry Cement Plant Expansion
- PPC Cement Jupiter Cement Plant Expansion
- PPC Cement PE Cement Plant Expansion
- PPC Cement Dwaalboom waste heat recovery
- PPC Cement De Hoek, PE, Slurry, and Dwaalboom postponement applications
- Afrisam Cement - Dudfield Environmental Management Programme update.
- ClinX Medical Waste Incineration plant expansion
- Goedemoed organic waste incineration
- AWPP pyrolysis of organic waste
- Interwaste Waste Recovery, Waste to Energy and Waste Incineration plant
- Eskom power generation emissions off-setting
- Hayes Lemmerz SA Aluminium Wheel Manufacturing
- Evraz Highveld Steel and Vanadium proposed Powered Generation - Furnace Off-Gases
- Assmang Ferrochrome and Ferromanganese plants Powered Generation - Furnace Off-Gases
- Resource Generation Proposed Boikarabelo Power Station – coal fired
- Weir Minerals Africa (Isando, Alrode and Heavy Bay Foundries)
- Goedemoed Prison proposed Waste incineration and Landfill
- Consolidated Wire Industries Expansion
- Sylvania Proposed Open Cast PGE Mine and Processing Plant
- Assmang Black Rock proposed manganese mine expansion and sinter plant
- Assmang machadodorp proposed smelter plant expansion and cross-over to manganese

- Dwarsrivier Chrome Mine
- Nkwe proposed Platinum Mine
- Agricultural Research Commission hazardous and infectious waste incineration
- Sephaku Aganang proposed use of AFR’s in cement manufacture
- Idwala Phalaborwa atmospheric emission licence for magnetite drying
- Mandini Wealth (Pty) Ltd tyre pyrolysis air quality health risk assessment
- Johnson Tiles a Division of Norcros Sa (Pty) Ltd Air quality health risk assessment
- Lanxess CISA (Pty) Ltd Air quality health risk assessment
- Namakwa Sands, South Africa – Tronox
- Devon Valley Landfill expansion
- Groblersdal limestone mine

2. WASTE CLASSIFICATION, HAZARD RISK ASSESSMENT AND MANAGEMENT

- Weir Minerals Africa
- Heavy Bay foundry Port Elizabeth
- Lafarge Gypsum
- Consolidated Wire Industries
- BPB Gypsum
- PG Bison melamine plant
- ABBW Electrical manufacturing plant
- CBI copper and fibre optical cable manufacture
- Holcim Cement
- Lanxess Chrome Chemicals
- Assmang Chrome
- Assmang Manganese
- Hayes Lemmerz SA Aluminium Wheel Manufacturing
- Auto industrial group (Pty) Ltd
- CBI Electrical
- Various mining residues

3. ENVIRONMENTAL IMPACT ASSESSMENT:

- Assmang Black Rock Mine expansions, tailings facilities, water treatment facilities
- Highveld Steel furnace off-gas power generation
- Lanxess CISA chrome chemicals plant expansion and hazardous waste landfilling
- Samancor chrome chemicals plant development
- Hernic Ferrochrome power generation from furnace off-gases
- Kanhym Biogas project
- Alumicor secondary aluminium recovery rotary salt furnaces
- Hays Lemmerz Aluminium smelters, furnace and alloy die casting
- Agricultural Research Commission hazardous waste incineration plant
- Darkling Metal Industries
- Idwala Lime Danielskuil asbestos waste disposal
- Plettenburg Polo Estates
- PG Bison Decorative Panels
- British Aerospace Land Based OMC Systems
- BPB Gypsum phosphogypsum plant
- Extrupet HPDE and PET recycling plants
- Assmang BRMO

- Assmang Machadodorp
- Interwaste waste recovery and waste to energy plants
- PPC Cement expansions, electricity generation, use of alternative fuels and resources
- Sephaku cement use of alternative fuels and resources
- ClinX Healthcare Risk Waste Management
- Turfontein Race Course night racing

4. ENVIRONMENTAL LEGAL COMPLIANCE ASSESSMENT & RECTIFICATION PLANNING:

- SASOL Synfuels
- NATCOS Petrochem
- Dwarsrivier Chrome Mine
- Angloplatinum Base Metals Recovery
- Samancor Hotazel Manganese Mines
- PG Bison (Pty) Ltd MDF manufacturing
- Samancor Manganese Division Samancor Metalloys Meyerton
- Holcim SA (Pty) Ltd Cement Plants:
    - Dudfield
    - Ulco
    - Roodepoort
- Natal Portland Cement Plants:
    - Newcastle
- Consolidated Wire Industries
- South African Airways (Pty) Ltd Technical Division
- TWK forestry strategic environmental legal compliance assessment
- Inergy Automotive Systems(Pty) Ltd
- Consolidated Wire Industries
- Mittal Steel Vereeninging and Dunswart plants – specialist assistance to DEAT environmental management inspectors
- Assmang Black Rock Mining Operations
- ClinX Medical Waste Management
- Extrupet PET and HDEP recycling plants
- Scaw Metals High Chromium Ball Plant
- Unilever waste recovery, recycling, and zero waste-to-landfill
- Numerous waste recycling facilities
- Oilflow
- The Smart Company
- Darkling Industrial Metals CC
- Unilever waste recovery, recycling, and zero waste-to-landfill
- Central Waste
- AT Packaging
- EWaste Africa
- Mpact Recycling
- Wasteplan
- Fine Metals
- Living Earth
- Industrial Plastic Recyclers
- SA Paper Mills
- Interwaste
- Matchem
- TGS
- Verigreen

- SB Boxes
- Drumpal
- Oscars Meat
- FOSECO South Africa (Pty) Ltd
-

5. GREENHOUSE GAS QUANTIFICATIONS AND ASSESSMENTS

- PPC Riebeeck
- Lafarge Licthenburg
- Ilangabi Investments coal mining
- Lanxess CISA (Pty) Ltd
- Consolidated Wire Industries
- ClinX Waste Management
- ArcelorMittal Newcastle
- Development of emission factors for ferrochrome smelting

6. CLEANER PRODUCTION AUDITS, WASTE TO ENERGY, ENERGY RECOVERY, WASTE RECOVERY AND RELATED PROJECTS:

- Tuffy Plastics
- Proplas plastics
- WHS Distribution
- Premier Foods Pretoria Wheat Mill
- Alfred Nzou municipality
- Lanxess chrome chemicals residue recovery
- Karbochem power generation ash to bricks project
- Cement kilns alternative fuels and raw materials assessment for South Africa
- Kanhym Estates Biogas Generation from piggery effluent
- British American Tobacco:
- Tobacco Processors Zimbabwe
- Souza Cruz Brazil

7. ENVIRONMENTAL MANAGEMENT SYSTEM DEVELOPMENT & IMPLEMENTATION:

- British American Tobacco (full system development from scratch – ISO 14001 and ISO 9001)
  - Weir Minerals Aspects Identification, Rating, Assessment and Development of EMPs
  - Lafarge Gypsum Aspects Identification, Rating, Assessment and Development of EMPs
  - Environmental Aspects Identification, rating and formulation of EMPs for Samancor Metalloys Meyerton
  - Environmental Aspects Identification, rating and formulation of EMPs for DMS Powders.
  - Holcim Slagment development & implementation of EMS components including waste and air quality management
  - Holcim Roodepoort development & implementation of EMS components including waste and air quality management
  - Consolidated Wire Industries Environmental Aspects Identification, rating and formulation of EMPs and operational control procedures.
  - Samancor Metalloys Ferro Silicon Manganese and FerroSilicon production
  - DMS FeSi dense media prodcution

8. ISO14001 AUDITING:

- Debswana Orapa and Letlhakane Mines
- Ingwe Colliery

- Arnot Colliery
- FOSECO South Africa (Pty) Ltd
- Lafarge Gypsum
- CWI

9. SPECIALIST TRAINING COURSE DEVELOPMENT & PRESENTATION

- 2011 Training of Atmospheric Emissions Licensing Authorities – air quality management, emissions quantification, regulation and enforcement.

- 2007-2015 Training of Authorities for EIA review and permiting

Responsible for development of NEMA EIA Review Course and Administrators EIA Review Manual, theoretical and practical training material, and training of Government Officials responsible for EIA Review - responsible for the whole manual other than Law applicable to EIA Review. As at May 2013 approximately 1000 officials from National, Provincial and Local Government.

- 2005&6 Bridging Training for Environmental Management Inspectors and Enforcement

ESA was part of a consortium selected to develop and conduct the EMI Training. More than 2000 officials and university students have completed the training.

- University Of Pretoria Specialist Lecturer
  - Environmental Legal Compliance inspections and investigations (RSA)
  - Environmental Legal Compliance achievement (RSA)
  - Environmental Legal Compliance inspections and investigations (Africa)

- University Of South Africa Specialist Lecturer
  - Environmental Legal Compliance inspections and investigations (RSA)

- Training for industry and mining

Development and presentation of training material for environmental impact identification and management in terms of South African environmental law for the SABS and other training institutions.

10. SOIL AND GROUNDWATER CONTAMINATION ASSESSMENT:

- Weir Heavy Bay Foundry
- Lafarge Gypsum
- Kanhym Estates
- SABAT (Pty) Ltd Johannesburg – investigation of heavy metal contamination of soils and groundwater
- Chemiphos SA (Pty) Ltd – investigation of phosphate and heavy metal contamination of soils and groundwater
- Castrol Lubricants Zimbabwe

11. ENVIRONMENTAL DUE DILIGENCE AUDITS, INCLUDING ASSESSMENT OF ENVIRONMENTAL AND CLOSURE LIABILITY:

- Determination and quantification of financial provision for the environmental rehabilitation and closure requirements of smelting operations for Highveld Steel & Vanadium operations:

    - Highveld Iron and Steel Works
    - Vanchem
    - Transalloys
    - Rand Carbide
    - Mapochs Mine

  - Determination and quantification of financial provision for the environmental rehabilitation and closure requirements of smelting operations for TransAlloys
  - Determination and quantification of financial provision for the environmental rehabilitation and closure requirements of mining operations for Samancor Chrome:
    - Middelburg Ferrochrome
    - Ferrometals
    - Tubatse Ferrochrome
    - Western Chrome Mines
    - Eastern Chrome Mines
  - Determination of critical environmental liability associated with the purchase of Xmeco Foundry by Weir Minerals Africa, and subsequent legal compliance achievement programme

12.

Possible timelines to commit to the assignment

- Available for assignments over the next two years
- Not available during the December holiday period - from 15 December until 3 January – due to company's closure for the festive season

CURRICULUM VITAE Zayd Ebrahim

Name	Zayd Ebrahim
Date of Birth	25 April 1993
Identity Number	9304256010080
Position	Air Quality and GIS Modeller

Qualifications

- BSc (Environmental and Geographical Sciences) 2013 – 2017
  University of Cape Town

Key Experience

- Emissions Inventory Quantification of criteria pollutants and greenhouse gases for industrial and non-industrial activities.
- Dispersion Modelling using the dispersion models Calpuff and Calmet.
- Mesoscale Modelling using the Weather Research and Forecast (WRF).
- Model Verification using statistics analysis to determine performance of Calmet/Calpuff/WRF models accuracy.
- Air Quality Impact Assessments, providing relevant modelling scenarios as well as report compiling for AQIAs.

Employment History & Project Experience

Environmental Science Associates 2018 – present

Air Quality and Geographical Information Systems Modeller 2018 - present

Mesoscale modelling and verification

The Weather Research and Forecast Model (WRF) and CALMET

- Verified WRF against surface and upper air measurements
  - Wind Speed
- Development of meteorological data for dispersion model for various projects, in numerous areas across South Africa;
  - The Highveld region,
    - Limpopo
    - Gauteng
    - Western Cape

Dispersion modelling (CALPUFF) and verification of:

- Point sources (scheduled emitters)
- Area sources
- Roads Emissions from un-tarred roads
- Cumulative scenarios

Point Source Modelling for Industry and Industrial / Mining Development

- PPC Cement Kiln Emissions
- Ezee Tile proposed Sand Drying Facility
- Stellenbosch Municipality Landfill Vents

Road Emissions modelling

- Un-tarred roads for Stellenbosch Municipality Impact Assessment
    - Devon Valley Landfill

Air Quality Projects (For further detail and references on VOC related and Ambient Air Quality Monitoring projects refer to annexure)

Assisted in the following Air Quality Impact Assessments/Reports, responsibilities include; modelling and/or report writing;

- PPC Cement De Hoek Plant
- PPC Cement Hercules Plant
- PPC Cement Dwaalboom Plant
- PPC Cement Riebeeck Plant
- Mandini Green Proposed Tyre Pyrolysis Plant
- Clinx Waste Management
- Norcross/ Johnson Tiles – VOC ambient air quality investigation

Research Projects

Assisted in the following research projects;

- Long term WRFChem modelling and verification of wet and dry acid deposition over South Africa, and investigation of impact of power generation stack emission limits on acid deposition (Water Research Council funded project)
    - Responsibilities include;
        - Weather Research and Forecast Chemistry (WRFChem) modelling
        - Report and scientific journal compiling

Education

University of Cape Town

- Bachelor of Science
    - Major Courses:
        - Environmental and Geographical Sciences
        - Geology

CURRICULUM VITAE **James Pugin**

Name	James Malcolm Pugin
Date of Birth	23 March 1989
Identity Number	8903235061089

Qualifications

MSc (Archaeology) (University of the Witwatersrand)	2013 – 2016
BSc Honours: Archaeology (University of the Witwatersrand)	2012 - 2012
Bachelor of Arts (University of the Witwatersrand)	2009 - 2011

Key Experience

- **GIS Mapping and Modelling**
- **Site Feasibility Analysis**
- **Atmospheric Impact Report Mapping**
- **Environmental Reporting**
- **Predictive Modelling for archaeological sites**
- **Database Coordinating**
- **Archaeological Survey and recording**
- **Baseline Archaeological Survey of Sehlabathebe National Park on behalf of UNESCO**

Employment History & Project Experience

Environmental Science Associates 2016 - Present

Environmental and Geographic Information System Consultant

Map Production

- Air Quality and Geographical Information Systems Isopleth Mapping
- Site Feasibility Analysis for prospective developments ranging from Wind Farms to Industrial sites

Other responsibilities

- Environmental reporting including Scoping and Environmental Impact Reports, Environmental Management Programmes, Basic Assessments etc.
- Environmental Applications for Water Use License, Waste Management Licences, and Environmental Authorisations
- Co-audited Water use licence and Waste management licences

Key Project Involvement

- Policy and Measures Assessment for the Department of Environmental Affairs
    - Assisting with development of models based on GIS datasets
- Mapping of Acid deposition, along with development of catchments based on points for WRC project: K5/2550 (Atmospheric deposition impact assessment)
- Mapping of Acid deposition for WRC project: K5/2466 (Development, Parameterisation and Verification of WRFChem Acid Deposition Modelling over the Highveld)
- Site Selection Assessment for the development of a new facility for Mandini Wealth based on specific developmental constraints.

Associate Researcher, Co-Author and Specialist Photographer 2015-2016

UNESCO world heritage survey of Sehlabathebe National Park, Lesotho

Baseline Archaeological Survey

- Geographic Information System and Remote Sensing that included the modelling of known rock art data to predict areas with a higher likelihood for containing rock art sites.
- Data capture and report writing
- Spatial Analysis, cartography and map production
- Site recording
- Field survey
- Data tabulation
- Photography

Database Coordinator (part time) 2013-2016

- Managing the Matatiele Archaeology and Rock Art (MARA) rock art site database
- Research Assistant
- Geographic Information System and Remote Sensing that includes the modelling of known rock art data to predict areas with a higher likelihood for containing rock art sites.
- Data capture and report writing
- Spatial Analysis, cartography and map production
- Site recording
- Field survey
- Data tabulation
- Photography

Presentations

Presentation	Date	Conference/Seminar
Locating the Rock art of the Maloti-Drakensberg	2014	Pan African Archaeologist Conference, The University of the Witwatersrand, South Africa
Lecture: Rock art survey techniques and tactics	2013	Association of South African Professional Archaeologists (ASAPA) Student Development Workshop – Parys, South Africa
Developments in Mountainous Rock Art Survey	2013	Association of South African Professional Archaeologists (ASAPA)- Gaborone, Botswana

Research Contribution

- Contributed towards digitisation and cartography of the distribution of canine species and disease spread for Mitchell, P 2017. Disease: A Hitherto Unexplored Constraint on the Spread of Dogs (Canis lupus familiaris) in Pre-Columbian South America. Journal of World Prehistory.
- Challis, W., Mullen, A., Pugin, J, 2016. Rock Art and Baseline Archaeological Survey of the Sehlabathebe National Park, Kingdom of Lesotho; Final Report to the World Heritage Committee of the United Nations Educational, Scientific and Cultural Organization. Publication to UNESCO

Education

University of the Witwatersrand

- **MSc (Archaeology)**
    - Dissertation: Locating the rock art of the Maloti-Drakensberg: Identifying areas of higher likelihoods using remote sensing

    - Geographic Information Systems and Remote Sensing
    - Predictive Modelling
    - Rock Art Field Surveying
    - Photographic recording of rock art sites

Available: at:
https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjz-qfVv8HbAhWDesAKHUcMAWIQFggoMAA&url=http%3A%2F%2Fwiredspace.wits.ac.za%2Fhandle%2F10539%2F21686&usg=AOvVaw0PF7e8F-Rs4WNkdx_OfCzC

- **BSc Honours (Archaeology)**
  - Dissertation: Improving rock art survey: finding the sandstone shelters of the Maloti- Drakensberg.
    - Geographic Information Systems
    - Rock Art Field Surveying
    - Photographic recording of rock art sites

- **Bachelor of Science**
  - Major Courses:
    - Geography
    - Archaeology

APPENDIX 2: PEER REVIEW LETTER

SUPPLIER-MAAA0498614
PO Box 905-827,
Garsfontein,
0042
Pretoria
15 September 2020

EScience and Associates (Pty) Ltd.
PO Box 2950,
Saxonwold,
2132
Johannesburg

The following report refers:

Air Quality Impact Assessment on the Proposed Chrome Tanning Salts and Vitamin K Compounds Production Facility at Brother CISA, Newcastle, KwaZulu-Natal.

At your request the above report was reviewed under the following terms of reference:

Review the (above) air quality impact assessment report to independently assess the need for an additional human health risk assessment.

Review report:

The focus of the review was on the sections of the report applicable to human health. The information required to decide whether human health risks were adequately addressed, was complete, no additional information is therefore required, even though more information might exist.

The report is well written, clear and the lay-out is logical. The main aim of the report, namely the impact on air quality from the proposed activities, was addressed in terms of three scenarios, using modelled data. These three scenarios were:

- (i) proposed pollutant concentrations,
- (ii) current pollutant concentrations and
- (iii) cumulative concentrations.

The areas expected to be significantly affected, which included residential areas where the public will be exposed, were indicated with the aid of suitable maps. Literature was consulted to obtain ambient (not occupational) air quality guidelines and standards, relevant to human health. This is important, as ambient air quality guidelines (not enforceable by law) and standards (enforceable by law) protect the health of the general public, including asthmatics, children and the aged, who are constantly exposed. Occupational standards are set to protect healthy individuals exposed for limited periods of time.

The standards and guidelines used, included the South African ambient standards and the World Health Organization (WHO) guidelines. Where South African standards were not available, international standards or guidelines were used.

The only human carcinogen identified from the pollutants, was hexavalent chromium. To address human health in terms of this pollutant, the incremental (over and above the back ground) cancer risk was quantified, using the correct United States-Environmental Protection Agency (US-EPA) method for cancer risk assessment through inhalation. The inhalation unit risks (IURs) used in the calculations were from the US-EPA and the WHO. These IURs are commonly used in Risk Assessments in South Africa and worldwide.

As this is not a Human Health Impact Specialist study, but an Air Quality Impact Assessment, it is the reviewer's opinion that human health was sufficiently addressed. Non-cancer risks were addressed in terms of comparison of concentrations of air pollutants to several standards and guidelines, of which most (including those from South Africa and the WHO) were health-based. Short-term (24-h or less) and long-term (annual) exposure were considered. Cancer risks were quantitatively assessed using the US-EPA method for air pollutants. This was done for all three scenarios, which included cumulative concentrations.

MA Oosthuizen

M A Oosthuizen MMedSc
HPCSA registration number MW0005320

Specific comments:

Page ii: PM_{10} -24 hour. Mention that the standards given are those for South Africa.

Page iii: Predicted lifetime carcinogenic risk using the US-EPA RfC, should read: “the US-EPA Inhalation Unit Risk (IUR)”

Page iv: Scenario 2; “modeled at measured emissions rates….” Should read “modeled at measured current emissions rates”.

Page v: Hexavalent Chromium. Should read “Predicted carcinogenic risk using **IUR”** instead of RfC

Page vii: Recommendation. Explain what the recommended 20 μg/Nm^3 was based on.

Page ix: Glossary. The new name for the Department of Environmental Affairs, namely DEFF, as well as Inhalation Unit Risk (IUR) should be added to the glossary.

Page 27: Last sentence on page; delete “it” before “therefore”.

Page 40: Second paragraph, first sentence not clear. Wording to be changed.

Page 45: Last paragraph; add “equal to or” smaller to diameter of particulates. The units should be in μm.

Page 47/48: As the WHO guidelines for sulphur dioxide are expected to be published in 2020, but have not as yet; the 2005 guidelines should be used including the interim values.

Page 49: The 5th sentence from the top of the pageshould read: “…body’s electrolyte pod”.

Page 51 Section 6.4.9- last sentence should read: “had” been identified.

Page 51: Section 6.4.10 – in the third sentence, add the units after 1000. And the last sentence should read: “had” been.

Also on Page 51, Section 6.4.11 – Second line – add “in” before industry.

Last sentence, change “have” been to “had” been.

Section 6.4.12 Last sentence: Add “also” after USA.

Page 52: Section 6.4.13 Second paragraph, last sentence, add “the” before atmosphere and “on” before environmental exposure.

Page 53: Section 6.4.13 Last paragraph - Write Cr(III) and CR(VI) to be consistent with the rest of the report.

Section 6.4.13.1: 3rd paragraph states that chromium and compounds are carcinogenic. This is however not correct, as only Cr (VI) compounds are considered carcinogenic.

Page 55: Section 6.4.13.2 – first paragraph, last sentence; add “cancer” before risk.

Second paragraph, second line; replace RfC with IUR.

Last paragraph, last sentence should read: “However, it is notable….”

Page 57: Table 6 – 14: in the comment column of the IUR of the US-EPA it should be stated that the risk is based on an IUR

Page 62: Section 6.4.13.4 – third paragraph, second sentence has to be referenced.

Page 65: Section 7, first sentence: insert the word “readily” before available.

Page 81: Heading 10.1 should include “air quality”.

Page 83: First paragraph, first sentence (below Table 10-2) should read: “Predicted incremental cancer risk from lifetime exposure to carcinogenic pollutants (Cr(VI) from the current operations at the plant are presented here”.

Page 85: Section 10.2.2.3.1, first sentence; insert “of” after exceedances.

Page 89: Section 10.2.2.6.2 In the heading, replace RfC with IUR.

Page 90: Section 10.2.2.6.3 In the heading, replace RfC with IUR.

Page 91: Figure 10 – 10; replace RfC with IUR

Page 100: Section 10.2.3.6.2 In the heading replace RfC with IUR.

Page 101: Figure 10-25 and in the heading of Section 10.2.3.6.3; Replace RfC with IUR.

Page 102: Figure 10-26 Replace RfC with IUR.

Page 110: In headings of Sections 10.2.4.6.2 and 10.2.4.6.3, replace RfC with IUR.

Page 111: Figure 10-39; Replace RfC with IUR.

Page 114: Sections 14.2.4.2 and Section 14.2.4.3 Replace RfC with IUR.

Page 116: In the headings of Sections 14.3.4.2 and 14.3.4.3 Replace RfC with IUR.

Page 117: In the heading of Section 14.4.4.2 Replace RfC with IUR.

Page 118: In the headings of Sections 14.4.4.3 Replace RfC with IUR.

Page 118: Section 14.5 Recommendations; second paragraph ; provide a motivation for the emission limit of 20 µg/Nm^3.

APPENDIX 4.2 ARCHAEOLOGICAL IMPACT ASSESSMENT

Proposed CTS Plant in Newcastle, KwaZulu-Natal

Phase 1 Archaeological Impact Assessment

Prepared by:

Drs Matt Lotter[1] and Tim Forssman[2]

[1]Association of Southern African Professional Archaeologists, Professional Member 339 with CRM accreditation
[2]Association of Southern African Professional Archaeologists, Professional Member 307 with CRM accreditation

Prepared for:

EScience Associates (Pty) Ltd
PO Box 2950, Saxonwold, 2132
9 Victoria Street, Oaklands, Johannesburg, 2192
VAT No: 473 025 4416
Reg No: 2009/014407/07

First draft: 10 July 2020
Second draft: 15 July 2020
Final draft:

Declaration of Independence

The report has been compiled by Drs Matt Lotter and Tim Forssman acting as heritage specialists. The results expressed in this report have been collected using standard archaeological procedures and are objective. The authors declare no other conflicting interests in this report.

Signed:

Tim Forss

Dr Matt Lotter

Dr Tim Forssman

This document has been prepared by:

Dr Matt Lotter
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Both authors were responsible for draft report compilation, archaeological fieldwork and report compilation.

Signed:

Dr Matt Lotter
Dr Tim Forssman

List of acronyms

AIA	Archaeological Impact Assessment
EIA	Environmental Impact Assessment
ESA	Earlier Stone Age
MSA	Middle Stone Age
POI	Point of Interest
LSA	Later Stone Age

Glossary of terms

Find / Find spot	Either term is used to refer to an isolated find, a single artefact or item of cultural heritage. These may be significant but are not considered sites.
Site	An accumulation of cultural heritage, domestic remains or other human traces of human activity. It is a term used to refer to any area of this nature from very small (a few finds spatially associated with one another) to large and obvious residential or activity areas.

Executive Summary

Introduction

Brother CISA (Pty) Ltd commissioned the services of EScience Associates (Pty) Ltd, as an independent Environmental Assessment Practitioner (EAP), to conduct an Environmental Impact Assessment as part of the permitting applications for the proposed expansion of its Newcastle Facility (KwaZulu-Natal) to incorporate a chrome tanning salts (CTS) plant. Drs Matt Lotter and Tim Forssman were then appointed by EScience Associates to perform an Archaeological Impact Assessment of an 8ha plot of land within which the proposed development will be situated.

Methods

The entire portion of land was investigated, both on foot and by vehicle, for any surface traces of cultural heritage. Where excavations and terracing had taken place on the property, these and their spoil heaps were also carefully examined to assess the possibility of sub-surface heritage preservation. All finds and/or sites were recorded following standard archaeological procedures. A specially designed site recording form was used to notate any observable traits, including cultural heritage types, deposit information and assemblage or site context, and this was graded following a set rating criteria. All survey routes were GPS recorded and every find was photographed along with the landscape.

Results

No cultural heritage items were found in the development area. Limiting the outcome of this investigation are the excavation spoil heap stockpiles for backfilling, which occur on the site covering parts of the surface, and this is especially relevant in the southern portion of the property. In addition, due to the largely modified nature of the overall landscape, having been terraced several decades prior, this has caused significant modifications to the surrounding landscape and it is highly unlikely that any heritage, if present, would occur within any valuable context. The middle and northern parts of the property have already been extensively developed through the construction of several concrete-floored workshops and site buildings, so in this particular area it is highly unlikely that any unmodified (natural) deposits occur within which archaeological traces could be contained. While there is a remote possibility that these developments may be obscuring cultural heritage, the notable lack of artefacts anywhere in the development area, including within the excavated areas, makes this possibility highly unlikely.

Conclusions

It is anticipated that the proposed development will have no impact on cultural heritage, and no recommendations are put forward. Nonetheless, there may still be cultural heritage subsurface that was not observable or inferrable from the lack of surface finds, as is always the case. Should any cultural heritage be observed once development commences, a specialist must be consulted to perform an examination of the finds.

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1. **Introduction**

a. Scope of the study

EScience Associates (Pty) Ltd was appointed by Brother CISA (Pty) Ltd to conduct an Environmental Impact Assessment (EIA) of a proposed chrome tanning salts plant in Newcastle, KwaZulu-Natal, on a parcel of land measuring approximately eight hectares. Drs Matt Lotter and Tim Forssman were subsequently appointed by EScience Associates to perform an Archaeological Impact Assessment (AIA) of the proposed area. As the proposed development plan is not known, the entire parcel of land was examined.

b. Project description

The AIA covers all portions of the proposed development. The aim of the study was to identify any tangible cultural heritage present on the land and assess its importance, and establish mitigation factors should the site be designated for destruction. To do so, a survey over the land was performed recording and grading all surface remains. Recording was performed following a standard record form. From these data, finds and sites were graded based on the rating criteria, which includes various conditions (**see Section 3, ii**). This follows standard archaeological procedures.

c. Specialist expertise

Dr Matt Lotter has undertaken extensive and in-depth research at several Stone Age, Iron Age and rock art localities around southern Africa, as well as internationally in China, Lesotho and Botswana. He has been involved in a number of Phase 1 Heritage and Archaeological Impact Assessments as well as Phase 2 mitigations. He has also published several scientific articles with a focus on Earlier Stone Age technologies and geoarchaeological landscape evolution. He is registered with the Association of Southern African Professional Archaeologists (ASAPA, ID 339).

Dr. Tim Forssman has undertaken extensive and in-depth research at several Stone Age, Iron Age and rock art localities around southern Africa. He has been involved in a number of Phase 1 Heritage and Archaeological Impact Assessments as well as Phase 2 mitigations. He was the Project Leader on the Polihali Project for a year, overseeing the mitigation of 12 Stone Age sites and coordinating several specialists in the Stone Age, rock art, Iron Age and Intangible Cultural Heritage fields. He has also published several scientific articles with a focus on the Later Stone Age, Iron Age, rock art and archaeological methods. He is registered with the Association of Southern African Professional Archaeologists (ASAPA, ID 307).

d. *South African legislation*

South African legislation (NHRA) dictates that any item of cultural heritage may not be disturbed, interfered with, or destroyed without authorisation from a heritage authority. Following Nema (No 107 of 1998; 23: 2(b)), one should "...identify, predict and evaluate the actual potential impact on the environment, socio-economic conditions and cultural heritage". A specialist is required to perform the correct and appropriate identification, evaluating and assessing of cultural heritage significance following a rating criteria (**see Section 3, ii**). Requiring and governing this assessment is the following South African legislation:

i. National Environmental Management Act (NEMA) Act 107 of 1998
ii. National Heritage Resources Act (NHRA) Act 25 of 1999
iii. Minerals and Petroleum Resources Development Act (MPRDA) Act 28 of 2002
iv. Development Facilitation Act (DFA) Act 67 of 1995

In each Act, the following sections are applicable in terms of the identification, evaluation and assessment of cultural heritage resources:

i. National Environmental Management Act (NEMA) Act 107 of 1998:
    a. Basic Environmental Assessment (BEA) – Section (23)(2)(d);
    b. Environmental Scoping Report (ESR) – Section (29)(1)(d);
    c. Environmental Impacts Assessment (EIA) – Section (32)(2)(d); and,
    d. EMP (EMP) – Section (34)(b).
ii. National Heritage Resources Act (NHRA) Act 25 of 1999:
    a. Protected Areas – Section 28;
    b. Protection of Heritage Resources – Sections 34 to 36; and,
    c. Heritage Resources Management – Section 38.
iii. Minerals and Petroleum Resources Development Act (MPRDA) Act 28 of 2002:
    a. Section 39(3).

2. Archaeological and historical background: desktop study

a. Overview of the local archaeological sequence

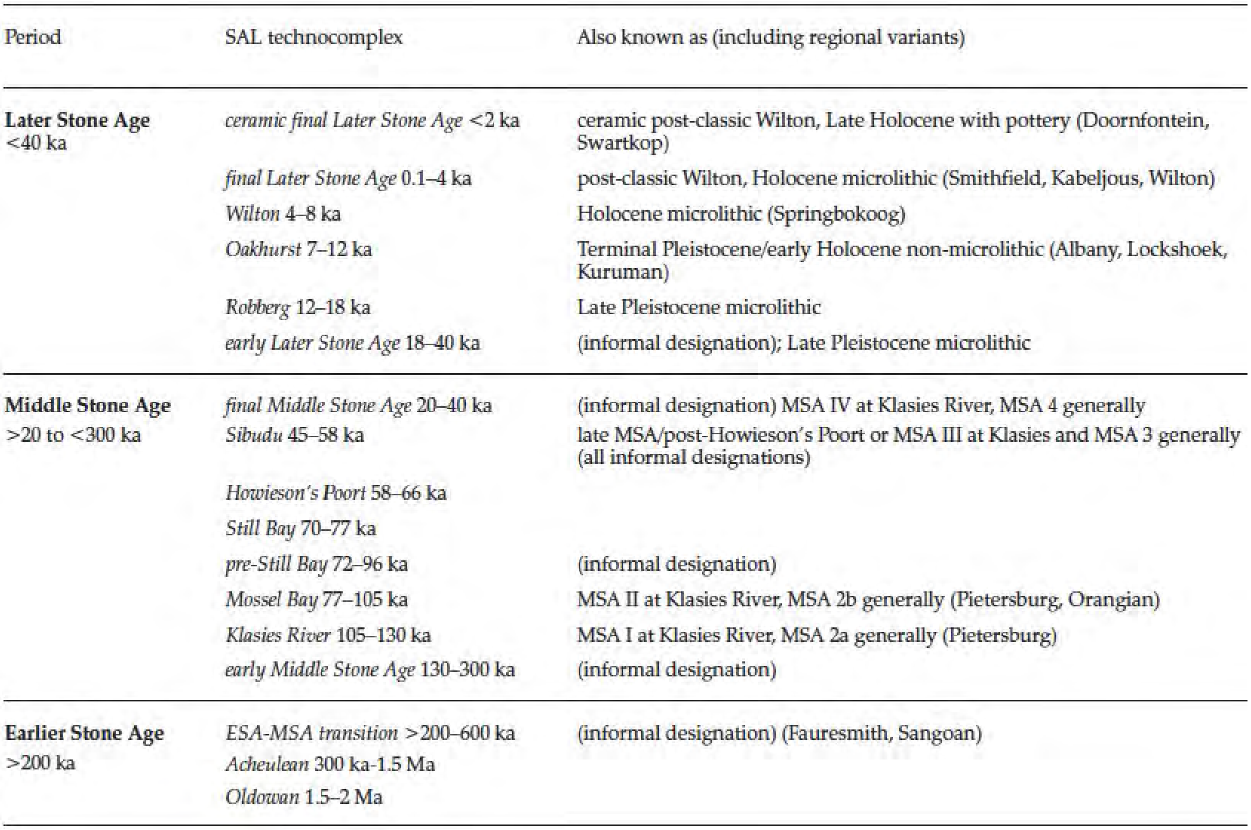
Southern Africa has a lengthy archaeological sequence spanning approximately the last two million years. This has been conveniently separated into 'Ages', which themselves are further divided. While there are many issues with doing so, it provides a useful gauge for understanding different techno-complexes, periods, and cultural sequences. We follow this same categorisation here.

i. Stone Age

The Stone Age is composed of three divisions, which are further subdivided (Table 1). These primary divisions are the Earlier, Middle and Later Stone Ages. In southern Africa, the Earlier Stone Age (ESA) begins at approximately 2.1 million years ago. Early tools, which are ascribed to the Oldowan Industry, are large tools most often made from locally available raw materials. Tool form is not yet standardised and artefacts generally retain a limited number of flake removals, which are struck off using a hammerstone (Kuman 2014). The Oldowan is followed by the Acheulean Industry, from c. 1.75 to 0.3 million years ago, which is characterised by the occurrences of handaxes and cleavers, although this is probably over-emphasised since some Acheulean assemblages lack these. While a number of sites are known in southern Africa, they are fairly scarce (Figure 1) (Lotter & Kuman 2018).

The Middle Stone Age (MSA) follows and begins between 300 and 250 thousand years ago and gradually disappears between 40 and 20 thousand years ago. Assemblages older than 130 thousand years are rare, and from this time onwards more MSA sites are known. Assemblages from these sites are generally thought to be characterised by blade technology, prepared cores, formal tools exhibiting secondary retouch and a range of ornaments, jewellery and symbolic devices, such as engraved ochre slabs. It must be noted that there is variability between regions and time periods from 130 thousand years ago and the period has been divided into several phases. Notably, the Howieson's Poort Industry is one that is marked by smaller formal tools and segmented artefacts; it is a unique development and an early example of what came to characterise the following Later Stone Age (LSA). Assemblages dating between c. 100 and 50 thousand years ago are generally thought to possess cultural traits that indicate the appearance of modern thought or cognition, sometimes called complexity (Wadley 2015).

Table 1: The Stone Age in southern Africa (from Lombard et al. 2012: 125).



Period	SAL technocomplex	Also known as (including regional variants)
Later Stone Age <40 ka	*ceramic final Later Stone Age* <2 ka	ceramic post-classic Wilton, Late Holocene with pottery (Doornfontein, Swartkop)
	final Later Stone Age 0.1–4 ka	post-classic Wilton, Holocene microlithic (Smithfield, Kabeljous, Wilton)
	Wilton 4–8 ka	Holocene microlithic (Springbokoog)
	Oakhurst 7–12 ka	Terminal Pleistocene/early Holocene non-microlithic (Albany, Lockshoek, Kuruman)
	Robberg 12–18 ka	Late Pleistocene microlithic
	early Later Stone Age 18–40 ka	(informal designation); Late Pleistocene microlithic
Middle Stone Age >20 to <300 ka	*final Middle Stone Age* 20–40 ka	(informal designation) MSA IV at Klasies River, MSA 4 generally
	Sibudu 45–58 ka	late MSA/post-Howieson's Poort or MSA III at Klasies and MSA 3 generally (all informal designations)
	Howieson's Poort 58–66 ka	
	Still Bay 70–77 ka	
	pre-Still Bay 72–96 ka	(informal designation)
	Mossel Bay 77–105 ka	MSA II at Klasies River, MSA 2b generally (Pietersburg, Orangian)
	Klasies River 105–130 ka	MSA I at Klasies River, MSA 2a generally (Pietersburg)
	early Middle Stone Age 130–300 ka	(informal designation)
Earlier Stone Age >200 ka	*ESA-MSA transition* >200–600 ka	(informal designation) (Fauresmith, Sangoan)
	Acheulean 300 ka-1.5 Ma	
	Oldowan 1.5–2 Ma	

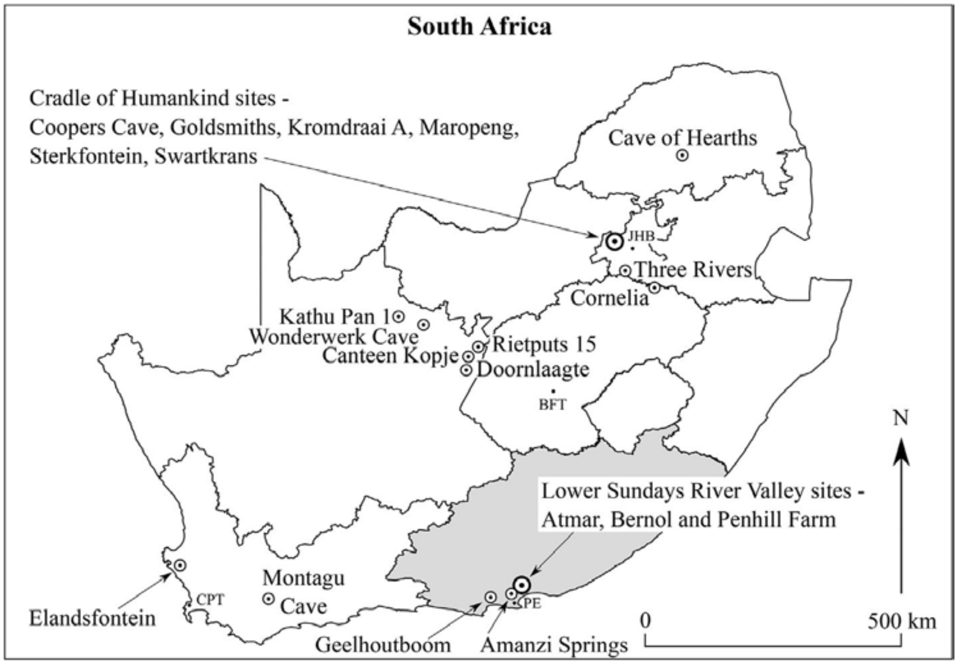


Figure 1: The distribution of Acheulean sites >0.5 million years in South Africa (from Lotter & Kuman 2018: 44).

The LSA is the final Age and begins during the transition from the MSA between 40 and 20 thousand years ago. This early period, though, is characterised by considerable variability that only gives way to a regionally standardised toolkit from after 20 thousand years ago. Small bladelets characterised this initial phase, which, around 12 thousand years ago, was replaced by a larger tool industry characterised by scrapers and adzes. Following this, the Wilton arose around eight thousand years ago and represents a highly standardised period of scraper, backed tool and adze production, although several phases are known, and includes a wide range of ornaments, jewellery, bone tools and rock art (Lombard et al. 2012). LSA-producing foragers, or hunter-gatherers, lived in almost every landscape in southern Africa and are represented today by Bushman or San[1] communities (Mitchell 2002).

Rock art was produced by many communities, but the best known is the rock art of hunter-gatherers who were also the producers of the LSA. The art typically captures trance experiences, which is when a shaman enters the spirit world through a trance dance. While in it, he or she will heal the sick, control game, ward off evil spirits and travel to neighbours or to God's village, as well as perform other tasks. Rock art generally depicts these scenes as well as folklore and mythology (Forssman & Gutteridge 2012). Khoekhoe herders had their own painting tradition, which is less well-understood, although at least some of it relates to girls' initiation. Bantu-language speaking groups also painted and generally their depictions are to do with initiation and conflict during the colonial era (Mitchell 2002). While their art is fairly well-studied, it is their occupation sequence of southern Africa that has dominated Iron Age research.

ii. Iron Age

Iron Age farmers began arriving in southern Africa little more than two thousand years ago. This was initially from Angola, through southern Zambia, the Caprivi Strip in Namibia, northern Zimbabwe and Botswana to settle in the central southern African region (Figure 2). Early settlements just north of the Limpopo River date to around AD 200. Soon afterwards, they entered what is now South Africa (Mitchell & Whitelaw 2005).

The most significant developments that occurred in the southern African region, at least at first, were those that began around AD 900 in northern South Africa. Here, farmers began exchanging local trade wealth for exotic items like glass beads from the Mozambique coastline where travelling merchants from the north based themselves. These items supported the local

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[1] The terms Bushman and San have been used derogatorily in the past. Modern communities who draw their identity from present and past hunter-gatherers have requested that these terms be used to identify them when not referring to language groups. We do so here with the utmost respect and do not invoke any pejorative connotations.

growth of wealth, which was initially based on cattle and on locally sourced value items. This growth led to the beginning of elite communities based at what came to be prominent settlements. These then developed into political centres where social stratification appeared. Around AD 1220, these developments, along with several others, resulted in the establishment of Mapungubwe, southern Africa's first state-level society. When it declined, around AD 1300, Great Zimbabwe rose to prominence, which was succeeded by Khami and Thulamela (Huffman 2009). Although this gives the impression of a fairly straight-forward developmental process, it was in fact fairly heterogeneous.

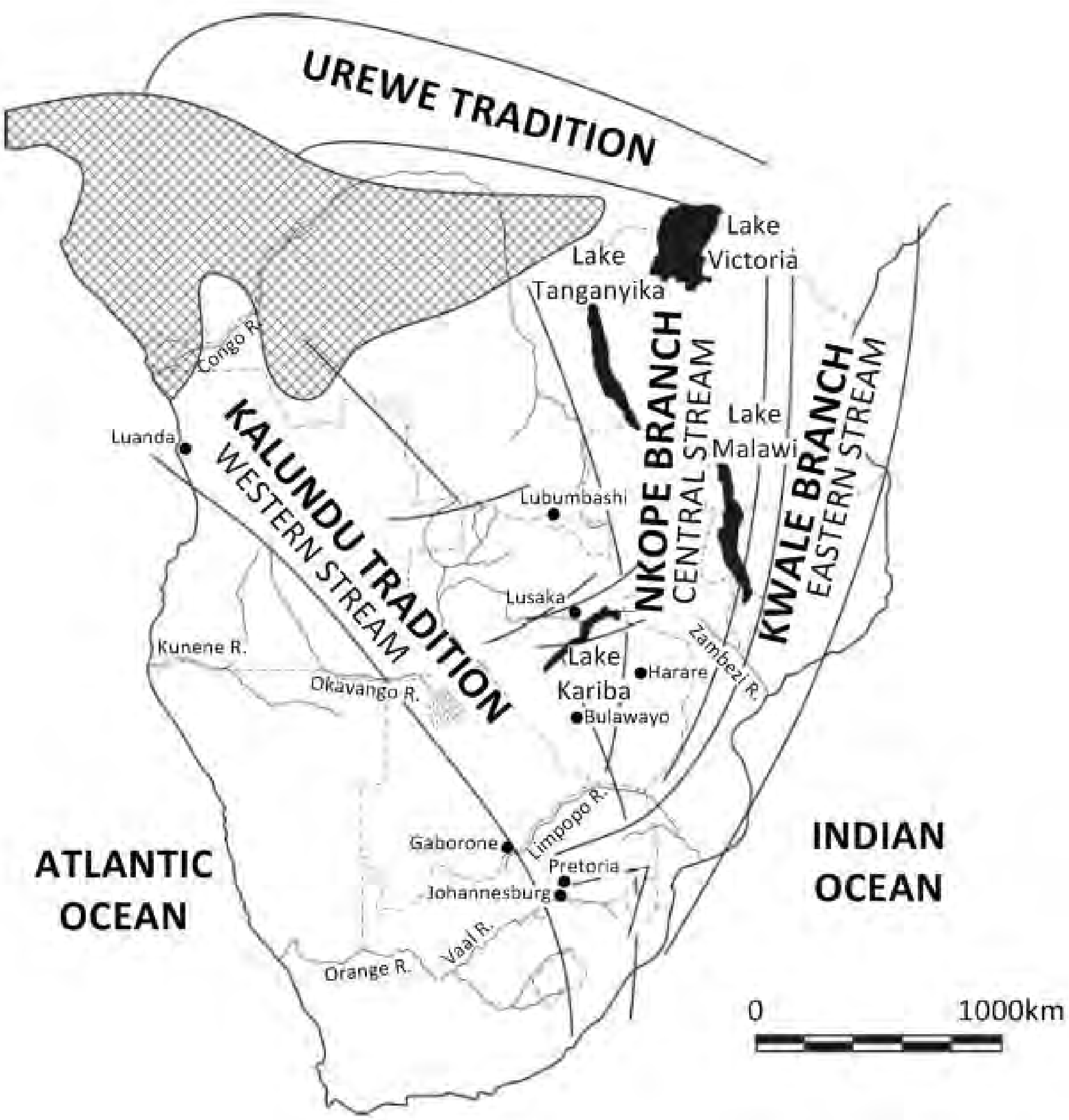

Figure 2: The appearance of farmer communities (Bantu-language speaking groups) in southern Africa (from Huffman 2007: 336).

Around the mid-second millennium AD, groups from the north, known by their ceramics called Ntsuanatsatsi, moved south into the North-West Province region. Here they established political control, around AD 1450 to 1500, and became the Tswana empire. These communities established massive urban centres, some over 3km in length, with complex political authorities (Pistorius 1994). Many are known through missionary and traveller accounts, such as those from William Burchell or Robert Moffatt in the 1800s, who encountered these capitals. The Tswana polity, which was made up of several totems, spread as far as modern-day Gauteng where they encountered Pedi, eSwati and Zulu communities (Sadr 2019).

Sometime between the 1810s and 1830s, the Difaqane (Sotho) or Mfecane (Zulu/Xhosa) took place. This was a period marked by conflict, raiding, food insecurity, and warfare. Although having its origins largely in KwaZulu-Natal, its impact was felt through-out much of eastern southern Africa and further north. At this time, different Zulu groups were covering vast regions and attacking settlements and villages taking resources, food, slaves and livestock. Some were driven as far north as Uganda. The impact of the conflict resulted in new settlement patterns, large-scale movements of people, and critical shortages of subsistence resources. It marked a tumultuous period in southern Africa's prehistory with the likely death of many thousands of people (Wright 1989).

The Iron Age is a notably diverse and complex period. Many different identities interacted, traded, fought, created alliances, and intermixed during this period. Thorough reviews exist but are not necessary in the context of this report; only some key events or histories have been discussed above (e.g. Huffman 2007). During this period, not only were farmer communities living in the region and meeting one another, but foragers and herders were also present. These three different communities had regular encounters that caused significant changes in one another's lifeways. The Iron Age also overlaps with the entire colonial period; even today many people practise subsistence-based farming much as they did in the past.

iii. Colonial period

Prior to the Dutch establishing a refreshment station in what is now the Western Cape in 1652, Portuguese traders and travellers had made contact with local communities. Trading along almost the entirety of southern Africa's coastline for supplies and what to them was exotica, they encountered many of the communities mentioned in the text here. Their interactions included often detailed note taking and mapping of certain regions, which are hugely valuable to this day in terms of understanding the local social landscape. For example, their accounts of Sofala are highly valuable since this immensely influential trading post on the Mozambique coastline has not been re-discovered. The Portuguese and also Arabic records are all we have of its existence and role in local economies (Wood 2000). From the settlement of the Western Cape, though, the influence of European colonisation was increasingly felt.

Settlement progressed slowly through southern Africa. At first, it was restricted to the fairly amicable Cape region with missionaries, travellers, biologists and explorers travelling inland. Contact with local herders and foragers was regular and there is evidence of some living or trading regularly with forts and outposts (Schrire 2014). Slaves were also taken and at some of the more prominent farms, such as Simon van der Stel's Vergelegen, a slave lodge was uncovered (Figure 3) (Markell et al. 1995). Interactions with local communities were highly nuanced and variable.

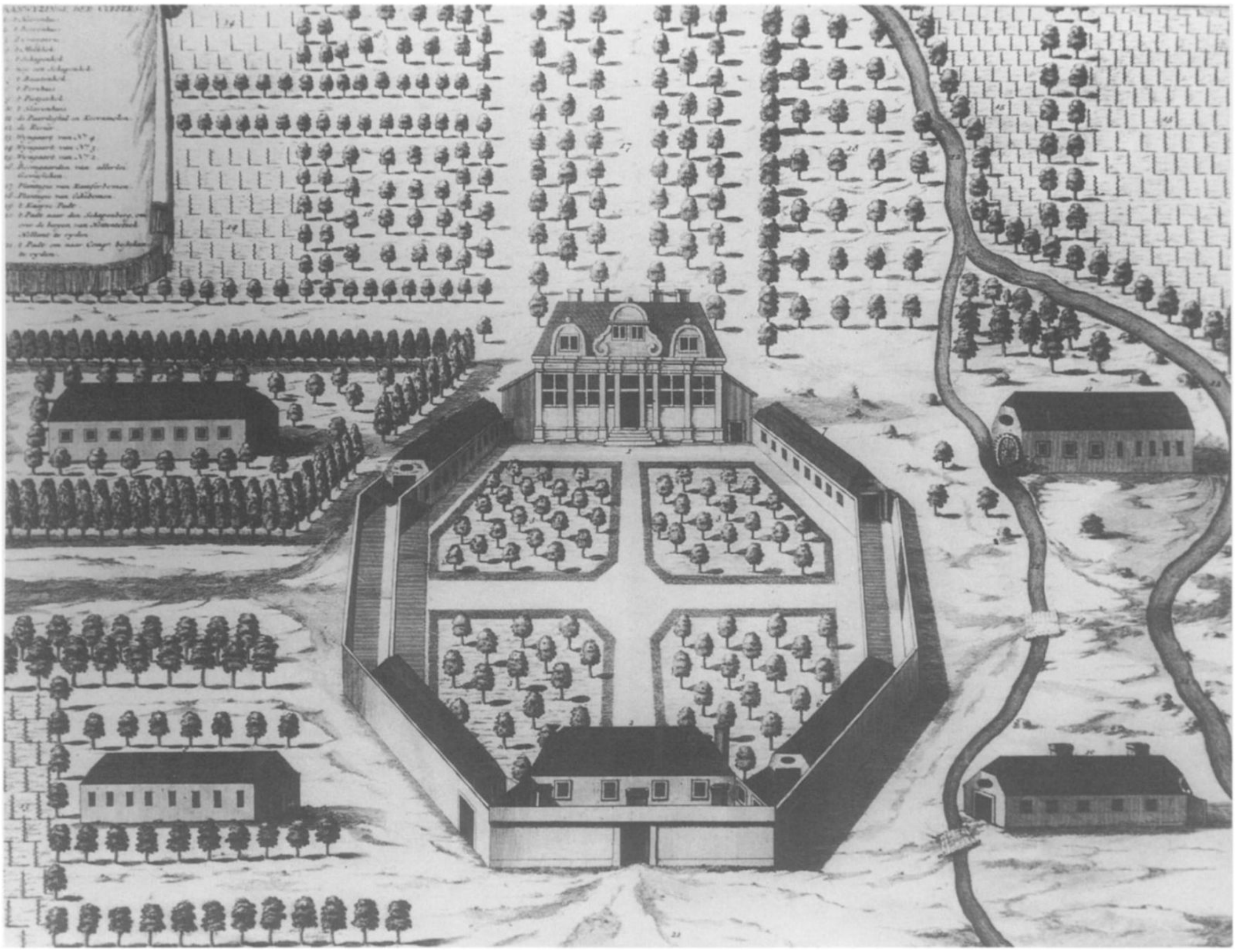

Figure 3: A depiction of Simon van der Stel's Vergelegen compound with the surrounding lodges (from Markell et al. 1995: 14).

The British took control of the Cape Colony in 1795 after the Battle of Muizenberg. This began a process of social disintegration with many European locals unwilling to contribute to the British government and crown (although from 1803 to 1806 the Dutch regained authority temporarily). The end result was the Great Trek. In 1832, Dr Andrew Smith and William Berg, an Englishman and a Boer, set-off on an early exploratory trek along the coast towards what is now KwaZulu-Natal. On returning, they convinced Boer leaders of the potential the land held for farming, livestock and settlement. After a larger exploratory trek in 1834, the first wave of trekkers left in 1835 followed in 1836 by more. About 6000 people in total left on the trek led by now historically recognised figures such as Louis Tregerdt, Hans van Renburg and Hendrik Potgieter, among others. This led to the widespread settlement of Boers and others in the eastern and northern territories of South Africa, as well as conflicts with the Matabele and Zulu; a notable battle was held at the contested Ncome/Blood River site (Ngobese & Mukhuba 2018).

In the late 1800s, when the Zuid Afrika Republic and Oranje Vrijstaat (Orange Free State) states had been established, gold was discovered in the Transvaal (d. 1886). By this time, *uitlanders* (European foreigners) were living among the local Boer community and working in Johannesburg and Pretoria as well as paying taxes, for which they received less than the local Boers. Tension between the British and Boer states arose. With the discovery of gold the British saw it fit to attempt to take over the two states in order to protect their people living under Boer rule and also to thwart a German attempt at taking control of large parts of Africa. While this is hotly contested, and an over-simplification, it contributed to the South African War (formerly Boer War) from 1899 to 1902. The war ultimately claimed the lives of probably over 50,000 Boer and black (from several communities) people as well as many British soldiers and those from the colonies. The Boer's ceded in May 1902 and the British formed the South African Republic. Boers continued living in the new republic although many resisted and wished to continue fighting. If it were not for the work of Jan Smuts and others, persistent warfare and angst may have continued (Judd & Surridge 2013).

While southern African archaeology and history is a complex matter, what is presented here is an overview and somewhat narrow summary of certain key events in the region's prehistory before about 1900. For a thorough review, see Mitchell (2002).

b. Archaeology and history of the study area and surrounds

It is worth noting at the outset that only a single archaeological site is on record for the region, which is situated approximately 3km south of the study area. Found here are Late Iron Age remains but no study of the site has been undertaken (Van Der Walt 2014). Additional surveying in the area revealed no sites and so no further archaeological work was required (for example, see: Anderson & Whitelaw 1998; van Schalkwyk & Wahl 2011; Prins 2013; Van Der Walt 2014). Therefore, very little archaeological traces are known of in the Newcastle area even though it is likely that the area has been occupied for a lengthy period of time.

Despite this lack of heritage resources, the region features regularly in historical sequences, especially in the more recent past. Farmer communities were living in the area since at least the mid- to late second millennium AD based on the only known Iron Age settlement. However, from the mid-1800s, colonial expansions began to affect regions to the south. With the expansion from Port Natal in the 1830s, after the Battle of Blood River in December of 1837, Pietermaritzburg was established and Port Natal reoccupied after a brief hiatus (see Evans 2000 for more details). By the end of the century, the South African War began (previously called the Boer War or Anglo-Boer War), in 1899, and Natal hosted significant conflicts because of its use as a secure British base during the war (Nasson 1988). Boers occupied Newcastle early in the war under Assistant Commandant-General D.J.E. Erasmus, who found the town to be empty but well-stocked. At the time, it was the northern-most advanced settlement in the territory (Toriage 1999). The British then took the town back through General Sir Redvers Buller and it became a war-time refreshment station (Evans 2000). There is little of this history that remains in the town and its vicinity, but 419 Imperial graves can be found in Newcastle’s cemetery.

Historical records, which includes farm histories, indicate no activity on the premises of the Brochem Plant. However, nearby and on other farms there are some noteworthy occurrences that might have had a bearing on the study site. For example, in 1895 a local chief, Chief Nkabana, was permitted to live in the area rent free. He occupied the extended Newcastle and Dundee Districts with people occupying 4000 huts. By the 1940s, only 150 individuals remained and were paying rent, and less than 10 years later they were forcibly removed by the government who reallocated them to a new area (National Archives of South Africa 1908-1948). Not all groups were removed from their land, though, and Alfred Vilikazi and Lakane Nkosi purchased a nearby farm in 1942 (National Archives of South Africa 1942). The settlement of the region by African communities, including on neighbouring farms such as Roy Point, appears regular in the area even though it was outside of the ‘Native Area’, located near the Ingangane Railway Station (National Archives of South Africa 1922; Van Der Walt 2014). By the 1950s, most of these people had been removed from the area.

Therefore, even though little remains of it, there are several historical events and occupations in the region. In some instances, there are still developments that indicate this, such as the grave yard south of the study area on Roy Point, but, for the most part these traces are hardly visible.

c. *Database consulted*

The South African Heritage and Resources Agency’s (SAHRA) online database, SAHRIS, was consulted to assess the nature of previous development and mitigation reports that will provide additional clarity on the archaeological richness of the area. Several studies, forming part of impact assessments, scoping reports and basic assessments, have been conducted in the nearby region.

Of greatest relevance for this report and within 1km east of the development area, and also just south of the Newcastle Aerodrome and landing strip, van der Walt (2014) conducted a Phase 1 AIA for the construction of a 5MW solar energy facility. The proposed development area comprised 10ha and was located within the Newcastle Local Municipality and Amajuba District Municipality. During this investigation, no archaeological sites were located within the development area and thus there was no direct impact foreseen on any heritage resources that included archaeological sites, built structures over 60 years old, sites of cultural significance associated with burial grounds and graves, graves of victims of conflict, and significant cultural landscapes or viewscapes. Based on a review of studies in the nearby area, van der Walt (2014) also provides the details of a nearby Late Iron Age site, a cemetery and historic sites, none of which occurred within the development area and thus the development posed no threat to their preservation; these heritage sites also occur well-beyond the current study area.

Van der Walt (2014) also provides some discussion on the general spareness of archaeological remains in the immediate area, which he attributed to the overall nature of the landscape and lack of specific geological features. For the latter, a lack of rock outcrops in the immediate area probably meant that this was not a favoured location for the production of stone tools during the Stone Age. For the former, the gently sloping topography of the land down towards the nearby Ingagane River probably lent itself well to cattle grazing, and the lack of any nearby pans (providing standing water) or other significant geological features probably meant that settlement here was probably not favoured.

Anderson (2020) conducted a desktop study Blaauwbosch bulk water transportation pipeline project, which is located roughly 8km due east of the current study area. This desktop study also provides some detail of the landscape, given its prior survey by the author in 2019. In this regard, Anderson (2020) notes that although Stone and Iron Age sites are known in the area, within the proposed development area no heritage sites occur. Roughly 65m beyond the development area though, a single settlement with a human grave was located.

An HIA was conducted by Hardwick and du Piesanie (2018) to assess the impacts of the Newcastle Landfill Project, which is located approximately 9km southwest of the study area. During this investigation, two late farming community settlements (Iron Age) were identified and a negative development impact was identified. However, due to the nature of the sites, a negligible cultural significance was attached to these sites, and their documentation within the report was sufficient for mitigation purposes.

A heritage basic assessment report was compiled by du Piesanie et al. (2016) for the proposed rehabilitation of the Eskom Kilbarchan Colliery, which is located approximately 5km to the southeast of the study area. This report provides some detail on burial grounds and graves that are located on the property, with the recommendation that these be conserved *in situ* with the development of a conservation management plan (CMP). However, the overall impact of the proposed development on heritage resources was negligible.

Gaigher (2015) conducted a Phase 1 HIA for the proposed upgrade of the P483 between Newcastle and Madadeni, which consisted of widening the preexisting road to a dual carriageway to improve road capacity, consisting in total of 7.1km running eastwards away from the southern part of Newcastle (this road is located north of the Newcastle Aerodrome). During this study, no heritage sites were identified and thus no development impacts were foreseen.

Van Schalkwyk (2014) conducted an HIA for the Madadeni bulk sewer pipeline, approximately 7km east of the current study area. During this survey, no heritage sites were identified. In the same year, Prins (2014) conducted a cultural HIA of the proposed Newcastle bypass, which is located north and west of the current study area within approximately 2km. During this survey, two heritage sites were identified consisting of two unmarked graves and a Late Iron Age stone circle. No impact was identified for this feature given the distance of the development from the stone circle, but given the proximity of the two graves, the consideration of alternative development layouts was recommended to avoid any direct heritage impacts.

An exemption application was put forward (van Schalkwyk & Wahl 2013) for a Phase 1 HIA for the proposed extension of the Muslim Cemetery, such that the current cemetery could be expanded to enlarge the areas capacity. This area is located approximately 3.5km to the northwest of the study area. This exemption was pursued as the surrounding landscape had already been extensively modified and disturbed, primarily through dumping. In this same year and roughly 12.5km southeast from the study area, Prins (2013) conducted an HIA for the Ikwezi Mining 20 MVA 88/22KV substation and associated Ingagane/Utrecht/Ikwezi 88KV powerline, and no heritage sites were identified during this study.

A Phase 1 HIA was also completed by van Jaarsveld (2012) for the planned development of the Siyahlahla-La Housing Project, which is approximately 6km due west of the study area. During the heritage survey, two graveyards and two isolated graves were identified, but no Stone Age, Iron Age or building older than 60 years were located. One of the graveyards contained approximately 15 graves and was still in current use. The second, larger graveyard also appeared to be in use and contained roughly 50-100 graves. The two isolated graves were described as being stone-packed and appearing older than 60 years. For these identified sites, it was recommended that these be properly marked and fenced-off, to avoid possible disruption from the development. Or, that grave relocations be pursued should the development not be able to accommodate their position within the immediate area.

Following these accounts, the overall area appears to have little preserved cultural heritage, but where present, this is generally in the form of human graves and settlements that fall within the Late Iron Age. As a result, all subsurface excavations should proceed with some level of caution due to the possibility of archaeological material preservation.

3. Materials and methods

a. Site location and description

The proposed CTS plant (27°46'44.79"S; 29°58'42.42"E) is located in Newcastle within the northern part of KwaZulu-Natal, east of the N11 that links Ermelo with Ladysmith (Figure 4). It is situated within the Newcastle Chemical Park, which is immediately south of the Newcastle Aerodrome, and the surrounding area falls within the Newcastle Local and the Amajuba District Municipalities. The site is accessed from the east when travelling on Karbochem Road. While the chemical park comprises multiple industrial facilities, the survey area for this study falls within property owned by Brother CISA (Pty) Ltd, comprising Erf numbers: 13361/3, 13361/1, 13361/5, 13361/4, 13744/2, 15432/0

The 8ha piece of land for this study comprises the entire eastern portion of the Newcastle Chemical Park. To the north and south the area is demarcated by railway lines that facilitate transport to and from the Newcastle Railway Station, which is north of the Chemical Park. West of the study area is the remaining portion of the Chemical Park, which is completely developed and comprises multiple industrial facilities; east of the area comprises several tailings dams.

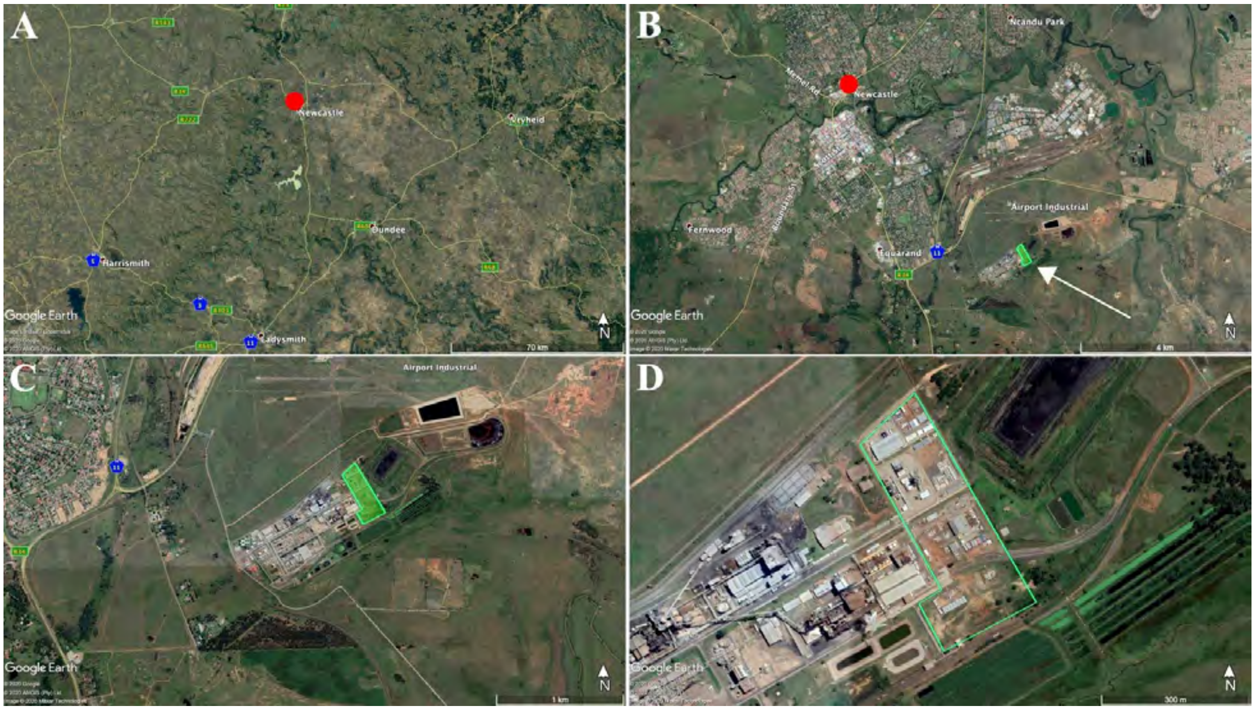

Figure 4: Google Earth map showing the study area: The study area’s context within KwaZulu-Natal and position relative to other major towns (A), Newcastle (B; site location is

shown by the white arrow), south of town in relation to the Newcastle Aerodrome (C) and a bird's eye view of the study area itself outlined in green (D).

The land currently comprises a largely modified landscape, especially for the central and northern parts. For the latter, this comprises a range of on-site buildings, workshops and additional industrial facilities. There is no preservation of any un-modified (natural) sediments here. To the south, the study area is open and largely flat, and beyond the train tracks to the south occur several artificial wetland channels. This southern area has been significantly terraced (flattened) and it has also been a favoured location for spoil heap stockpiling for backfilling, of which there is clear evidence. Shallow surface excavations have also taken place in several areas here. Collectively, these activities have significantly disturbed the local landscape. Movement of people and vehicles across the parcel of land is common.

b. *Study methods*

i. Archival study: background literature review

An archival and heritage desktop study was performed. Literary sources from previous archaeological, anthropological and historical studies from the region were consulted, as well as previous impact assessment from the area. The results from this study are presented in **Section 2: Archaeological and Historical Background: desktop study**.

ii. Site visit and survey

The site visit was conducted on Friday, June 26th, 2020. This involved a foot and vehicle survey across the property as indicated by the supplied location information (property delineation). A systematic sampling method was employed during the survey, in which high profile areas and areas most likely to contain preserved archaeology were visited. All archaeological occurrences were sufficiently recorded, photographed and described and a GPS (Garmin 64s) was used to record the surveyed tracks.

The following equipment was utilised during the field assessment:

- Garmin GPS 64s
- Canon D70 DSLR camera
- Samsung Note tablet
- Field journal and stationery
- Photographic scales
- Compass

- Cellular telephones
- Tape measures

To record heritage remains, a standard site recording form designed by the consultants was relied on in order to ensure consistency. This form records: location, site and deposit context, human and animal interference, cultural material, chronological markers, deposit depth and cultural material diversity. From this, each recording is provided a grading which is then combined to generate an overall site rating out of 10. Sites above six are considered important and assessed further in order to determine what mitigation, if any, is required.

Points of interest (POI) were also recorded. These are locations that have some item of interest, although in the case of this report, these did not have any cultural heritage significance.

iii. Reporting

All finds are reported herein. Every detail recorded in the site recording form is presented along with the location of the find or site and photographs, where applicable. The results from the grading assessment, with their justification, are also presented alongside the find or site data. In cases where no finds or sites are made, such an assessment is not provided.

c. Constraints and limitations

Ground surface visibility was limited due to the abundance of spoil heap stockpiles for backfilling, specifically in the southern portion of the study area, making the identification of surface archaeology very difficult. It is possible that archaeological find spots or sites were missed as a result; however, in many areas of the property, digging at the surface has exposed the underlying sediments, which illustrate a complete lack of subsurface archaeology. The central and northern part of the property is largely developed so visibility of any archaeological deposits here was severely constrained.

As with all archaeological surveys, the primary goal is to identify cultural material exposed on the surface. From this, one is able to make inferences about what may also lie below the surface. However, without actual test trenches or geotrenches, it is not possible to be certain what is represented underground. Furthermore, underground heritage remains may not be represented on the surface making their identification impossible. This serves as a considerable limitation. Should any cultural heritage be identified when the development begins, a specialist must be consulted to examine the finds.

4. Results and discussion

Figures 5 and 6 below provide an indication of the survey tracklog and the nature of the landscape during the assessment. The survey tracklog shows that ample coverage of the 8ha property was attained. Figures 5 and 6 also demonstrate that all portions of the property have already been extensively developed and modified through spoil heap stockpiling for backfilling, digging, landscape terracing and extensive on-site building construction. No archaeological heritage was identified anywhere within the proposed development area.

The abundance of surface digging throughout the property also suggests that the preservation of archaeological material, at depth, is unlikely. Furthermore, that this has occurred provided some sense of what may lie below the surface. Based on investigations at these excavations and in their spoil heaps, no archaeological traces were noted; although, this does not exclude the possibility that they may still exist in other areas within or beyond the development zone.

Figure 5: Survey tracklog indicated in red. Green line demarcates the property boundary.

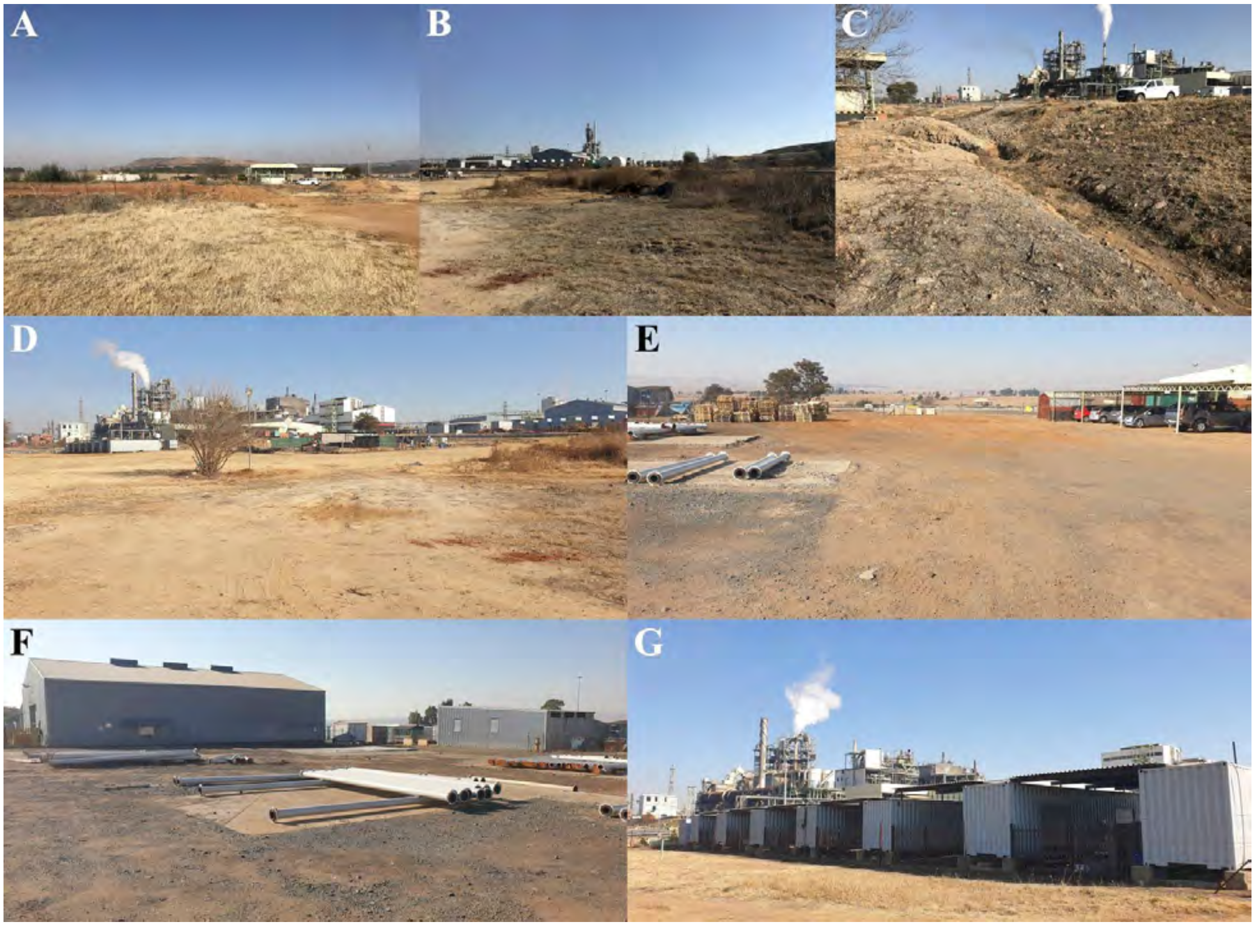

Figure 6: Disturbed nature of the landscape. A: southern part of the property looking south, showing spoil heap stockpiles for backfilling and excavations in the mid-ground; B: southern part of the property looking north, showing extensive on-site facilities in the background and vegetated spoil heaps in the mid-ground; C: southern part of the property with subsurface excavations and no associated archaeological heritage; D: southern part of the property looking west, showing the significantly altered (flattened/terraced) landscape; E: central part of property looking south, showing vehicle and secondary (access) road disturbances to the area; F: central part of the property looking southeast, showing concrete workshop floors and additional on-site buildings; G: central part of the property looking northwest towards the Newcastle Chemical Park, with on-site buildings in the foreground.

5. Development impact and proposed mitigation

a. Development impact

The development within the proposed CTS area delineation is not anticipated to have any impact on cultural heritage, based on the absence of heritage finds on the surface or in the excavated areas.

b. Recommendations

No heritage finds of any significance were identified in the impact footprint of the proposed development area. Therefore, regarding visible cultural heritage, there are no recommendations.

However, developers should be cognisant of the possibility that once development commences, cultural heritage buried underground may be exposed. Should this occur, the development in the vicinity of the find should be halted and a specialist must be consulted to examine the finds.

6. Conclusions

EScience Associates contracted Drs Matt Lotter and Tim Forssman to perform an Archaeological Impact Assessment of an 8ha plot of land to be developed into a CTS plant in the Newcastle Chemical Park, in Newcastle, KwaZulu-Natal. The entire portion of land was investigated for surface traces of cultural heritage. Where excavations had taken place on the property, these and their spoil heaps were also examined for any heritage traces. None were found.

Limiting the outcome of this investigation are the spoil heap stockpiles for backfilling, which occur on the site covering some parts of the southern property surface, as well as the considerable developments in the central and northern portions of the property. This is potentially obscuring cultural heritage; however, the sheer lack of remains anywhere else, including its general sparsity in the surrounding area (previous reported surveys) and in the excavated areas on the property, makes the possibility of this unlikely. Nonetheless, there may still be cultural heritage subsurface that was not observable or inferrable from surface finds, as is always the case. Should any cultural heritage be observed once development commences, a specialist must be consulted to perform an examination of the finds. Despite this, it is anticipated that development will have no impact on cultural heritage in the proposed development area and no recommendations are put forward.

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APPENDIX 4.3 PALAEONTOLOGICAL IMPACT ASSESSMENT

A Phase I Palaeontological Impact Assessment for the development of the Brother CISA (PTY) LTD chemical plant property, Newcastle, Kwa-Zulu Natal Province

Client: EScience Associates (Pty) Ltd
PO Box 2950, Saxonwold, 2132
9 Victoria Street, Oaklands, Johannesburg, 2192
VAT No: 473 025 4416
Reg No: 2009/014407/07

Date: 10/July/2020
Prepared by: Dr Matthew V. Caruana

DECLARATION OF INDEPENDENCE

I, Dr Matthew V. Caruana, declare that I acted as the independent palaeontological practitioner and performed the work relating to the application in an objective manner. I declare that there are no circumstances that compromised my objectivity in performing this work, and I have expertise in conducting heritage impact assessments, including knowledge of the Act, Regulations and relevant guidelines. I had no conflicting interests in undertaking this work.

Contact Person:	Matthew V. Caruana Tel: +27 (0) 78 103 1627 Email: mv.caruana79@gmail.com

Signature: ______________________

EXECUTIVE SUMMARY

Brother CISA (Pty) Ltd ('Brother CISA') is a chemical enterprise company specializing in the development, manufacture and sale of plastics, rubber, specialty chemicals and intermediates. They wish to expand their product range to include chrome tanning salts (CTS) at its Newcastle plant in KwaZulu Natal. Brother CISA intends to develop existing facilities to process inorganic and organic CTS at 50 000 t/a and 30 000 t/a, respectively, as well as 2 000 t/a of synthetic vitamin K. This involves the installation of equipment within the existing plant. The proposed expansion requires an Environmental Authorisation in terms of The National Environmental Management Act, 1998 (Act No. 107 of 1998, as amended) (NEMA), and Brother CISA have contracted EScience Associates (Pty) Ltd to conduct an Environmental Impact Assessment (EIA). A palaeontological impact assessment (PIA) is required as a section of the EIA, which is outlined below.

Desktop Study Findings

Anderson (2020) and Bamford (2020) conducted PIA's near to the study area (~8 km), although did not report any fossil accumulations. Moreover, Anderson (2020) recommended exemption from further survey or mitigation. PIA studies in Kwa-Zulu Natal focused on the Ecca Group geological formation, which underlies the Brother CISA plant, have concluded that construction and mining activities were unlikely to disturb important palaeontological resources, which also applies to work reviewed in this report (see Bamford, 2013, 2019. 2020; Rubidge, 2013).

Survey Findings

1. The Brother CISA property consists of pre-existing, industrial structures;
2. The property has been disturbed by previous development activities;
3. It is highly unlikely that any further development activities in the study would expose or endanger any palaeontological materials.

Recommendations

If development on this property should involve any excavation that exposes fossil deposits, a professional palaeontologist should be contacted to assess whether mitigation actions are necessary. Trace fossil (plants & insects) are associated with the Witbank Coalfield as a part of the Vryheid Formation, although it is unlikely that they will be of any importance (cf. Bamford, 2013; Rubidge, 2013).

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SPECIALIST QUALIFICATIONS

Dr. Matthew V. Caruana is a Stone Age specialist and surveyor. He has undertaken extensive and in-depth research at several palaeoanthropological localities around southern Africa including Swartkrans, Drimolen and Taung. He has also published several scientific articles with a focus on Earlier Stone Age technologies, as well as palaeoanthropological finds. He is registered with the Association of Southern African Professional Archaeologists (ASAPA) and has CRM accreditation within the said organisation. He is also a member of the Palaeontological Society of South Africa.

BACKGROUND

Project Background

Brother CISA (Pty) Ltd (hereafter 'Brother CISA') has commissioned the services of EScience Associates (Pty) Ltd (hereafter 'EScience Associates') to conduct an Environmental Impact Assessment (EIA) to expand its existing product range to include the production of chrome tanning salt (CTS) and synthetic vitamin K production at its Newcastle plant in the Kwa-Zulu Natal Province. Brother CISA is a chemicals enterprise that currently develops, manufactures and sells plastics, rubber, specialty chemicals and intermediates. They intend to install necessary equipment in existing facilities to process inorganic and organic CTS at 50 000 t/a and 30 000 t/a, respectively, as well as 2 000 t/a of synthetic vitamin K. According to the SAHRIS PalaeoSensitivity Map (https://sahris.sahra.org.za/map/palaeo), the Brother CISA plant is located on palaeontologically sensitive ground (Ecca Group, Karoo Supergroup) (Fig. 1). As such, Brother CISA requires a Phase I PIA report, which forms a portion of the EIA. Mr. James Pugin of EScience Associates contacted Dr M. V. Caruana to conduct the Phase I PIA.

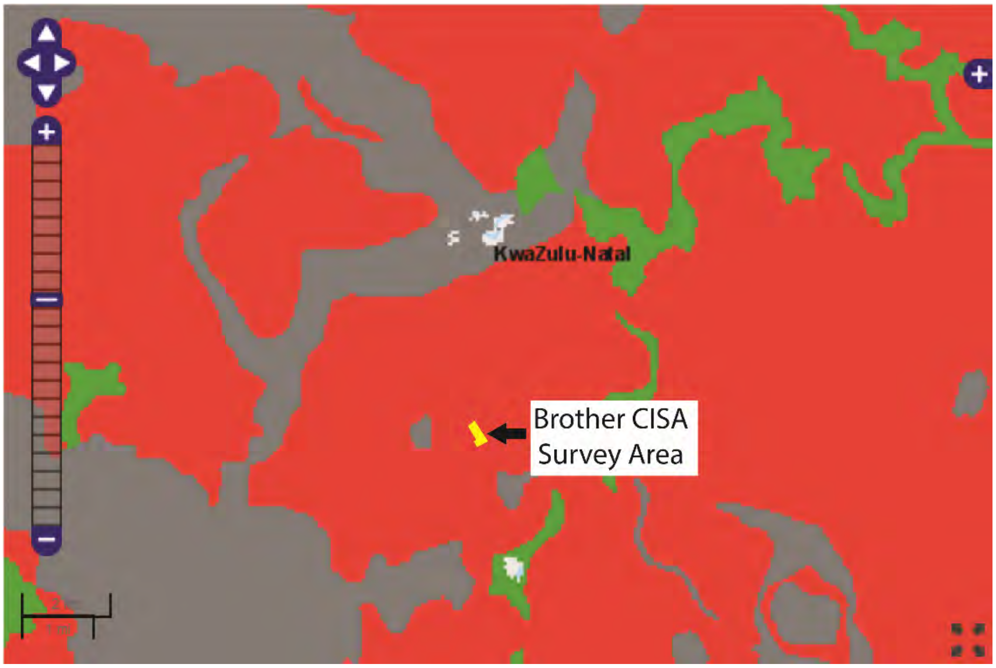

Figure 1. Location of the Brother CISA chemical plant and survey area on the SAHRIS PalaeoSensitivity Map. (Colours reflect sensitivity scale: Red = Very high; Green = Moderate; Grey = No significance).

DESCRIPTION OF THE BROTHER CISA SURVEY AREA

Property Location

Brother CISA Industrial Plant, Newcastle Chemical Plant, Albert Wessels Drive, Amajuba District, Newcastle, Kwa-Zulu Natal Province, South Africa (Fig. 2).

Geographic Coordinates

27°46'44.79"S; 29°58'42.42"E

Physical Description of the Survey Area

Figure 2 shows the geographic location of the study area on the Brother CISA chemical plant property, approximately 6 km southeast from the city center of Newcastle, Kwa-Zulu Natal Province. It is situated within the Newcastle Chemical Park (comprising ERF#: 13361/3, 13361/1, 13361/5, 13361/4, 13744/2, 15432/0). Figure 3 displays the physical property (~8 ha) within the study area, which is largely composed of pre-existing industrial buildings and terraced (flattened) veld to the south, which contains spoil heaps from previous construction activities (Fig. 4). Previous developments have disturbed the property significantly and there are no fossil outcrops or scatters noted.

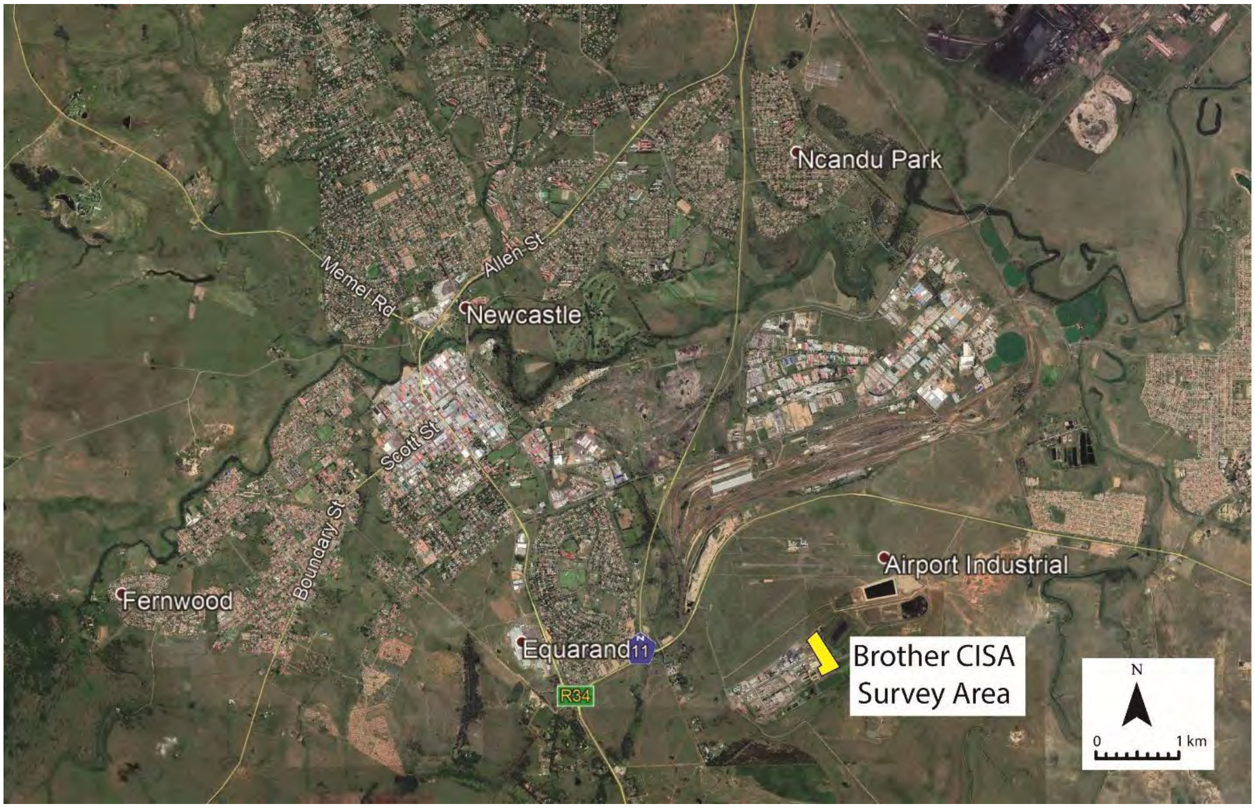

Figure 2. Geographical location of the Brother CISA chemical plant and survey area.

Figure 3. Physical location of the Brother CISA chemical plant survey area.

Figure 4. Open veld in the southern portion of the Brother CISA chemical plant survey area.

METHODOLOGY

According to the NHRA (no 25 of 1999) and the National Environmental Management Act (NEMA) (no 107 of 1998). The PIA process consisted of three steps:

Step I – Literature Review: Background information on the study area was based on archival reports available in SAHRIS, as well as available academic literature on relevant fossiliferous formations.

Step II – Physical Survey: The physical survey was conducted on foot and by vehicle according to safety protocols. The survey aimed to identify fossil scatters within the study area, and to inspect any exposed sediment profiles. Any significant finds are recorded through standard palaeo-science procedures including GPS notation, photographic records and descriptions of finds.

Step III – Report: The final step involved the recording and documentation of the survey results, which were analysed and summarized here by Dr Matthew V. Caruana. The purpose of the report is to provide a field rating and significance statement, recommending if any mitigation procedures are necessary before development commences.

The field rating and significance of the survey area was based on four main criteria:

- Site integrity (i.e. primary vs. secondary context);
- Abundance of fossil materials;
- Density of fossils;
    - Low - <10/50m^2
    - Medium - 10-50/50m^2
    - High - >50/50m^2
- Uniqueness; and
- Potential to answer scientific research questions.

Study Limitations

Not detracting in any way from the comprehensiveness of the survey undertaken, it is necessary to realise that the lack of palaeontological resources located during the survey does not reflect an overall lack of fossil-bearing deposits in the area. The presence of the Ecca Group formation indicates possible trace fossils, such as plants and insects preserved in this area.

IMPACT ASSESSMENT

Palaeontological Background

The Brother CISA survey area is geologically located within the Ecca Group (Karoo Supergroup), which formed during the Early to Middle Permian period, and is affiliated with the

Gondwanaland sequence in South Africa (Anderson and McLauchlan, 1976; Stainstreet et al., 1980; Cairncross and Cadle, 1987; Bamford, 2004; Johnson et al., 2006; Rubidge, 2014;) (Fig. 5). Sedimentary formations within the Ecca Group that are known to outcrop in the Kwa-Zulu Natal region, specifically the Vryheid Formation, preserve important plant trace fossils including *Diplocraterion parallelum, Skolithos, Monocraterwn, Scalaruuba, Siphonichnus eccaensis* and *Glossopteris* flora, which have contributed to the formation of the Witbank coalfield (Anderson and McLauchlan, 1976; Cairncross and Cadle, 1987). It should be noted that fossil materials are exclusively found within the coal seam zones of the Ecca Group. An extensive review of the plant fossils from the Ecca Group can be read in Bamford (2004). While no macro-fossils (i.e. mammalin/reptilian animals) have been found in the Vryheid Formation, its trace fossils of plants and invertebrates have been important for understanding palaeoenvironmental conditions during the Permian Period (Stainstreet et al., 1980).

Archival Findings

Previously Conducted Palaeontological Impact Assessment of Significance to this Study:

- Bamford, M. 2013. Palaeontological Impact Assessment for the Establishment of a 600 MW Power Plant and Ash Disposal Facility at Delmas (Mpumalanga/Gauteng). Phase I Report.

- Rubidge, B. 2013. Palaeontological Desktop Study Leeuwpan Mine, Delmas, Nkangala District Municipality, Mpumalanga Province. Phase I Report.

- Fourie, H. 2015. Palaeontological Impact Assessment: Phase 1 Field study - Ngululu Resources Opencast Coal Mine, Nkangala District Municipality, Mpumalanga Province. Farm: Portion 26, 46 and 47 Droogenfontein 242 IR. Phase I Report.

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- Bamford, M. 2020. Palaeontological Impact Assessment for the proposed iThala Madadeni Industrial Economic Hub, south of Newcastle, Kwa-Zulu Natal Province. Phase I Report.

- Anderson, G. 2020. Desktop Study for the Blaauwbosch BWSS, Osizweni, Newcastle, Kwa-Zulu Natal. Phase I Report.

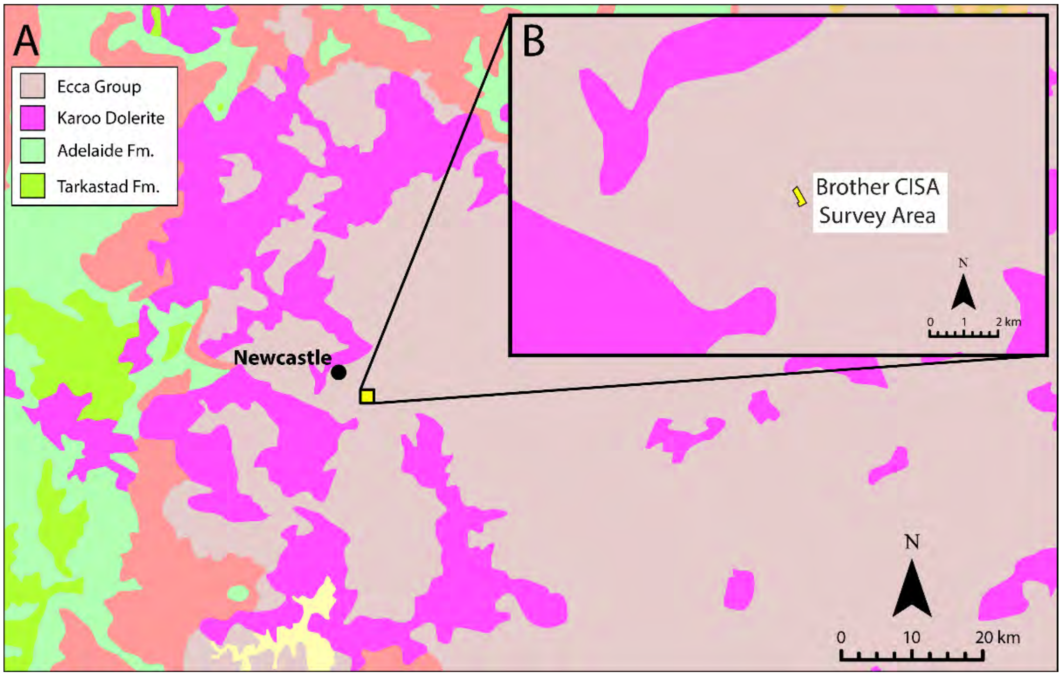

Figure 5. Geological location of the Brother CISA chemical plant survey area. A) Yellow box indicates the area near the Brother CISA chemical plant; B) Inlay indicating the location of the survey area.

Researching the SAHRA APM Report Mapping Project records and the SAHRIS online database (http://www.sahra.org.za/sahris; accessed 06/30/20), showed that Anderson (2020) and Bamford (2020) have previously conducted palaeontological impact assessments within ~8 km of the study area. Both these reports did not recommend any mitigation and Anderson (2020) applied for an exemption letter to forgo any further palaeontological surveys related to developments. All above mentioned PIAs (Bamford, 2013, 2019, 2020; Rubidge, 2013; Fourie, 2015; Anderson, 2020) were conducted in a similar geological region (i.e. Ecca Group) and thus are relevant to this study. These assessments did not report any significant fossils or outcrops nor recommended mitigation. The Brother CISA property is already developed, consisting of industrial buildings, and thus it is extremely unlikely that any important palaeontological resources will be exposed or disturbed by any further development of the property (cf. Bamford, 2013, 2019, 2020; Rubidge, 2013; Fourie, 2015).

It should be noted that Bamford (2019) estimated that the uppermost Witbank coal seam in the Kwa-Zulu Natal region, where fossil materials would be located, is approximately 100 m below current surface levels. As such, without significant earth moving activities, it is extremely unlikely that any development of the Brother CISA survey area will disturb fossil outcrops or palaeontological materials.

Survey Findings

The survey was conducted on Friday, June 26th, 2020, on foot and by vehicle in line with safety protocols. All open spaces were surveyed for cultural and fossil materials (Fig. 6). During the survey, significant modification via terracing (landscape flattening activities) was noted, particularly in the southern portion of the property. Spoil heaps were located and surveyed, but no fossil materials were identified (Fig. 7). The majority of the property is occupied by industrial buildings and no fossils or fossiliferous deposits were identified.

Figure 6. Survey track log (red) and survey area perimeter (green).

Figure 7. Spoil heap located in the southern portion of the survey area.

Field Rating

Field Rating: Low significance and no mitigation required.

- **Site integrity**: highly disturbed
- **Abundance of fossils**: none
- **Density of fossils**: none
- **Uniqueness**: low
- **Potential to answer scientific questions**: none

Statement of Significance (Heritage Value)

Given the previous development and disturbance of the property noted in the survey findings, the proposed upgrade of the Brother CISA property is extremely unlikely to expose or disturb any fossil deposits. As such, it is deemed that the survey area represents a low priority for mitigation, and highly unlikely that any palaeontological resources will be endangered.

RECOMMENDATIONS

According to current development plans, no mitigation measures are required. If construction activities on this property should involve excavation of the property (i.e. earth movement) that expose any fossil deposits, a professional palaeontologist should be contacted to assess if mitigation actions are necessary. In the latter scenario, it is possible that trace fossils of plants and insects associated with the Vryheid Formation may be exposed, although it is unlikely that they will be of any scientific importance (cf. Bamford, 2013, 2019, 2020).

CONCLUSIONS

The results of the archival study show that two PIAs have been conducted near the study area, although these concluded that no mitigation was required (Anderson, 2020; Bamford, 2020). Conclusions reached in all PIA's consulted in the archival study suggested that it is highly unlikely that any significant fossils will be exposed and/or disturbed by development activities that did not involve mining. Furthermore, the survey component of this study found no fossils exposed on the property. However, if developments should expose any fossil deposits, SAHRA should be contacted immediately and a professional palaeontologist should be brought in to assess their significance and provide recommendations (e.g. recording, sampling, collection and mitigation).

The absence of fossils on the property, combined with a lack of mitigation of palaeontological resources in the local area, suggests a low negative impact on palaeontological resources. As such, no mitigation is recommended at this time and development of the Brother CISA property should continue.

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Bamford, M. 2019. Palaeontological Impact Assessment for the Proposed Prospecting Rights Application on Rietvlei 150 HU, ~20km east of Vryheid, KwaZulu-Natal Province. Phase II Report. Sourced: http://www.sahra.org.za/sahris on June 30th, 2020.

Bamford, M. 2020. Palaeontological Impact Assessment for the proposed iThala Madadeni Industrial Economic Hub, south of Newcastle, KwaZulu Natal Province. Phase I Report. Sourced: http://www.sahra.org.za/sahris on June 30th, 2020.

Cairncross, B., and Cadle, A.B. 1987. A genetic stratigraphy for the Permian coal-bearing Vryheid Formation in the east Witbank Coalfield, South Africa. South African Journal of Geology 90: 219-230.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.d-V., Christie, A.D.M., Roberts, D.L., Brandle, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J. (Eds). The Geology of South Africa. Geological Society of South Africa. Johannesburg: Council for Geoscience. Pp 461 – 499.

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Stainstreet, I.G., Smith, G.L-B., Cadle, A.B. 1980. Trace Fossils as Sedimentological and Palaeoenvironmental Indices in the Ecca Group (Lower Permian) of the Transvaal. Transactions of the Geological Society of South Africa 83: 333-344.

I. APPENDIX

LEGISLATIVE CONTEXT

The identification, evaluation and assessment of any cultural heritage site, artefact or find in the South African context is required and governed by the following legislation:

- i. National Environmental Management Act (NEMA), Act 107 of 1998
- ii. National Heritage Resources Act (NHRA), Act 25 of 1999
- iii. Mineral and Petroleum Resources Development Act (MPRDA), Act 28 of 2002

The following sections in each Act refer directly to the identification, evaluation and assessment of cultural heritage resources.

- i. National Environmental Management Act (NEMA) Act 107 of 1998
  - a. Basic Environmental Assessment (BEA) – Section (23)(2)(d)
  - b. Environmental Scoping Report (ESR) – Section (29)(1)(d)
  - c. Environmental Impact Assessment (EIA) – Section (32)(2)(d)
  - d. Environmental Management Plan (EMP) – Section (34)(b)
- ii. National Heritage Resources Act (NHRA) Act 25 of 1999
  - a. Protection of Heritage Resources – Sections 34 to 36; and
  - b. Heritage Resources Management – Section 38
- iii. Mineral and Petroleum Resources Development Act (MPRDA) Act 28 of 2002
  - a. Section 39(3)

The NHRA stipulates that cultural heritage resources may not be disturbed without authorization from the relevant heritage authority. Section 34(1) of the NHRA states that, “no person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority…” The NHRA is utilized as the basis for the identification, evaluation and management of heritage resources and in the case of CRM those resources specifically impacted on by development as stipulated in Section 38 of NHRA, and those developments administered through NEMA, MPRDA legislation. In the latter cases the feedback from the relevant heritage resources authority is required by the State and Provincial Departments managing these Acts before any authorizations are granted for development. The last few years have seen a significant change towards the inclusion of heritage assessments as a major component of Environmental Impacts Processes required by NEMA and MPRDA. This change requires us to evaluate the Section of these Acts relevant to heritage.

The NEMA 23(2)(b) states that an integrated environmental management plan should, “…identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage”.

A study of subsections (23)(2)(d), (29)(1)(d), (32)(2)(d) and (34)(b) and their requirements reveals the compulsory inclusion of the identification of cultural resources, the evaluation of the impacts of the proposed activity on these resources, the identification of alternatives and the management procedures for such cultural resources for each of the documents noted in the Environmental Regulations. A further important aspect to be taken account of in the Regulations under NEMA is the Specialist Report requirements laid down in Section 33 of the regulations.

APPENDIX 4.4 MAJOR HAZARD INSTALLATION RISK ASSESSMENT

TITLE PAGE

Company name	Brother CISA (Pty) Ltd	
Contact persons at the company	Jacque Hunlun	
Contact details	Cell: +27 (0) 83 633 1391 Fax: +27 (0) 34 370 7120 E-Mail: jacque.hunlun@brothercisa.com	
Facility or installation name and physical address	Brother CISA (previously Lanxess CISA) 1 Karbochem Road; Newcastle Chemical Park Newcastle	
Geographic location of the installation	S 27.780616; E 29.977255	
Type of risk assessment	Existing installation; 5-year review	X
	Proposed / new installation	
	Existing, modified installation	
Date of site survey	23 March 2020	
Date of risk assessment	23 March 2020 – 14 April 2020	
Date of report	14 April 2020	
Risk assessor	Dr Alfonso Niemand Nature & Business Alliance Africa (Pty) Ltd	
Contact details of risk assessor	13 Sedona Complex Flora Haase Street; Amorosa; Roodepoort PO Box 1753; Strubens Valley; 1735 Tel 083 225 4426 alfonso@natbus-alliance.co.za	
Report reference number	MHI-536/20-2	
Classification of site	MHI	

Nature & Business Alliance Africa (Pty) Ltd
MHI Risk Assessor

MHI-0004

Final Copy for Submission to Authorities

CONTROL PAGE

Date of last revision of this report	20 April 2015
Names of persons present during MHI site survey	Dawie van der Merwe Jacque Hunlun
Reference numbers for previous risk assessments of the installation	MHI-292/14-2

EXECUTIVE SUMMARY

1. Brother CISA (Newcastle Chemical Park) (Pty) Ltd requested a quantitative assessment 5-year review of the MHI risks associated with its plant in Newcastle Chemical Park, Newcastle. Nature & Business Alliance Africa (Pty) Ltd has been appointed for this purpose.
2. The Occupational Health and Safety Act (Act 85 of 1993) defines a major hazard installation as "*an installation-*
   - *where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or*
   - *where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident*".
3. The Explanatory Notes on the Major Hazard Installation Regulations issued in April 2005 by the Chief Directorate of Occupational Health and Safety of the Department of Employment and Labour explains the following:

   "*What is important here is to know that there are two reasons that can determine when an installation is a major hazard installation (MHI). The first reason is when there is more than the prescribed quantity of a substance. The quantities and type of substances are prescribed in the General Machinery Regulation 8 and its Schedule A, on notifiable substances. The second reason is where substances are produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident. The important issue is the potential of an incident and not whether the incident is a major incident or not. The potential will be determined by the risk assessment.*

   A major incident means an occurrence of catastrophic proportions, resulting from the use of plant or machinery, or from activities at a workplace.
   It is impossible to put a specific value to "catastrophic" because it will always differ from person to person and from place to place. However, when the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident can be seen as catastrophic".

4. The identification of different hazardous installations within the premises is given in the table below:

No T1 Updated	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	Sulphur dioxide liquid	1079 7446-09-5	2.3	60 m3 (84 000 kg)	80 m2	60 m3 every two weeks	84 000 kg
2	Ammonia liquid	1005 7664-41-7	2.3	850 kg One compressor; 12 barg	-	Closed system	850 kg
3	Carbon dioxide	1013 124-38-9	2	Two tanks of 25 m3; 17 barg	-	Own production and storage	25 m3
4	Methane via pipeline (natural gas)	1971 74-82-8	2.1	150-mm pipeline; 6.25 barg to kiln	-	6 000 nm3 per hour	150-mm hole for 10 minutes
5	Steam boiler	-	-	25 m3; 21 barg	-	-	-
6	Compressed air vessels	-	-	Three tanks of 5.3 m3; each 8 barg	-	-	-
7	Liquid sulphur storage tank (molten)	2448 7704-34-9	4.1	80 000 liters	45 m2	30 tons per day	80 000 liters
8	Liquid sulphur road tanker (molten)	2448 7704-34-9	4.1	20 000 liters	-	30 tons per day	20 000 liters
9	Methyl naphthalene storage tank	1760 91-20-3	4.1	200 000 liters	120 m2	10 tons per day	200 000 liters
10	Methyl naphthalene road tanker	1760 91-20-3	4.1	20 000 liters	-	10 tons per day	20 000 liters
11	n-Heptane storage tank	1206 142-82-5	3	50 000 liters	80 m2	45 000 liters every six months	50 000 liters
12	n-Heptane road tanker	1206 142-82-5	3	20 000 liters	-	20 000 liters every six months	20 000 liters
13	Hydrogen storage tank	1049 1333-74-0		37 m^3 at a pressure of 0.5 barg.	-	3 m3 per day	37 m3

5. The facility is classified as a major hazard installation, because a major incident at the site will have an effect zone such that it will impact members of the public outside the boundaries of the premises.
6. It is essential that risk mitigation measures are applied at this site, as outlined in this report.
7. To the best knowledge of the risk assessor there are no major hazard installation within a major effect zone of the worst-case major incident that can occur at this site.
8. If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.
9. Hazard scenarios identified

    - A total of 47 hazard scenarios were evaluated for the site.

10. The risk rankings for the site are as follows:

    - First priority: Loss of containment of liquid sulphur dioxide from the storage tank to release a toxic gas cloud.

- Second priority: Loss of containment of ammonia from the compressor station and loop to release a toxic gas cloud.
- Third priority: Pool fire at the molten sulphur storage tank or road tanker.
- Fourth priority: Pool fire at the methyl naphthalene storage tank or road tanker.
- Fifth priority: Loss of containment of n-heptane from the storage tank or road tanker to create a VCE.

11. <u>Societal risk</u>

- Societal safety risks on this site are acceptably low.

12. <u>Individual risk</u>

- The cumulative individual safety risks for the site is 2.75 E-4 d/p/yr, which is lower than the norm of 1.0 E-3 d/p/yr for the public and for employees on site.

13. <u>Future land use development around the site</u>

- There are no developing conflicts for this site at the time of the risk assessment.
- To the best knowledge of the risk assessor there are no major hazard installation within the effect zone of a relevant worst-case major incident that can occur at this site.
- If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

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Appendix 7	Inspection protocol
Appendix 8	Societal and individual risk criteria

TABLE OF ACRONYMS AND DEFINITIONS

AIChE	American Institute of Chemical Engineers, USA
AIHA	American Industrial Hygiene Association
ALARP	As low as reasonably practicable
ALOHA	Areal Locations of Hazardous Atmospheres
Baseline risk assessment	A quantitative assessment of the safety risks associated with a particular major hazard installation, irrespective of the organisational mitigation measures implemented at the installation.
BEVI	Netherlands: *Besluit externe veiligheid inrichtingen* (Decree on safety of devices)
BLEVE	Boiling liquid expanding vapour explosion
BP	Boiling point
CASRN	Chemical abstracts service registry number
CCPS	Centre for Chemical Process Safety, USA
CFD	Computational fluid dynamics
d/p/yr	Deaths per person per year (individual risk measure)
EIA	Environmental impact assessment
EPA	Environmental Protection Agency, USA
ERPG-1	values estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. Sensitive members of the public—such as old, sick, or very young people—aren't covered by these guidelines and they may experience adverse effects at concentrations below the values. A chemical may have up to three ERPG values, each of which corresponds to a specific tier of health effects. It is developed by the American Industrial Hygiene Association is used by the US National Oceanic and Atmospheric Administration ERPG-1 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.
ERPG-2	ERPG-2 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health

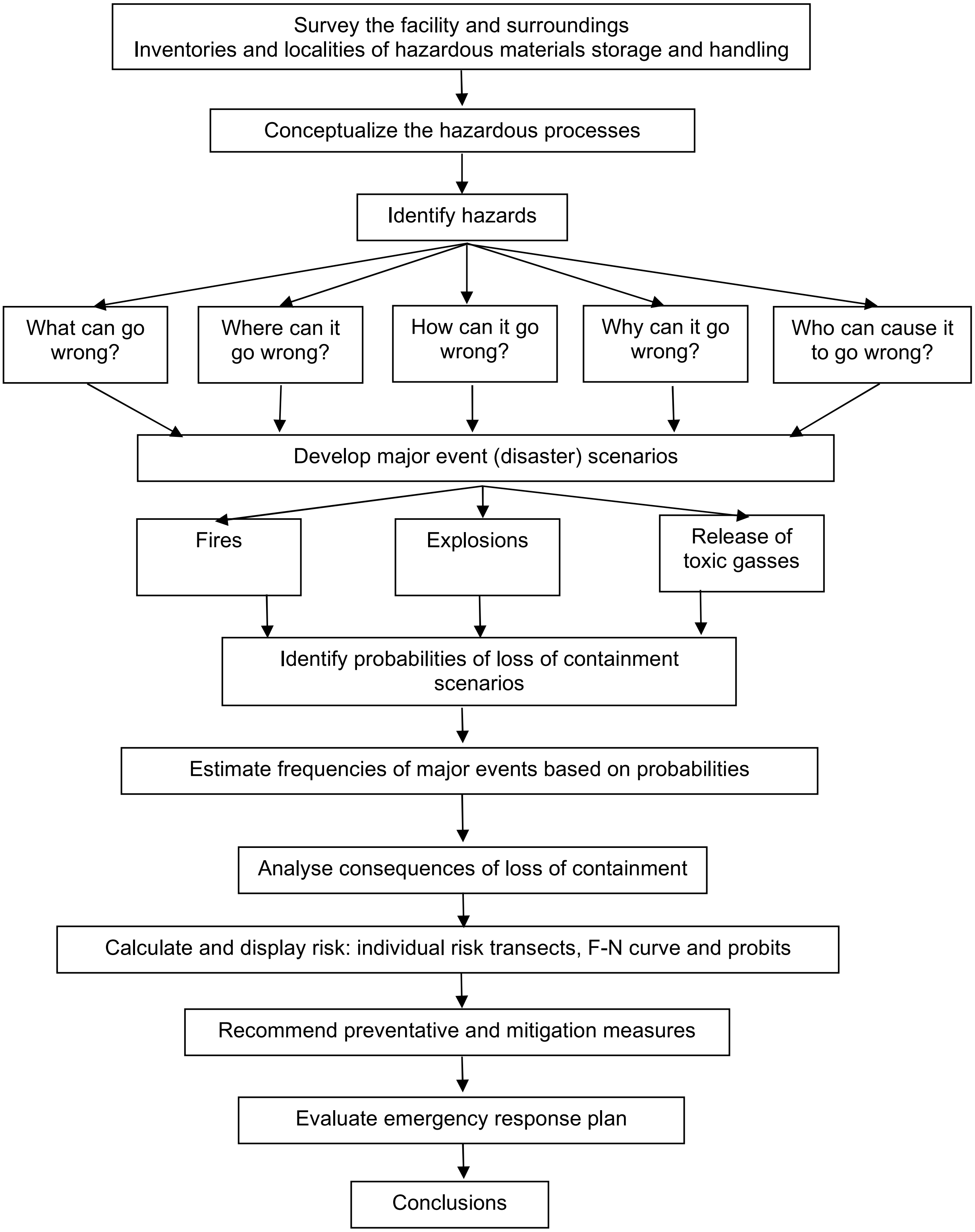
	effects or symptoms which could impair an individual's ability to take protective action.
ERPG-3	ERPG-3 is the most serious maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
Event	An occurrence (a condition or situation) that is caused by a fault and that can trigger a major incident. This is best explained by means of an example: A leak in a storage tank that contains a flammable liquid is an event. The leak was caused by corrosion (the fault). If the leaking liquid is set alight, a fire will start, which would be a major incident, because it can cause injury or death due to thermal radiation or an explosion.
FMECA	Failure mode effect and criticality analysis
FP	Flash point
HAZAN	Hazard analysis
HAZID	Hazard identification
Human impact	The effect that a major incident could have on human beings, whether they are present inside the facility or whether they are present beyond the facility boundaries within the surrounding community, including minor injury, major injury and fatality and the destructive effect on assets.
HFO	Heavy fuel oil or heavy furnace oil
IBC	Intermediate bulk container
ERPG	Immediately dangerous to life or health. It is defined by the US National Institute for Occupational Safety and Health as exposure to airborne contaminants that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.
IZ	Inner zone
LFO	Light fuel oil
LOC	Loss of containment
LOPA	Layer of protection analysis
LPG	Liquefied petroleum gas
Major incident	An occurrence of catastrophic proportions, resulting from the use of facility or machinery, or from activities at a work place. A “catastrophic occurrence” is interpreted [28] as an occurrence (incident), which can be fatal, disastrous, of definite threat to the

	health and lives of employees and members of the public. It is important to note that human lives (injury, fatal or not) as well as assets (damage) are included in this definition.
MHI	Major hazard installation
MOP	Mean operating pressure
MZ	Middle zone
NIOSH	US National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration, USA
OHS Act	Occupational Health and Safety Act, 1993 (Act 85 of 1993)
OZ	Outer zone
PAC	Protective action criteria. These are essential components for planning and response to uncontrolled releases of hazardous chemicals. These criteria, combined with estimates of exposure, provide the information necessary to evaluate chemical release events for the purpose of taking appropriate protective actions to save lives. PAC values are inter alia based on the exposure limit values.
PADHI	Planning advice for developments near hazardous installations
Probit function	Mathematical probability unit function. The probit function is a statistical analysis method based on a binary response, such as death or no death, because of a specified threatening major incident. It is used, inter alia, for the modelling of major incidents that can cause human fatalities and is usually based on a linear probability regression estimate (probit) equation.
PRV	Pressure relieve valve
PSM	Process safety management
QRA	Quantitative risk assessment
Residual risk assessment	A quantitative assessment of the safety risks associated with a particular major hazard installation, after successful implementation of all organisational mitigation measures, assuming that these measures are infallible.
SANAS	South African National Accreditation System
SLOD	Significant likelihood of death
SLOT	Specified level of toxicity

TNT	Trinitrotoluene
UK HSE	United Kingdom’s Health and Safety Executive
VCE	Vapour cloud explosion

1 Introduction

1. The following quantitative risk assessment algorithm was followed:



2. This risk assessment focuses on the requirements of the Major Hazard Installation Regulations R.692 of 30 July 2001 issued in terms of the Occupational Health and Safety Act (Act No 85 of 1993) and SABS Standard SANS 1461:2018 Edition 1.

3. The risk assessment does not address the following aspects:

   - The storage and use of radioactive materials. The National Nuclear Regulatory Act (Act No 47 of 1999) governs this aspect.
   - The environmental impacts that the facility, or part of it, could have on the biophysical and socio-economic environment. The National Environmental Management Act, 1998 (Act No 107 of 1998) and the related EIA regulations govern this aspect.
   - Future development of residential, commercial, industrial or recreational areas around the site.
   - Future modifications that may be made to the pipeline and related equipment.

4. <u>Scope of the risk assessment</u>: This major hazard installation risk assessment has been conducted against the requirements of the following legal prescriptions:

   - The Major Hazard Installation (MHI) Regulations of 2001 under the Occupational Health and Safety Act, 1993 (Act 85 of 1993).
   - South African Bureau of Standards 1461:2018 Edition 1, Major Hazard installation – Risk Assessments.
   - The following hazardous materials are included in this risk assessment:

5. <u>Legal aspects</u>:

   a) Nature & Business Alliance Africa (Pty) Ltd conducts its risk assessments in accordance with a quality manual that complies with the requirements of the ISO/IEC-17020 Standards for Various Bodies Performing Inspections. Nature & Business Alliance Africa (Pty) Ltd is accredited by the South African National Accreditation System (SANAS) as a Type A Major Hazard Risk Installation Inspection Body (accreditation number MHI-0004).
   b) Nature & Business Alliance Africa (Pty) Ltd is registered by the Department of Employment and Labour as an Approved Inspection Authority (AIA) for toxic, flammable and explosive substances (registration number MHI-0002).
   c) This risk assessment specifically pertains to the facilities assessed in this report. Modifications or alterations made to the site, equipment, facilities or operating procedures and parameters after completion of this risk assessment are not covered by the assessment outcomes and are explicitly excluded. Nature & Business Alliance Africa (Pty) Ltd will not be liable for damage to any assets, injury to any persons or the death of any person as a direct result of the activities of the client or the client's

subcontractors, before, during and after the requested risk assessment has been conducted.

d) The risk assessment conducted by Nature & Business Alliance Africa (Pty) Ltd and the related findings are based on the circumstances, external factors and conditions that prevailed at the time when the study was conducted.

e) The risk assessment, related reports and all recommendations must not be interpreted as automatic safeguards against an incident that could lead to damage, injury or death and Nature & Business Alliance Africa (Pty) Ltd does not accept liability for such damage, injury or death.

f) Nature & Business Alliance Africa (Pty) Ltd retain copyright of this report. No part of the report may be copied or reproduced in any format without written approval from the author. If any part of the report is to be used for other work by another party, clear reference must be made to Nature & Business Alliance Africa (Pty) Ltd as the owner and copyright holder of the report.

g) It is declared that Nature & Business Alliance Africa (Pty) Ltd did not allow any form of external influencing of this assessment results, conclusions and recommendations, including undue time constraints imposed on the author, bribery, incentives offered to personnel and alterations made to this report. The submission of any draft report to the client does not grant the client the opportunity or the right to alter the findings, conclusions or recommendations in its favour in any way, without sound substantiation.

h) Nature & Business Alliance Africa (Pty) Ltd and Alfonso Niemand (the author) in particular, declare that the organization and its personnel are not related to the client or to its employees or contractors for this assignment. It is declared that the risk assessment report and the findings are unbiased and was not influenced by any commercial, financial or other pressures imposed on the organization or the author.

i) All information disclosed to us by the client or its contractors, are treated as confidential. The information contained in this study report will also be treated as confidential and will not be disclosed by the author to any party other than the client.

j) This report is valid for a period of 5 years, in accordance with the Major Hazard Installation Regulations, 2001.

6. <u>Methodologies used</u>:

a) Causal analysis and international failure data (BEVI and AIChE) were applied to determine the frequency of an event (fault) that could eventually lead to a major incident.

b) An event-tree analysis method was applied to determine the potential major incidents that could be the end result of the event, with its frequency. The logic is explained as follows:

c) The frequency of occurrence of a major incident was calculated, based on analysis of international historical data for similar incidents. Similar data does not exist for South African industry.
d) The toxicity, flammability and explosivity potential of liquid and gas releases were evaluated by means of internationally accepted mathematical modeling techniques [1, 2, 3 and 18].
e) Toxic releases were modeled by means of the ALOHA mathematical dispersion model [3] of the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the USA.
f) Heat radiation flux caused by a fire was simulated by means of the equations proposed by *Mudan* and *Groce* [1, p243].
g) The overpressure blast effects of vapour cloud explosions and solid explosions were simulated by means of the trinitrotoluene (TNT) equivalency methods described by *Baker et al, Decker, Lees* and *Stull* [1, p174].
h) Meteorological tendencies at the site were taken into consideration.
i) Individual and societal risks were assessed, based on the frequencies of major incidents, minimum safety distances and the predicted number of potential fatalities.
j) The occurrence and effect of a boiling liquid expanding vapour explosion (BLEVE) was modeled based on work done by the Centre for Chemical Process Safety of the American Institute of Chemical Engineers.
k) The frequency of occurrence of a major incident was calculated based on analysis of international historical data for similar incidents in Europe and the USA. Similar data does not exist for South African industry.

2 Descriptions

1. Company's main activities and products

Brother CISA (Pty) Ltd operates a chrome chemicals production facility at the Newcastle Chemical Park, in Newcastle, KwaZulu Natal. The facility produces sodium dichromate (SDC) and various related chrome chemicals and by-products.

Brother CISA proposes to expand its existing product range to include chrome tanning salts (CTS). It is intended to establish an inorganic and an organic process producing 50 000 t/a and 30 000 t/a each respectively, as well as synthetic vitamin K of 2 000 t/a. One of the primary raw materials of for producing these is sodium dichromate (SDC) coming from the existing operations.

The manufacture of inorganic CTS involves the reaction of Sodium Dichromate (SDC) and Sulphur Dioxide gas (SO_2). The SO_2 gas is generated from burning sulphur in a furnace. The SO_2 gas from the burner is fed into a set of absorption columns where it reacts with, and reduces the SDC, to form CTS. This produces a CTS liquor which is then dried to form a powder which is bagged and/or stored as product.

To manufacture organic CTS and synthetic vitamin K, methyl-naphthalene and sulphuric acid are mixed with SDC to produce crystalline menadione. This is subsequently dissolved with heptane and sulphonated to produce menadione-sodium-bisulphite (MSB). It is a water-soluble form of menadione, which belongs to the Vitamin K class of compounds. A portion of the MSB is then purified, dried and packaged, and the remainder is converted to menadione-nicotinamide-bisulphite (MNB). MNB is subsequently purified, dried and packaged. MNB is a bioactive source of vitamin K.

Sodium sulphate recovered as a by-product of the above is then used to produce organic CTS. The sodium sulphate is mixed with SDC, glycol, and sulphuric acid to produce CTS solution. The solution is concentrated by evaporation, mixed with further sodium sulphate and then dried and packaged.

2. Non-technical process description

Table 2.1: Hazardous material inventory

No T1 Updated	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	Sulphur dioxide liquid	1079 7446-09-5	2.3	60 m3 (84 000 kg)	80 m2	60 m3 every two weeks	84 000 kg
2	Ammonia liquid	1005 7664-41-7	2.3	850 kg One compressor; 12 barg	-	Closed system	850 kg
3	Carbon dioxide	1013 124-38-9	2	Two tanks of 25 m3; 17 barg	-	Own production and storage	25 m3
4	Methane via pipeline (natural gas)	1971 74-82-8	2.1	150-mm pipeline; 6.25 barg to kiln	-	6 000 nm3 per hour	150-mm hole for 10 minutes
5	Steam boiler	-	-	25 m3; 21 barg	-	-	-
6	Compressed air vessels	-	-	Three tanks of 5.3 m3; each 8 barg	-	-	-
7	Liquid sulphur storage tank (molten)	2448 7704-34-9	4.1	80 000 liters	45 m2	30 tons per day	80 000 liters
8	Liquid sulphur road tanker (molten)	2448 7704-34-9	4.1	20 000 liters	-	30 tons per day	20 000 liters
9	Methyl naphthalene storage tank	1760 91-20-3	4.1	200 000 liters	120 m2	10 tons per day	200 000 liters
10	Methyl naphthalene road tanker	1760 91-20-3	4.1	20 000 liters	-	10 tons per day	20 000 liters
11	n-Heptane storage tank	1206 142-82-5	3	50 000 liters	80 m2	45 000 liters every six months	50 000 liters
12	n-Heptane road tanker	1206 142-82-5	3	20 000 liters	-	20 000 liters every six months	20 000 liters
13	Hydrogen storage tank	1049 1333-74-0		37 m^3 at a pressure of 0.5 barg.	-	3 m3 per day	37 m3

3. Simplified block/process flow diagram

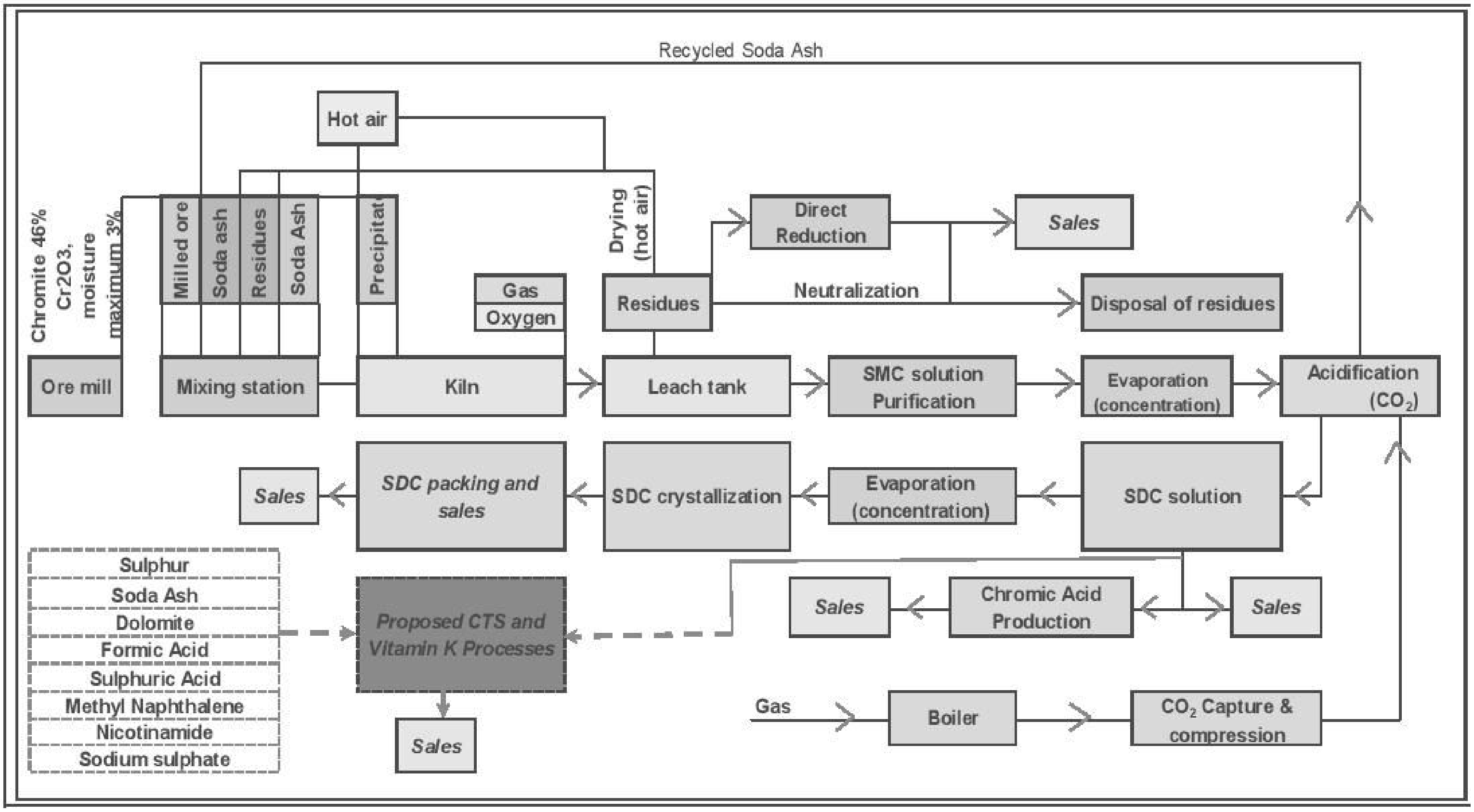


Figure 2.1: Process description

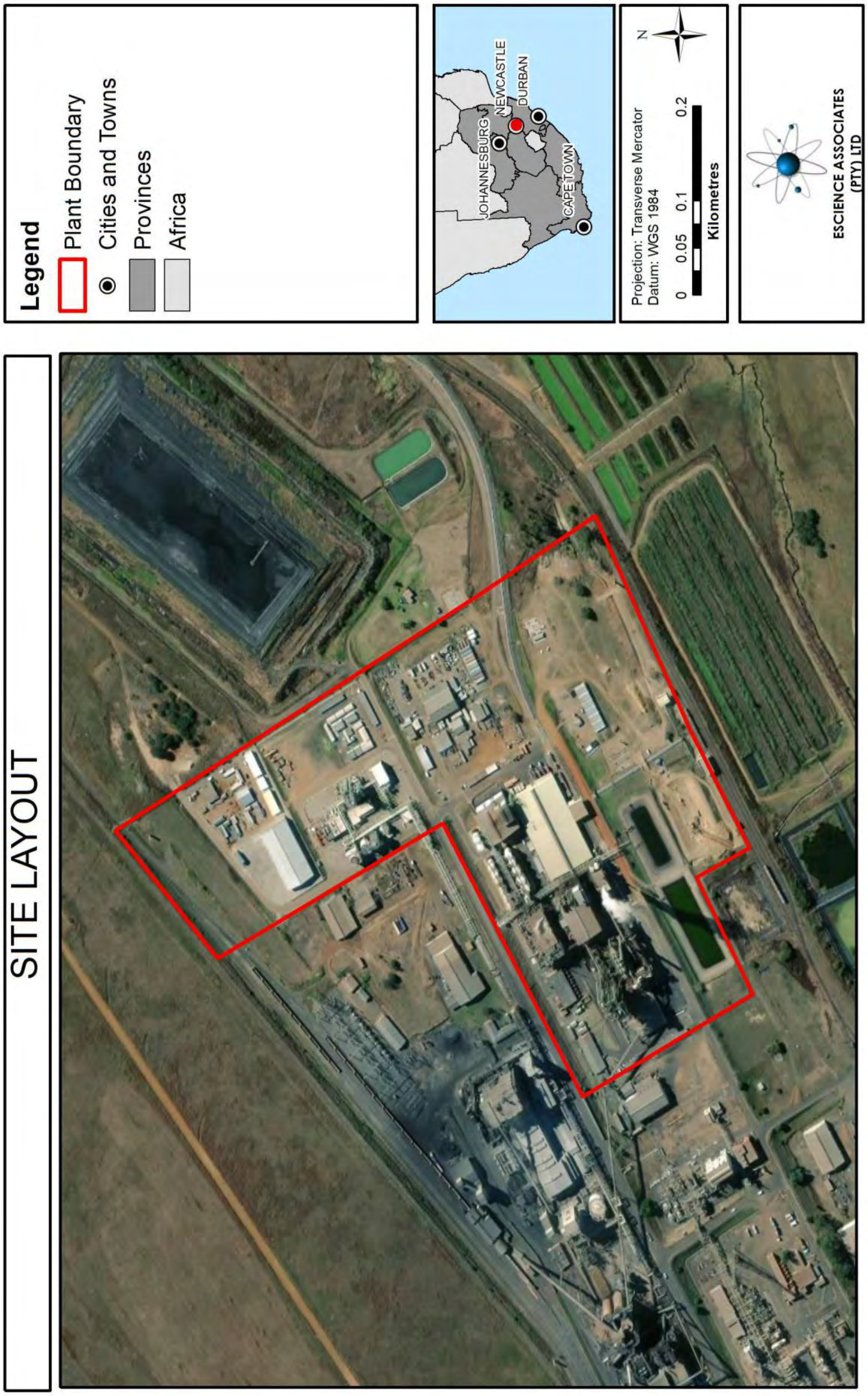


Figure 2.2: Site lay-out plan (courtesy EScience Associates)

Figure 2.3: Aerial view of the site

4. Details of neighbouring facilities including other hazardous installations in the vicinity, sources of additional risk (for example, flight paths, natural hazards) and vulnerable developments/sensitive receptors

No	Adjacent facility	Safe separation distance, m	MHI status of neighbours
1	Medium-density residential	2 150	Not MHI
2	Newcastle Airfield	1 150	Not MHI
3	Karbochem boiler plant	315	Not MHI
4	Undeveloped land	400	Not MHI
5	Undeveloped land	890	Not MHI
6	Undeveloped land	1 200	Not MHI

Figure 2.4: Aerial view of adjacent facilities

5. Relevant local meteorology

SA Weather station	**Wind direction**	**Wind speed m/s**	**Wind calm %**	**Precipitation mm**	**Cloud cover %**	**Ambient temperature ^{0}C**
Newcastle	E	11	15	300	40	14-16

Lightning: 8 to 9 strikes per square kilometer (10^6 m^2) per year.

Table 2.1: Pasquill atmospheric stability classification

Surface wind speed in m/s	Daytime conditions			**Night time conditions**	
	Strong sunlight Cloudiness <10%	Moderate sunlight Cloudiness <50%	Slight sunlight Cloudiness >50%	Cloudiness >50% **	Cloudiness <50% **
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D
A	Extremely unstable conditions (calm wind, clear sky, hot daytime)				
B	Moderately unstable conditions (clear sky, daytime)				
C	Slightly unstable conditions (moderate wind, slightly overcast, daytime)				
D	Neutral conditions * (high winds, cloudy, day or night)				
E	Slightly stable conditions (moderate wind, slightly overcast, night time)				
F	Moderately stable conditions (low winds, clear sky, cold, night time)				
* Applicable to heavy overcast conditions, day or night					
** Degree of cloudiness: Fraction of sky above the horizon covered by clouds					

6. Relevant topography of the area (*red ovals indicate qualitatively where heavy gas and smoke may settle during wind-still times; not to scale)*

Elevation from East (R) to West (L)

Elevation from North (L) to South (R)

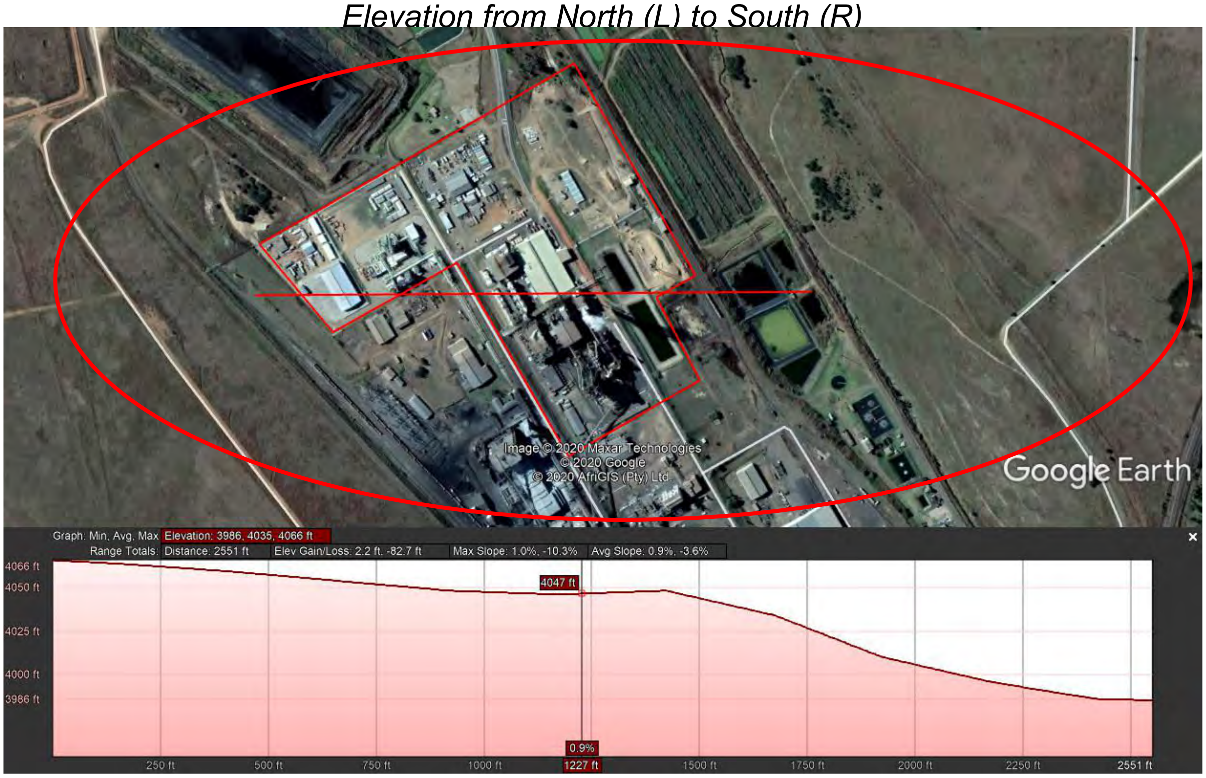


Figure 2.5: Topography of the site

3 Hazard identification

1. Inventory of hazardous materials on site: (Name, UN/CASRN number, inventories, through-put (or batches) and maximum release quantities, SANS 10228 category)

Table 3.1: Hazardous material inventory

No T1 Updated	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	Sulphur dioxide liquid	1079 7446-09-5	2.3	60 m3 (84 000 kg)	80 m2	60 m3 every two weeks	84 000 kg
2	Ammonia liquid	1005 7664-41-7	2.3	850 kg One compressor; 12 barg	-	Closed system	850 kg
3	Carbon dioxide	1013 124-38-9	2	Two tanks of 25 m3; 17 barg	-	Own production and storage	25 m3
4	Methane via pipeline (natural gas)	1971 74-82-8	2.1	150-mm pipeline; 6.25 barg to kiln	-	6 000 nm3 per hour	150-mm hole for 10 minutes
5	Steam boiler	-	-	25 m3; 21 barg	-	-	-
6	Compressed air vessels	-	-	Three tanks of 5.3 m3; each 8 barg	-	-	-
7	Liquid sulphur storage tank (molten)	2448 7704-34-9	4.1	80 000 liters	45 m2	30 tons per day	80 000 liters
8	Liquid sulphur road tanker (molten)	2448 7704-34-9	4.1	20 000 liters	-	30 tons per day	20 000 liters
9	Methyl naphthalene storage tank	1760 91-20-3	4.1	200 000 liters	120 m2	10 tons per day	200 000 liters
10	Methyl naphthalene road tanker	1760 91-20-3	4.1	20 000 liters	-	10 tons per day	20 000 liters
11	n-Heptane storage tank	1206 142-82-5	3	50 000 liters	80 m2	45 000 liters every six months	50 000 liters
12	n-Heptane road tanker	1206 142-82-5	3	20 000 liters	-	20 000 liters every six months	20 000 liters
13	Hydrogen storage tank	1049 1333-74-0		37 m^3 at a pressure of 0.5 barg.	-	3 m3 per day	37 m3

2. <u>The relevant physical, chemical and toxicological characteristics of the materials, mixtures, reactions; both under normal and foreseeable abnormal conditions</u>

Table 3.2: Characteristics of the hazardous materials

No	Name	Hazard
1	Sulphur dioxide liquid	Toxic effect of gas cloud
2	Ammonia liquid	Toxic effect of gas cloud
3	Carbon dioxide gas	Suffocating effect of gas cloud
4	Methane	Jet fire VCE
5	Boiler	Pressure burst
6	Compressed air vessels	Pressure burst
7	Liquid sulphur	Pool fire Toxic effect of sulphur dioxide combustion gas cloud
8	Methyl naphthalene	Toxic effect of gas cloud
9	n-Heptane	Jet fire VCE
10	Hydrogen	Jet fire VCE

3. Key reactions especially any exothermic reactions or reactive chemicals

- Methyl naphthalene may react violently with oxidizers in an exothermal reaction.
- Ammonia may react with compressor oil to create a fire or explosive cloud mixture.

4. License restrictions (for example, flammables)

A flammable certificate may be required from the local authority.

5. Significant accidents and incidents that have occurred at the installation with lessons learned and measures implemented to prevent re-occurrence

None recorded.

6. Major accidents and incidents at related facilities or with related materials (case study)

Refer to Appendix 2.

7. Containment systems for analysis (major equipment considering control systems and blocking systems)

- The liquid sulphur dioxide storage tank is equipped with a deluge system inside a bund, in case of a leak, which is linked to an alarm at the central security office.
- The ammonia engine room is equipped with a detector, linked to an alarm at the central security office.
- The molten sulphur storage tank is mounted inside a bund and equipped with a deluge system in case of a leak, linked to an alarm at the central security office.

8. Description of safety systems, equipment and devices used for prevention and mitigation of major incidents

- The liquid sulphur dioxide storage tank is equipped with a deluge system inside a bund, in case of a leak, which is linked to an alarm at the central security office.
- The ammonia engine room is equipped with a detector, linked to an alarm at the central security office.
- The molten sulphur storage tank is mounted inside a bund and equipped with a deluge system in case of a leak, linked to an alarm at the central security office.

4 Hazard analysis

a) <u>Scenarios to be modelled for each containment system</u>

The minimum scenarios to be identified and modelled are listed in Table 4.1 below, in accordance with SANS 1461:

Table 4.1: Mandatory minimum scenarios to be modelled

Equipment type	***Scenario***
A *Fixed storage or processing units classified as pressure vessels (for example, reactors, storage spheres) and pressurized transport units (for example, pressurized road tankers, cylinders)*	*1) Catastrophic rupture with instantaneous failure (including a boiling liquid expanding vapour explosion (BLEVE where applicable).* *2) Entire contents released in 10 min or large hole in the processing unit (a large hole is typically the size of the largest appurtenance on the processing unit).* *3) Small hole in vessel (leak typically 10 mm diameter).* *4) Pressure safety valve release (if applicable).*
B *Fixed storage or processing units at atmospheric pressure or lower (for example, tanks, blending vessels) and atmospheric transport units (for example, standard road tankers, intermediate bulk containers (IBCs)*	*1) Catastrophic rupture (with bund overtopping if necessary).* *2) Entire contents released in 10 min or large hole in the processing unit (a large hole is typically the size of the largest appurtenance on the processing unit).* *3) Small hole in vessel (leak typically 10 mm diameter).* *4) Overfilling (if applicable).*
C *Pipe, hose, arm (onsite pipelines)*	*1) Pipeline, hose, arm full bore rupture.* *2) Small hole in pipeline, hose, arm (typically a leak with effective diameter of 10 % to 50 % of the pipeline diameter).*
D *Pipe (cross country pipelines) (refer also to Clause 7 of this standard)*	*1) Pipeline full bore rupture.* *2) Small hole in pipeline (leak as in accordance with Clause 5).*
NOTE *If the scenarios given in this table are not in the risk assessment, justification for their exclusion should be provided in the assessment report.*	

The hazard scenarios applicable to this site are as follows:

- Sulphur dioxide liquid: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Ammonia liquid: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Carbon dioxide gas: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Methane: leak from 50-mm hole; leak from 10-mm hole.
- Boiler: Pressure burst.
- Compressed air vessels: Pressure burst.
- Liquid sulphur: pool fire.
- Methyl naphthalene: toxic aerosol cloud.
- n-Heptane: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Hydrogen: full loss; leak from 50-mm hole; leak from 10-mm hole.

b) Description of specific postulated causes for the various major hazard scenarios or groups of scenarios

- All storage tanks
    - Mechanical damage to the tank or pipe work.
    - Workers not trained in the operation of the tank, pump, valves and filler pipe.
    - Poor maintenance of the tank such as corrosion protection, flange integrity, valve integrity, pump and seal and pipe integrity.
    - Degradation of the tank from internal and external corrosion and negligence regarding tanker inspections.
    - Human error regarding maintenance or operation.
    - Operation of equipment beyond design parameters such as overfilling of the tank.

- All road tankers
    - Mechanical damage to the tanker or pipe work.
    - Workers not trained in the operation of the delivery tanker, pump, valves and filler pipe.
    - Poor maintenance of the tanker such as corrosion protection, flange integrity, valve integrity, pump and seal and pipe integrity.
    - Degradation of the tanker from internal and external corrosion and negligence regarding tanker inspections.
    - Human error regarding maintenance or operation.
    - Operation of equipment beyond design parameters such as overfilling of the road tanker at the supply depot.
    - Road tanker collisions on site with other vehicles or stationary objects.

5 Consequence analysis

Table 5.1: Hazardous material inventory

No T1 Updated	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	Sulphur dioxide liquid	1079 7446-09-5	2.3	60 m3 (84 000 kg)	80 m2	60 m3 every two weeks	84 000 kg
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4	Methane via pipeline (natural gas)	1971 74-82-8	2.1	150-mm pipeline; 6.25 barg to kiln	-	6 000 nm3 per hour	150-mm hole for 10 minutes
5	Steam boiler	-	-	25 m3; 21 barg	-	-	-
6	Compressed air vessels	-	-	Three tanks of 5.3 m3; each 8 barg	-	-	-
7	Liquid sulphur storage tank (molten)	2448 7704-34-9	4.1	80 000 liters	45 m2	30 tons per day	80 000 liters
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11	n-Heptane storage tank	1206 142-82-5	3	50 000 liters	80 m2	45 000 liters every six months	50 000 liters
12	n-Heptane road tanker	1206 142-82-5	3	20 000 liters	-	20 000 liters every six months	20 000 liters
13	Hydrogen storage tank	1049 1333-74-0		37 m^3 at a pressure of 0.5 barg.	-	3 m3 per day	37 m3

1. Indication of scenarios for consequence analysis and those included in the calculation of risk

- Sulphur dioxide liquid: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Ammonia liquid: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Carbon dioxide gas: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Methane: leak from 50-mm hole; leak from 10-mm hole.
- Boiler: Pressure burst.
- Compressed air vessels: Pressure burst.
- Liquid sulphur: pool fire.
- Methyl naphthalene: toxic aerosol cloud.
- n-Heptane: full loss; leak from 50-mm hole; leak from 10-mm hole.
- Hydrogen: full loss; leak from 50-mm hole; leak from 10-mm hole.

2. Relevant key process data for each major hazard scenario

Refer to the raw data in Annexure 1 and the model inputs below.

3. Consequences modelled

a) Sulphur dioxide liquid in storage tank: full loss

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: SULFUR DIOXIDE
  CAS NUMBER: 7446-9-5              MOLECULAR WEIGHT: 64.06 G/MOL
  AEGL-1 (60 MIN): 0.2 PPM   AEGL-2 (60 MIN): 0.75 PPM   AEGL-3 (60 MIN): 30 PPM
  IDLH: 100 PPM
  AMBIENT BOILING POINT: -22.9° C
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 84000 KILOGRAMS        SOURCE HEIGHT: 0
  RELEASE DURATION: 1 MINUTE
  RELEASE RATE: 1,400 KILOGRAMS/SEC
  TOTAL AMOUNT RELEASED: 84,000 KILOGRAMS
  NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.

 THREAT ZONE:
  MODEL RUN: HEAVY GAS
  RED: GREATER THAN 10 KILOMETERS --- (30 PPM = AEGL-3 [60 MIN])
  ORANGE: GREATER THAN 10 KILOMETERS --- (0.75 PPM = AEGL-2 [60 MIN])
  YELLOW: GREATER THAN 10 KILOMETERS --- (0.2 PPM = AEGL-1 [60 MIN])
```

b) Sulphur dioxide liquid in storage tank: leak from 50-mm hole for 10 minutes

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:		
Heat capacity ratio of gas:	1.15	
Hole size:	50	mm
Upstream pressure:	4	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	64	

Excess Head Loss Factors:	
Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:		
Hole area:	0.001963495	m**2
Upstream gas density:	10.33	kg/m**3
Expansion factor, Y:	0.614	
Actual pressure ratio:	0.75	

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	1.86	1.70	1.53	bar
Mass flow:	2.0729	2.1468	2.2259	kg/s

Interpolation table:	1.2	2.07290729
	1.4	2.146836252

Interpolated mass flow:	2.054425	kg/s
Gas release in 60 minutes	7395.9	kg
Gas release in 10 minutes	1232.7	kg

```
SITE DATA:
   LOCATION: NEWCASTLE, SOUTH AFRICA
   BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
   CHEMICAL NAME: SULFUR DIOXIDE
   CAS NUMBER: 7446-9-5                  MOLECULAR WEIGHT: 64.06 G/MOL
   AEGL-1 (60 MIN): 0.2 PPM   AEGL-2 (60 MIN): 0.75 PPM   AEGL-3 (60 MIN): 30 PPM
   IDLH: 100 PPM
   AMBIENT BOILING POINT: -22.9° C
   VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
   AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   WIND: 11 METERS/SECOND FROM E AT 3 METERS
   GROUND ROUGHNESS: OPEN COUNTRY         CLOUD COVER: 5 TENTHS
   AIR TEMPERATURE: 25° C                STABILITY CLASS: D
   NO INVERSION HEIGHT                   RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
   DIRECT SOURCE: 2.05 KILOGRAMS/SEC      SOURCE HEIGHT: 0
   RELEASE DURATION: 60 MINUTES
   RELEASE RATE: 123 KILOGRAMS/MIN
   TOTAL AMOUNT RELEASED: 7,380 KILOGRAMS
   NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.

 THREAT ZONE:
   MODEL RUN: HEAVY GAS
   RED: 681 METERS --- (30 PPM = AEGL-3 [60 MIN])
   ORANGE: 4.7 KILOMETERS --- (0.75 PPM = AEGL-2 [60 MIN])
   YELLOW: 9.4 KILOMETERS --- (0.2 PPM = AEGL-1 [60 MIN])
```

c) Sulphur dioxide liquid in storage tank: leak from 10-mm hole

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:

Heat capacity ratio of gas:	1.15	
Hole size:	10	mm
Upstream pressure:	4	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	64	

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	7.85398E-05	m**2
Upstream gas density:	10.33	kg/m**3
Expansion factor, Y:	0.614	
Actual pressure ratio:	0.75	

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	1.86	1.70	1.53	bar
Mass flow:	0.0829	0.0859	0.0890	kg/s

Interpolation table:		
	1.2	0.082916292
	1.4	0.08587345

Interpolated mass flow:	0.082177	kg/s
Gas release in 60 minutes	295.8	kg
Gas release in 10 minutes	49.3	kg

SITE DATA:
LOCATION: NEWCASTLE, SOUTH AFRICA
BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

CHEMICAL DATA:
CHEMICAL NAME: SULFUR DIOXIDE
CAS NUMBER: 7446-9-5 MOLECULAR WEIGHT: 64.06 G/MOL
AEGL-1 (60 MIN): 0.2 PPM AEGL-2 (60 MIN): 0.75 PPM AEGL-3 (60 MIN): 30 PPM
IDLH: 100 PPM
AMBIENT BOILING POINT: -22.9° C
VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
WIND: 11 METERS/SECOND FROM E AT 3 METERS
GROUND ROUGHNESS: OPEN COUNTRY CLOUD COVER: 5 TENTHS
AIR TEMPERATURE: 25° C STABILITY CLASS: D
NO INVERSION HEIGHT RELATIVE HUMIDITY: 50%

SOURCE STRENGTH:
DIRECT SOURCE: 0.082 KILOGRAMS/SEC SOURCE HEIGHT: 0
RELEASE DURATION: 60 MINUTES
RELEASE RATE: 4.92 KILOGRAMS/MIN
TOTAL AMOUNT RELEASED: 295 KILOGRAMS
NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.

THREAT ZONE:
MODEL RUN: HEAVY GAS
RED: 127 METERS --- (30 PPM = AEGL-3 [60 MIN])
ORANGE: 878 METERS --- (0.75 PPM = AEGL-2 [60 MIN])
YELLOW: 1.8 KILOMETERS --- (0.2 PPM = AEGL-1 [60 MIN])

d) Ammonia liquid: full loss

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: AMMONIA
  CAS NUMBER: 7664-41-7              MOLECULAR WEIGHT: 17.03 G/MOL
  AEGL-1 (60 MIN): 30 PPM   AEGL-2 (60 MIN): 160 PPM   AEGL-3 (60 MIN): 1100 PPM
  IDLH: 300 PPM      LEL: 150000 PPM     UEL: 280000 PPM
  AMBIENT BOILING POINT: -45.1° C
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 850 KILOGRAMS         SOURCE HEIGHT: 0
  RELEASE DURATION: 1 MINUTE
  RELEASE RATE: 14.2 KILOGRAMS/SEC
  TOTAL AMOUNT RELEASED: 850 KILOGRAMS
  NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.
    USE BOTH DISPERSION MODULES TO INVESTIGATE ITS POTENTIAL BEHAVIOR.

 THREAT ZONE:
  MODEL RUN: GAUSSIAN
  RED: 377 METERS --- (1100 PPM = AEGL-3 [60 MIN])
  ORANGE: 1.2 KILOMETERS --- (160 PPM = AEGL-2 [60 MIN])
  YELLOW: 2.7 KILOMETERS --- (30 PPM = AEGL-1 [60 MIN])
```

e) Ammonia liquid: leak from 50-mm hole

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:

Heat capacity ratio of gas:	1.15	
Hole size:	50	mm
Upstream pressure:	4	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	17	

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	0.001963495	m**2
Upstream gas density:	2.74	kg/m**3
Expansion factor, Y:	0.614	
Actual pressure ratio:	0.75	<-- Must be greater than sonic pressure ratio below to insure sonic flow.

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	1.86	1.70	1.53	bar
Mass flow:	1.0684	1.1065	1.1472	kg/s

Interpolation table:	1.2	1.068351964
	1.4	1.106454078

Interpolated mass flow:	1.058826	kg/s
Gas release in 60 minutes	3811.8	kg
Gas release in 10 minutes	635.3	kg

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: AMMONIA
  CAS NUMBER: 7664-41-7              MOLECULAR WEIGHT: 17.03 G/MOL
  AEGL-1 (60 MIN): 30 PPM   AEGL-2 (60 MIN): 160 PPM   AEGL-3 (60 MIN): 1100 PPM
  IDLH: 300 PPM     LEL: 150000 PPM     UEL: 280000 PPM
  AMBIENT BOILING POINT: -45.1° C
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 1.0588 KILOGRAMS/SEC    SOURCE HEIGHT: 0
  RELEASE DURATION: 60 MINUTES
  RELEASE RATE: 63.5 KILOGRAMS/MIN
  TOTAL AMOUNT RELEASED: 3,812 KILOGRAMS
  NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.
    USE BOTH DISPERSION MODULES TO INVESTIGATE ITS POTENTIAL BEHAVIOR.

 THREAT ZONE:
  MODEL RUN: GAUSSIAN
  RED: 94 METERS --- (1100 PPM = AEGL-3 [60 MIN])
  ORANGE: 262 METERS --- (160 PPM = AEGL-2 [60 MIN])
  YELLOW: 669 METERS --- (30 PPM = AEGL-1 [60 MIN])
```

f) Ammonia liquid: leak from 10-mm hole

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:		
Heat capacity ratio of gas:	1.15	
Hole size:	10	mm
Upstream pressure:	4	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	17	

Excess Head Loss Factors:	
Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:		
Hole area:	7.85398E-05	m**2
Upstream gas density:	2.74	kg/m**3
Expansion factor, Y:	0.614	

Actual pressure ratio: 0.75 <-- Must be greater than sonic pressure ratio below to insure sonic flow.

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	1.86	1.70	1.53	bar
Mass flow:	0.0427	0.0443	0.0459	kg/s

Interpolation table:		
	1.2	0.042734079
	1.4	0.044258163

Interpolated mass flow:	0.042353	kg/s
Gas release in 60 minutes	152.5	kg
Gas release in 10 minutes	25.4	kg

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: AMMONIA
  CAS NUMBER: 7664-41-7             MOLECULAR WEIGHT: 17.03 G/MOL
  AEGL-1 (60 MIN): 30 PPM   AEGL-2 (60 MIN): 160 PPM   AEGL-3 (60 MIN): 1100 PPM
  IDLH: 300 PPM      LEL: 150000 PPM     UEL: 280000 PPM
  AMBIENT BOILING POINT: -45.1° C
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 0.0424 KILOGRAMS/SEC    SOURCE HEIGHT: 0
  RELEASE DURATION: 60 MINUTES
  RELEASE RATE: 2.54 KILOGRAMS/MIN
  TOTAL AMOUNT RELEASED: 153 KILOGRAMS
  NOTE: THIS CHEMICAL MAY FLASH BOIL AND/OR RESULT IN TWO PHASE FLOW.
    USE BOTH DISPERSION MODULES TO INVESTIGATE ITS POTENTIAL BEHAVIOR.

 THREAT ZONE:
  MODEL RUN: GAUSSIAN
  RED: 19 METERS --- (1100 PPM = AEGL-3 [60 MIN])
  NOTE: THREAT ZONE WAS NOT DRAWN BECAUSE EFFECTS OF NEAR-FIELD
PATCHINESS
    MAKE DISPERSION PREDICTIONS LESS RELIABLE FOR SHORT DISTANCES.
  ORANGE: 49 METERS --- (160 PPM = AEGL-2 [60 MIN])
  NOTE: THREAT ZONE WAS NOT DRAWN BECAUSE EFFECTS OF NEAR-FIELD
PATCHINESS
    MAKE DISPERSION PREDICTIONS LESS RELIABLE FOR SHORT DISTANCES.
  YELLOW: 116 METERS --- (30 PPM = AEGL-1 [60 MIN])
```

g) Carbon dioxide gas: full loss from large tank (25 m3; 27 500 kg)

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

SITE DATA:
LOCATION: NEWCASTLE, SOUTH AFRICA
BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

CHEMICAL DATA:
CHEMICAL NAME: CARBON DIOXIDE
CAS NUMBER: 124-38-9 MOLECULAR WEIGHT: 44.01 G/MOL
IDLH: 40000 PPM
NORMAL BOILING POINT: -UNAVAIL-
VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%
NOTE: NOT ENOUGH CHEMICAL DATA TO USE HEAVY GAS OPTION

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
WIND: 11 METERS/SECOND FROM E AT 3 METERS
GROUND ROUGHNESS: OPEN COUNTRY CLOUD COVER: 5 TENTHS
AIR TEMPERATURE: 25° C STABILITY CLASS: D
NO INVERSION HEIGHT RELATIVE HUMIDITY: 50%

SOURCE STRENGTH:
DIRECT SOURCE: 27500 KILOGRAMS SOURCE HEIGHT: 0
RELEASE DURATION: 1 MINUTE
RELEASE RATE: 458 KILOGRAMS/SEC
TOTAL AMOUNT RELEASED: 27,500 KILOGRAMS

THREAT ZONE:
MODEL RUN: GAUSSIAN
RED: 211 METERS --- (40000 PPM = IDLH)

h) Carbon dioxide gas: leak from 50-mm hole

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:

Heat capacity ratio of gas:	1.15	
Hole size:	50	mm
Upstream pressure:	32	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	44	

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	0.001963495	m**2
Upstream gas density:	56.83	kg/m**3
Expansion factor, Y:	0.614	
Actual pressure ratio:	0.97	<-- Must be greater than sonic pressure ratio below to insure sonic flow.

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	14.85	13.61	12.23	bar
Mass flow:	13.7501	14.2405	14.7649	kg/s

Interpolation table:	1.2	13.75011141
	1.4	14.24050067

Interpolated mass flow:	13.627514	kg/s
Gas release in 60 minutes	49059.1	kg
Gas release in 10 minutes	8176.5	kg

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: CARBON DIOXIDE
  CAS NUMBER: 124-38-9                MOLECULAR WEIGHT: 44.01 G/MOL
  IDLH: 40000 PPM
  NORMAL BOILING POINT: -UNAVAIL-
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%
  NOTE: NOT ENOUGH CHEMICAL DATA TO USE HEAVY GAS OPTION

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 13.63 KILOGRAMS/SEC     SOURCE HEIGHT: 0
  RELEASE DURATION: 60 MINUTES
  RELEASE RATE: 818 KILOGRAMS/MIN
  TOTAL AMOUNT RELEASED: 49,068 KILOGRAMS

 THREAT ZONE:
  MODEL RUN: GAUSSIAN
  RED: 34 METERS --- (40000 PPM = IDLH)
  NOTE: THREAT ZONE WAS NOT DRAWN BECAUSE EFFECTS OF NEAR-FIELD
PATCHINESS
    MAKE DISPERSION PREDICTIONS LESS RELIABLE FOR SHORT DISTANCES.
```

i) Carbon dioxide gas: leak from 10-mm hole

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:

Heat capacity ratio of gas:	1.15	
Hole size:	10	mm
Upstream pressure:	32	bar abs
Downstream pressure:	1.01	bar abs
Temperature:	298	K
Gas molecular weight:	44	

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	7.85398E-05	m**2
Upstream gas density:	56.83	kg/m**3
Expansion factor, Y:	0.614	
Actual pressure ratio:	0.97	<-- Must be greater than sonic pressure ratio below to insure sonic flow.

Heat capacity ratio, k:	1.2	1.4	1.67	
Sonic pressure ratios:	0.536	0.575	0.618	
Choked pressure:	14.85	13.61	12.23	bar
Mass flow:	0.5500	0.5696	0.5906	kg/s

Interpolation table:		
	1.2	0.550004457
	1.4	0.569620027

Interpolated mass flow:	0.545101	kg/s
Gas release in 60 minutes	1962.4	kg
Gas release in 10 minutes	327.1	kg

```
SITE DATA:
  LOCATION: NEWCASTLE, SOUTH AFRICA
  BUILDING AIR EXCHANGES PER HOUR: 2.30 (UNSHELTERED SINGLE STORIED)

 CHEMICAL DATA:
  CHEMICAL NAME: CARBON DIOXIDE
  CAS NUMBER: 124-38-9               MOLECULAR WEIGHT: 44.01 G/MOL
  IDLH: 40000 PPM
  NORMAL BOILING POINT: -UNAVAIL-
  VAPOR PRESSURE AT AMBIENT TEMPERATURE: GREATER THAN 1 ATM
  AMBIENT SATURATION CONCENTRATION: 1,000,000 PPM OR 100.0%
  NOTE: NOT ENOUGH CHEMICAL DATA TO USE HEAVY GAS OPTION

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  WIND: 11 METERS/SECOND FROM E AT 3 METERS
  GROUND ROUGHNESS: OPEN COUNTRY        CLOUD COVER: 5 TENTHS
  AIR TEMPERATURE: 25° C               STABILITY CLASS: D
  NO INVERSION HEIGHT                  RELATIVE HUMIDITY: 50%

 SOURCE STRENGTH:
  DIRECT SOURCE: 0.545 KILOGRAMS/SEC     SOURCE HEIGHT: 0
  RELEASE DURATION: 60 MINUTES
  RELEASE RATE: 32.7 KILOGRAMS/MIN
  TOTAL AMOUNT RELEASED: 1,962 KILOGRAMS

 THREAT ZONE:
  MODEL RUN: GAUSSIAN
  RED: LESS THAN 10 METERS (10.9 YARDS) --- (40000 PPM = IDLH)
  NOTE: THREAT ZONE WAS NOT DRAWN BECAUSE EFFECTS OF NEAR-FIELD
PATCHINESS
    MAKE DISPERSION PREDICTIONS LESS RELIABLE FOR SHORT DISTANCES.
```

j) Methane: leak from 50-mm hole, jet fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	5	m
Hole diameter:	50	mm
Leak height above ground:	1	m
Gas pressure:	6.25	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	50100	kJ/kg
Molecular weight of gas:	16	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:		
Area of hole:	0.001963	m**2
Gas discharge rate:	2.092	kg/s
L/d ratio for flame:	199.7	
Flame height:	9.98	m
Location of flame centre above ground:	5.99	
Radiation path length:	7.80	m
Point source view factor:	0.001307	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.865	

Flux at receptor location:	35.55	kW/m**2

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	11	m
Hole diameter:	50	mm
Leak height above ground:	1	m
Gas pressure:	6.25	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	50100	kJ/kg
Molecular weight of gas:	16	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:

Area of hole:	0.001963	m**2
Gas discharge rate:	2.092	kg/s
L/d ratio for flame:	199.7	
Flame height:	9.98	m
Location of flame centre above ground:	5.99	
Radiation path length:	12.53	m
Point source view factor:	0.000507	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.829	

Flux at receptor location:	13.22	kW/m**2

k) Methane: leak from 10-mm hole, jet fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	1	m
Hole diameter:	10	mm
Leak height above ground:	1	m
Gas pressure:	6.25	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	50100	kJ/kg
Molecular weight of gas:	16	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:		
Area of hole:	7.85E-05	m**2
Gas discharge rate:	0.084	kg/s
L/d ratio for flame:	199.7	
Flame height:	2.00	m
Location of flame centre above ground:	2.00	
Radiation path length:	2.23	m
Point source view factor:	0.015936	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.968	

Flux at receptor location:	19.41	kW/m**2

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	3	m
Hole diameter:	10	mm
Leak height above ground:	1	m
Gas pressure:	6.25	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	50100	kJ/kg
Molecular weight of gas:	16	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:		
Area of hole:	7.85E-05	m**2
Gas discharge rate:	0.084	kg/s
L/d ratio for flame:	199.7	
Flame height:	2.00	m
Location of flame centre above ground:	2.00	
Radiation path length:	3.60	m
Point source view factor:	0.006124	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.928	

Flux at receptor location:	7.15	kW/m**2

I) Boiler: Pressure burst

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.24: Baker's Method for Overpressure from a Ruptured Vessel

Input Data:

Vessel burst pressure:	35	bar abs
Distance from vessel centre:	23	m
Vessel volume:	25	m**3
Final pressure:	1.01325	bar abs
Heat capacity ratio:	1.4	
Molecular weight of gas:	18	
Gas temperature:	298	K
Speed of sound in ambient gas:	340	m/s

Calculated Results:

Energy of explosion using Brode's equation for constant volume expansion:

Energy of explosion:	212.42	MJ
TNT equivalent:	45.29	kg TNT
Effective energy of explosion (x 2):	424.83	MJ
Scaled distance:	1.43	
Interpolated scaled overpressure:	0.211225	
Interpolated scaled impulse:	0.034854	

Vessel shape:	Spherical		Cylindrical	
Overpressure multiplier for vessel shape:	1.1		1.6	
Corrected scaled overpressure:	0.2323		0.3380	
Actual overpressure:	0.2354	bar	0.3424	bar
	3.42	psi	4.97	psi
Impulse multiplier for vessel shape:	1		1.1	
Corrected scaled impulse:	0.0349		0.0383	
Actual impulse:	132.94	kPa - ms	146.23	kPa - ms

Cross-correlation 2.24: Baker's Method for Overpressure from a Ruptured Vessel

Input Data:

Vessel burst pressure:	35	bar abs
Distance from vessel centre:	42	m
Vessel volume:	25	m**3
Final pressure:	1.01325	bar abs
Heat capacity ratio:	1.4	
Molecular weight of gas:	18	
Gas temperature:	298	K
Speed of sound in ambient gas:	340	m/s

Calculated Results:

Energy of explosion using Brode's equation for constant volume expansion:

Energy of explosion:	212.42	MJ
TNT equivalent:	45.29	kg TNT
Effective energy of explosion (x 2):	424.83	MJ
Scaled distance:	2.60	
Interpolated scaled overpressure:	0.086438	
Interpolated scaled impulse:	0.019791	

Vessel shape:	Spherical		Cylindrical	
Overpressure multiplier for vessel shape:	1.1		1.6	
Corrected scaled overpressure:	0.0951		0.1383	
Actual overpressure:	0.0963	bar	0.1401	bar
	1.40	psi	2.03	psi
Impulse multiplier for vessel shape:	1		1	
Corrected scaled impulse:	0.0198		0.0198	
Actual impulse:	75.49	kPa - ms	75.49	kPa - ms

m) Compressed air vessels: Pressure burst

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.24: Baker's Method for Overpressure from a Ruptured Vessel

Input Data:

Vessel burst pressure:	20	bar abs
Distance from vessel centre:	11	m
Vessel volume:	5.3	m**3
Final pressure:	1.01325	bar abs
Heat capacity ratio:	1.4	
Molecular weight of gas:	18	
Gas temperature:	298	K
Speed of sound in ambient gas:	340	m/s

Calculated Results:

Energy of explosion using Brode's equation for constant volume expansion:

Energy of explosion:	25.16	MJ
TNT equivalent:	5.36	kg TNT
Effective energy of explosion (x 2):	50.31	MJ
Scaled distance:	1.39	
Interpolated scaled overpressure:	0.221643	
Interpolated scaled impulse:	0.035772	

Vessel shape:	Spherical		Cylindrical	
Overpressure multiplier for vessel shape:	1.1		1.6	
Corrected scaled overpressure:	0.2438		0.3546	
Actual overpressure:	0.2470	bar	0.3593	bar
	3.58	psi	5.21	psi
Impulse multiplier for vessel shape:	1		1.1	
Corrected scaled impulse:	0.0358		0.0393	
Actual impulse:	67.00	kPa - ms	73.70	kPa - ms

Cross-correlation 2.24: Baker's Method for Overpressure from a Ruptured Vessel

Input Data:

Vessel burst pressure:	20	bar abs
Distance from vessel centre:	21	m
Vessel volume:	5.3	m**3
Final pressure:	1.01325	bar abs
Heat capacity ratio:	1.4	
Molecular weight of gas:	18	
Gas temperature:	298	K
Speed of sound in ambient gas:	340	m/s

Calculated Results:

Energy of explosion using Brode's equation for constant volume expansion:

Energy of explosion:	25.16	MJ
TNT equivalent:	5.36	kg TNT
Effective energy of explosion (x 2):	50.31	MJ
Scaled distance:	2.65	
Interpolated scaled overpressure:	0.084329	
Interpolated scaled impulse:	0.019303	

Vessel shape:	Spherical		Cylindrical	
Overpressure multiplier for vessel shape:	1.1		1.6	
Corrected scaled overpressure:	0.0928		0.1349	
Actual overpressure:	0.0940	bar	0.1367	bar
	1.36	psi	1.98	psi
Impulse multiplier for vessel shape:	1		1	
Corrected scaled impulse:	0.0193		0.0193	
Actual impulse:	36.16	kPa - ms	36.16	kPa - ms

n) Liquid sulphur storage tank: pool fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		68	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			48.10909	
L	SQRT	Safety distance		6.9	meter
	Actual surface area of bund			45	m2
	Worst-case surface area of bund	50% increase		67.5	m2

Model for the calculation of thermal radiation flux safety distance from a pool fire

AIChE

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		68	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			144.3273	
L	SQRT	Safety distance		12.0	meter
	Actual surface area of bund			45	m2
	Worst-case surface area of bund	50% increase		67.5	m2

a) Liquid sulphur road tanker: pool fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			4751.515	
L	SQRT	Safety distance		68.9	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			14254.55	
L	SQRT	Safety distance		119.4	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

b) Methyl naphthalene: storage tank pool fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		180	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			128.2909	
L	SQRT	Safety distance		11.3	meter
	Actual surface area of bund			120	m2
	Worst-case surface area of bund	50% increase		180	m2

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		180	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			384.8727	
L	SQRT	Safety distance		19.6	meter
	Actual surface area of bund			120	m2
	Worst-case surface area of bund	50% increase		180	m2

c) Methyl naphthalene: road tanker pool fire

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			4751.515	
L	SQRT	Safety distance		68.9	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

Model for the calculation of thermal radiation flux safety distance from a pool fire

AIChE

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			14254.55	
L	SQRT	Safety distance		119.4	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

d) n-Heptane, full loss, pool fire at storage tank

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		120	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			85.52727	
L	SQRT	Safety distance		9.2	meter
	Actual surface area of bund			80	m2
	Worst-case surface area of bund	50% increase		120	m2

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface				m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		120	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			256.5818	
L	SQRT	Safety distance		16.0	meter
	Actual surface area of bund			80	m2
	Worst-case surface area of bund	50% increase		120	m2

e) n-Heptane storage tank: full loss, VCE when 80% of the liquid is converted to aerosol or vapour

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	27200	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	40000	liters
Equivalent TNT mass	8788	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	8788	kg
Distance from blast:	117	m

Calculated Results:

Scaled distance, z:	5.6697	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.803197	
Overpressure:	34.85	kPa
	5.056249	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.1333	
Impulse:	52.91737	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.92632	
Duration:	3.968174	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.835856	
Arrival time:	9.967	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	27200	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	40000	liters
Equivalent TNT mass	8788	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	8788	kg
Distance from blast:	215	m

Calculated Results:

Scaled distance, z:	10.4186	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.160028	
Overpressure:	14.00	kPa
	2.03089	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.502755	
Impulse:	29.80874	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01108	
Duration:	4.85146	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.199955	
Arrival time:	22.787	ms

f) n-Heptane storage tank: leak from 50-mm hole, VCE

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.1: Liquid Discharge through a Hole in a Tank

[CCPS Model]

Input Data:

Tank pressure above liquid:	1.5	barg
Pressure outside hole:	0	barg
Liquid density:	0.65	kg/m**3
Liquid level above hole:	5	m
Hole diameter:	50	mm

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	0.001963	m**2

Equation terms:

Pressure term:	-230769	m**2/s**2
Height term:	-49	m**2/s**2
Velocity coefficient:	1.25	

Exit velocity:	429.71	m/s
Mass flow:	0.54843	kg/s
Liquid flow:	0.844	l/s
Leaked volume in 10 minutes:	506	liter
Surface area of pool forming	168.7485	m2
Leaked mass in 10 minutes	329	kg

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	344.08	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	506	liters
Equivalent TNT mass	111	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	111	kg
Distance from blast:	27	m

Calculated Results:

Scaled distance, z:	5.6153	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.797545	
Overpressure:	35.42	kPa
	5.138157	psig

Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.14337	
Impulse:	53.38235	Pa s

Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.94082	
Duration:	3.95446	ms

Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.830089	
Arrival time:	9.825	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	344.08	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	506	liters
Equivalent TNT mass	111	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	111	kg
Distance from blast:	50	m

Calculated Results:

Scaled distance, z:	10.3987	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.158905	
Overpressure:	14.04	kPa
	2.036198	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.500752	
Impulse:	29.86395	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01396	
Duration:	4.848457	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.198808	
Arrival time:	22.732	ms

g) n-Heptane storage tank: leak from 10-mm hole, VCE

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.1: Liquid Discharge through a Hole in a Tank

[CCPS Model]

Input Data:

Tank pressure above liquid:	1.5	barg
Pressure outside hole:	0	barg
Liquid density:	0.65	kg/m**3
Liquid level above hole:	5	m
Hole diameter:	10	mm

Excess Head Loss Factors:

Entrance:	0.5
Exit:	1
Others:	0
TOTAL:	1.5

Calculated Results:

Hole area:	7.85E-05	m**2

Equation terms:

Pressure term:	-230769	m**2/s**2
Height term:	-49	m**2/s**2
Velocity coefficient:	1.25	

Exit velocity:	429.71	m/s
Mass flow:	0.02194	kg/s
Liquid flow:	0.034	l/s
Leaked volume in 10 minutes:	20	liter
Surface area of pool forming	6.74994	m2
Leaked mass in 10 minutes	13	kg

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13.6	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20	liters
Equivalent TNT mass	4	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4	kg
Distance from blast:	9	m

Calculated Results:

Scaled distance, z:	5.4949	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.784832	
Overpressure:	36.73	kPa
	5.328429	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.16603	
Impulse:	54.4407	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.97342	
Duration:	3.923471	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.817118	
Arrival time:	9.513	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13.6	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20	liters
Equivalent TNT mass	4	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4	kg
Distance from blast:	17	m

Calculated Results:

Scaled distance, z:	10.3792	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.157805	
Overpressure:	14.07	kPa
	2.041408	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.498793	
Impulse:	29.91809	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01678	
Duration:	4.84552	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.197686	
Arrival time:	22.678	ms

h) n-Heptane road tanker, full loss, pool fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		37.5	37.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			4751.515	
L	SQRT	Safety distance		68.9	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

Model for the calculation of thermal radiation flux safety distance from a pool fire **AIChE**

Norm for maximum thermal radiation exposure:

				Value	
V	Volume of fuel in pool, impermeable surface			20	m3
E	Maximum allowable thermal radiation flux		12.5	12.5	kW/m2
t	Atmospheric transmissivity for the specific site			0.5	
n	Fraction of the combustion energy radiated			0.35	
m	Mass burning rate for the specific fuel type			0.04	kg/m2/s
H	Heat of combustion of the fuel			48000	kJ/kg
A	Total area of the burning fuel pool	0.003		6667	m2
F	View factor for point source heat radiation			-	
L	Thermal radiation safety distance				
L2	[(tnmHA)/(4*E*Π)]			14254.55	
L	SQRT	Safety distance		119.4	meter
	Actual surface area of bund				m2
	Worst-case surface area of bund	50% increase			m2

i) n-Heptane road tanker: full loss, VCE when 80% of the liquid is converted to aerosol or vapour

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13600	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20000	liters
Equivalent TNT mass	4394	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4394	kg
Distance from blast:	94	m

Calculated Results:

Scaled distance, z:	5.7391	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.810334	
Overpressure:	34.15	kPa
	4.955103	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.12057	
Impulse:	52.33507	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.90802	
Duration:	3.985443	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.843139	
Arrival time:	10.147	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13600	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20000	liters
Equivalent TNT mass	4394	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4394	kg
Distance from blast:	170	m

Calculated Results:

Scaled distance, z:	10.3792	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.157805	
Overpressure:	14.07	kPa
	2.041408	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.498793	
Impulse:	29.91809	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01678	
Duration:	4.84552	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.197686	
Arrival time:	22.678	ms

j) n-Heptane road tanker: leak from 50-mm hole, VCE

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.1: Liquid Discharge through a Hole in a Tank

[CCPS Model]

Input Data:

Tank pressure above liquid:	1.5	barg
Pressure outside hole:	0	barg
Liquid density:	0.65	kg/m**3
Liquid level above hole:	5	m
Hole diameter:	50	mm

Excess Head Loss Factors:

Entrance:		0.5
Exit:		1
Others:		0
	TOTAL:	1.5

Calculated Results:

Hole area:	0.001963	m**2

Equation terms:

Pressure term:	-230769	m**2/s**2
Height term:	-49	m**2/s**2
Velocity coefficient:	1.25	

Exit velocity:	429.71	m/s
Mass flow:	0.54843	kg/s
Liquid flow:	0.844	l/s
Leaked volume in 10 minutes:	506	liter
Surface area of pool forming	168.7485	m2
Leaked mass in 10 minutes	329	kg

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	344.08	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	506	liters
Equivalent TNT mass	111	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	111	kg
Distance from blast:	27	m

Calculated Results:

Scaled distance, z:	5.6153	m/kg**(1/3)

Overpressure Calculation: (only valid for z > 0.0674 and z < 40)

a+b*log(z):	0.797545	
Overpressure:	35.42	kPa
	5.138157	psig

Impulse Calculation: (only valid for z > 0.0674 and z < 40)

a+b*log(z):	-0.14337	
Impulse:	53.38235	Pa s

Duration Calculation: (only valid for z > 0.178 and z < 40)

a+b*log(z):	-0.94082	
Duration:	3.95446	ms

Arrival Time Calculation: (only valid for z > 0.0674 and z < 40)

a+b*log(z):	0.830089	
Arrival time:	9.825	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	344.08	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	506	liters
Equivalent TNT mass	111	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	111	kg
Distance from blast:	50	m

Calculated Results:

Scaled distance, z:	10.3987	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.158905	
Overpressure:	14.04	kPa
	2.036198	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.500752	
Impulse:	29.86395	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01396	
Duration:	4.848457	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.198808	
Arrival time:	22.732	ms

k) n-Heptane road tanker: leak from 10-mm hole, VCE

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.1: Liquid Discharge through a Hole in a Tank

[CCPS Model]

Input Data:

Tank pressure above liquid:	1.5	barg
Pressure outside hole:	0	barg
Liquid density:	0.65	kg/m**3
Liquid level above hole:	5	m
Hole diameter:	10	mm

Excess Head Loss Factors:

Entrance:		0.5
Exit:		1
Others:		0
	TOTAL:	1.5

Calculated Results:

Hole area:	7.85E-05	m**2

Equation terms:

Pressure term:	-230769	m**2/s**2
Height term:	-49	m**2/s**2
Velocity coefficient:	1.25	

Exit velocity:	429.71	m/s
Mass flow:	0.02194	kg/s
Liquid flow:	0.034	l/s
Leaked volume in 10 minutes:	20	liter
Surface area of pool forming	6.74994	m2
Leaked mass in 10 minutes	13	kg

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13.6	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20	liters
Equivalent TNT mass	4	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4	kg
Distance from blast:	9	m

Calculated Results:

Scaled distance, z:	5.4949	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.784832	
Overpressure:	36.73	kPa
	5.328429	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.16603	
Impulse:	54.4407	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.97342	
Duration:	3.923471	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.817118	
Arrival time:	9.513	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	13.6	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	20	liters
Equivalent TNT mass	4	kg
Density of liquid:	0.68	kg/l

Input Data:

TNT Mass:	4	kg
Distance from blast:	17	m

Calculated Results:

Scaled distance, z:	10.3792	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.157805	
Overpressure:	14.07	kPa
	2.041408	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.498793	
Impulse:	29.91809	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.01678	
Duration:	4.84552	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.197686	
Arrival time:	22.678	ms

l) Hydrogen storage tank: full loss, VCE

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	3.034	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	37000	liters
Equivalent TNT mass	1	kg
Density of liquid:	0.000082	kg/l

Input Data:

TNT Mass:	1	kg
Distance from blast:	6	m

Calculated Results:

Scaled distance, z:	6.0400	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.840308	
Overpressure:	31.41	kPa
	4.556539	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0.06714	
Impulse:	49.94769	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.83113	
Duration:	4.057499	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.873724	
Arrival time:	10.935	ms

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0.03	%
Mass of gas	3.034	kg
Higher heating value of gas	50100	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	37000	liters
Equivalent TNT mass	1	kg
Density of liquid:	0.000082	kg/l

Input Data:

TNT Mass:	1	kg
Distance from blast:	10	m

Calculated Results:

Scaled distance, z:	10.0667	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.13988	
Overpressure:	14.67	kPa
	2.128652	psig

Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0.466841	
Impulse:	30.81413	Pa s

Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0.06276	
Duration:	4.797876	ms

Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1.179396	
Arrival time:	21.819	ms

m) Hydrogen storage tank: leak from 50-mm hole, jet fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	1	m
Hole diameter:	50	mm
Leak height above ground:	1	m
Gas pressure:	0.5	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	144000	kJ/kg
Molecular weight of gas:	2	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:

Area of hole:	0.001963	m**2
Gas discharge rate:	0.059	kg/s
L/d ratio for flame:	551.1	
Flame height:	27.55	m
Location of flame centre above ground:	14.78	
Radiation path length:	14.81	m
Point source view factor:	0.000363	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.817	

Flux at receptor location:	0.76	kW/m**2

n) Hydrogen storage tank: leak from 10-mm hole, jet fire

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	1	m
Hole diameter:	10	mm
Leak height above ground:	1	m
Gas pressure:	0.5	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1.32	
Heat of combustion for gas:	144000	kJ/kg
Molecular weight of gas:	2	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0.095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0.3	

Calculated Results:

Area of hole:	7.85E-05	m**2
Gas discharge rate:	0.002	kg/s
L/d ratio for flame:	551.1	
Flame height:	5.51	m
Location of flame centre above ground:	3.76	
Radiation path length:	3.89	m
Point source view factor:	0.005269	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0.921	

Flux at receptor location:	0.50	kW/m**2

4. Probit functions for the estimation of the number of fatalities

Cross-correlation 2.35: Thermal Flux Estimate *CCPS/AIChE*

Input Data:

Exposure time:	60	seconds	Cannot exceed 98.7
Percent Fatalities:	1	%	

Calculated Results:

Thermal Flux Estimate for:

Significant injury threshold:		5.56	kW/m**2
Percent Fatalities:	1	9.87	kW/m**2
	50	22.81	kW/m**2
	100	34.68	kW/m**2

Extra interpolation tables for EXCEL:

1	9.87
50	22.81

Interpolated Flux for Specified Percent:	9.87	kW/m**2

Thermal Flux Estimate Based on **Eisenberg** Fatality Probit:

Probit:	2.67	
Thermal Flux:	7.98	kW/m**2

Cross-correlation 2.32: Dose-Response Correlation via Probits Overpressure

Input Data: Equation 2.3.7 Page 269

1 psi = 6903,8 N/m**2

Percentage Affected	Probit	Peak Overpressure (N/m**2)	Peak Overpressure psi	N/m**2 LN(Overpressure)	Calculated Probit	Table for interpolation by EXCEL:				Calculated Percentage
1	2.67	13807	2.00	9.53	2.66	2.65	2.7	0.94	1.07	0.97
10	3.72	19300	2.80	9.87	3.34	3.30	3.35	4.46	4.95	4.84
50	5.00	34490	5.00	10.45	4.52	4.50	4.55	30.85	32.64	31.41
90	6.28	84300	12.23	11.34	6.33	6.30	6.35	90.32	91.15	90.76

Cross-correlation 2.33: Percent Fatalities from a Fixed Concentration-Time Relationship

Input Data:				
Concentration:		1000	ppm	ERPG-3
Exposure Time:		60	minutes	
Probit Equation:				
	k1:	-35.9		Ammonia
	k2:	1.85		
	Exponent:	2		

Calculated Results:			
Probit Value:	-2.77		
Percent:	0.00	%	Eq. 2.3.2 Page 247 of CCPS

6 Frequency analysis

1) Postulated cause-event analysis

Hazardous material
Flammable liquids
Flammable gases
Explosive liquid vapours
Explosive gases
Toxic gases

Causal Factor	Probability
Routine task on schedule	0.064
Routine task on demand	0.008
Special task on schedule	0.037
Ad hoc, improvisation	0.015
Other	0.019
Paced by system dynamics	0.006
Paced by programme or orders	0.003
Self-paced	0.119
Spontaneous error in undisturbed task	0.067
Change in condition of familiar task	0.019
Operator distracted in task, preoccupied	0.007
Unfamiliar task	0.016
Monitoring and inspection	0.002
Supervisory control	0.009
Manual operation and control	0.012
Inventory control	0.022
Test and calibration	0.034
Repair and modification	0.043
Administrative and recording	0.003
Management and staff planning	0.009
Specified act not performed	0.074
Positive effect of wrong act	0.047
Extraneous effect	0.011
Sneak path	0.009
Effect not immediately reversible	0.021
Effect not immediately observable	0.098
Absent-mindedness	0.002
Familiar association	0.004
Capability exceeded	0.001
Low alertness	0.007
Manual variability and lack of precision	0.007
Topographic and spatial orientation inadequate	0.007
Familiar routine interference	0.000
Omission of functionally isolated act	0.040
Omission of administrative act	0.009
Other omissions	0.006
Mistake, interchange among alternative possibilities	0.008
Expect and assume rather than observe	0.007
System knowledge insufficient	0.001
Side-effects of process not adequately considered	0.011
Latent causal condition or relations not adequately considered	0.014
Reference data recalled wrongly	0.001
Sabotage	0.001
Poor maintenance	0.012
Corrosion/material defect/operating spec exceeded/mechanical damage/container overfilled/no training/natural hazard/drive to increase production/poor construction/wrong product/tank contamination/chemical incompatibility/ignition source	0.110

Event

Loss of containment

Human Error	Probability
Task condition	
Routine task on schedule	0.064
Routine task on demand	0.008
Special task on schedule	0.037
Ad hoc, improvisation	0.015
Other	0.019
Task control	
Paced by system dynamics	0.006
Paced by programme or orders	0.003
Self-paced	0.119
Other	0.015
Error situation	
Spontaneous error in undisturbed task	0.067
Change in condition of familiar task	0.019
Operator distracted in task, preoccupied	0.007
Unfamiliar task	0.016
Other	0.034
Task	
Monitoring and inspection	0.002
Supervisory control	0.009
Manual operation and control	0.012
Inventory control	0.022
Test and calibration	0.034
Repair and modification	0.043
Administrative and recording	0.003
Management and staff planning	0.009
Other	0.009
Effect from	
Specified act not performed	0.074 max
Positive effect of wrong act	0.047
Extraneous effect	0.011
Sneak path	0.009
Other	0.004
Potential for recovery	
Effect not immediately reversible	0.021
Effect not immediately observable	0.098
Other	0.024
Error categories	
Absent-mindedness	0.002

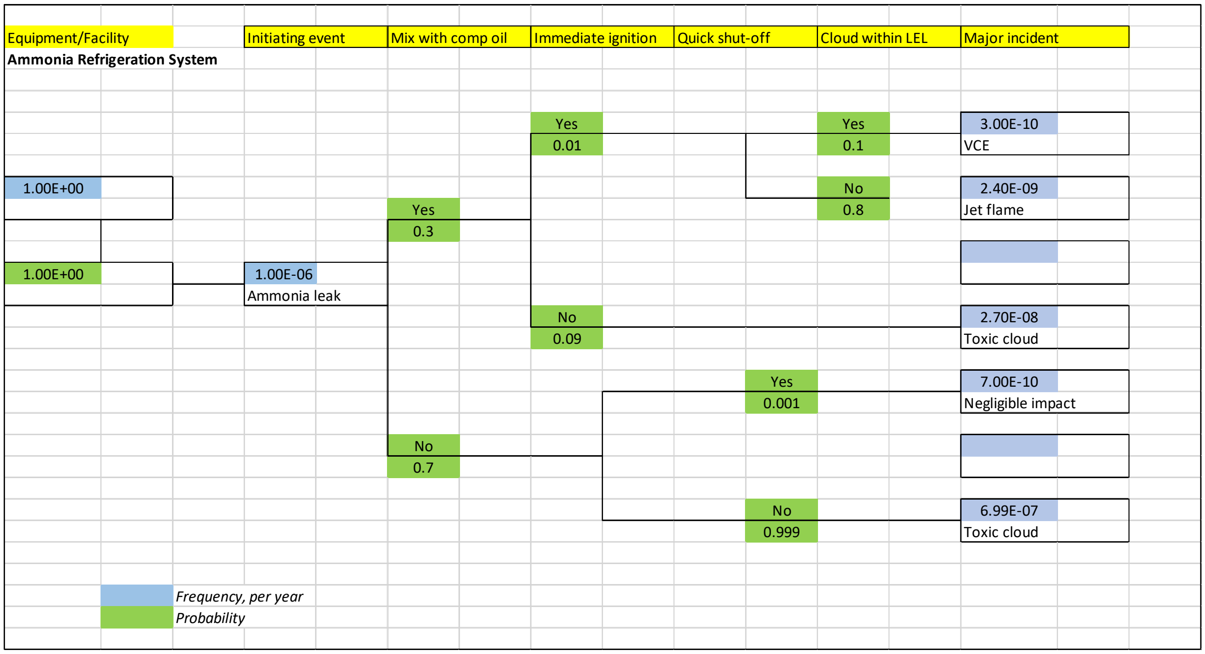
Familiar association	0.004
Capability exceeded	0.001
Low alertness	0.007
Manual variability and lack of precision	0.007
Topographic and spatial orientation inadequate	0.007
Familiar routine interference	0.000
Omission of functionally isolated act	0.040
Omission of administrative act	0.009
Other omissions	0.006
Mistake, interchange among alternative possibilities	0.008
Expect and assume rather than observe	0.007
System knowledge insufficient	0.001
Side-effects of process not adequately considered	0.011
Latent causal condition or relations not adequately considered	0.014
Reference data recalled wrongly	0.001
Sabotage	0.001
Other	0.012

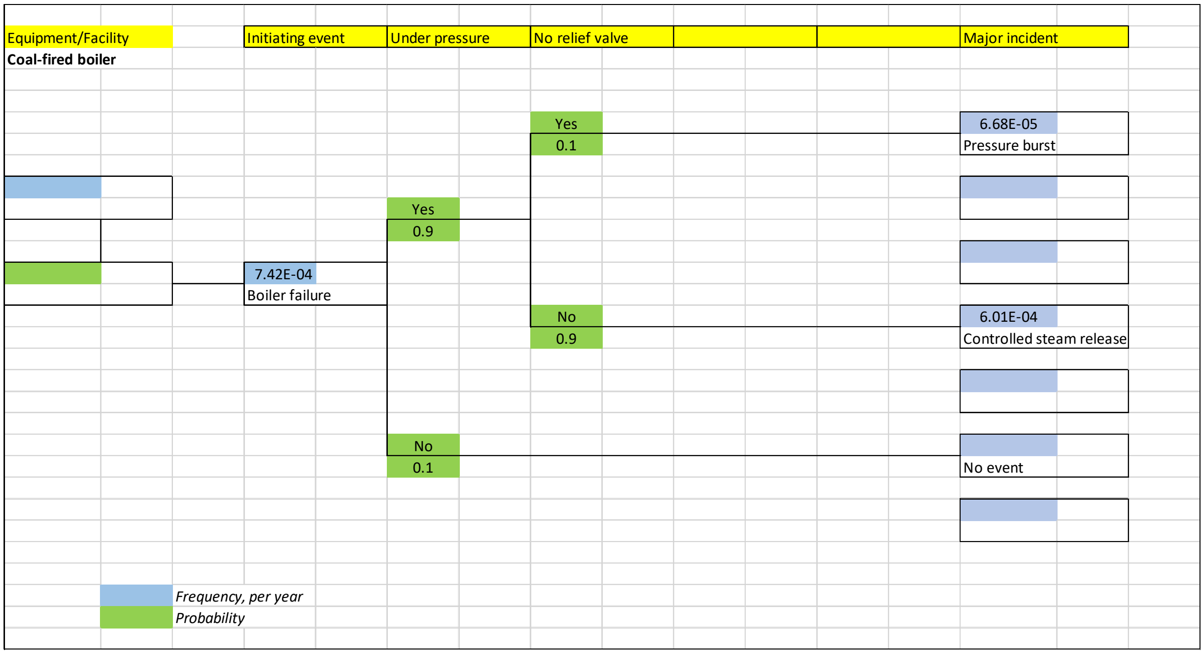
Failure data used – equipment and systems

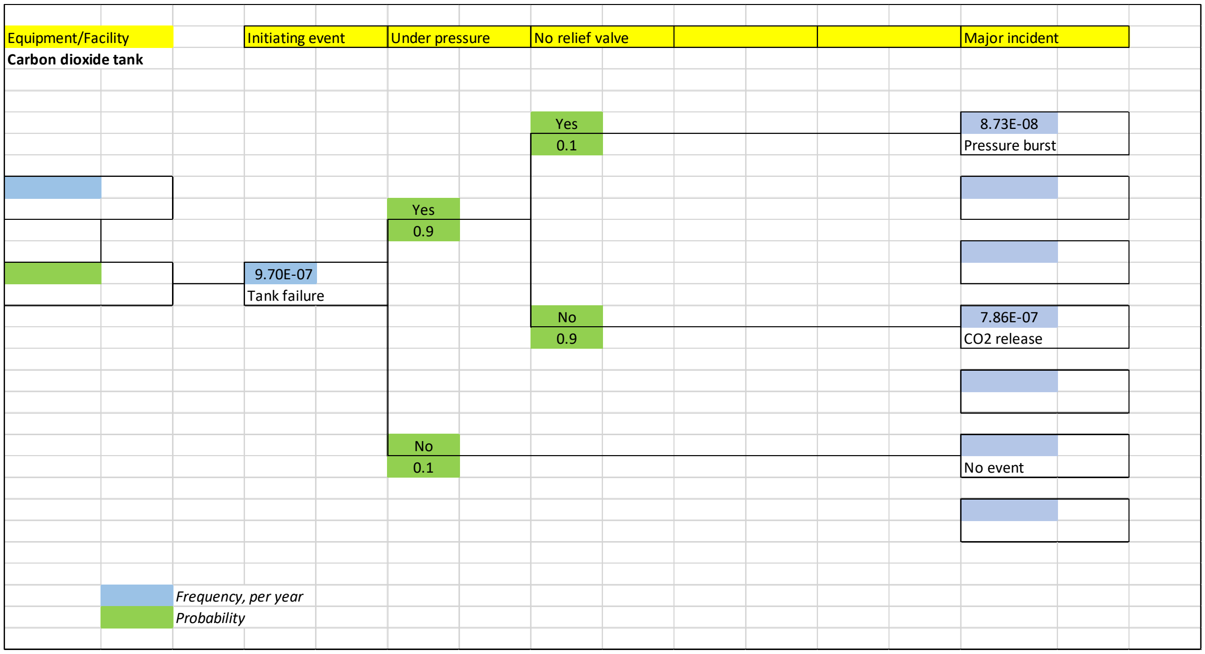
Table 6.1: Failure data from BEVI

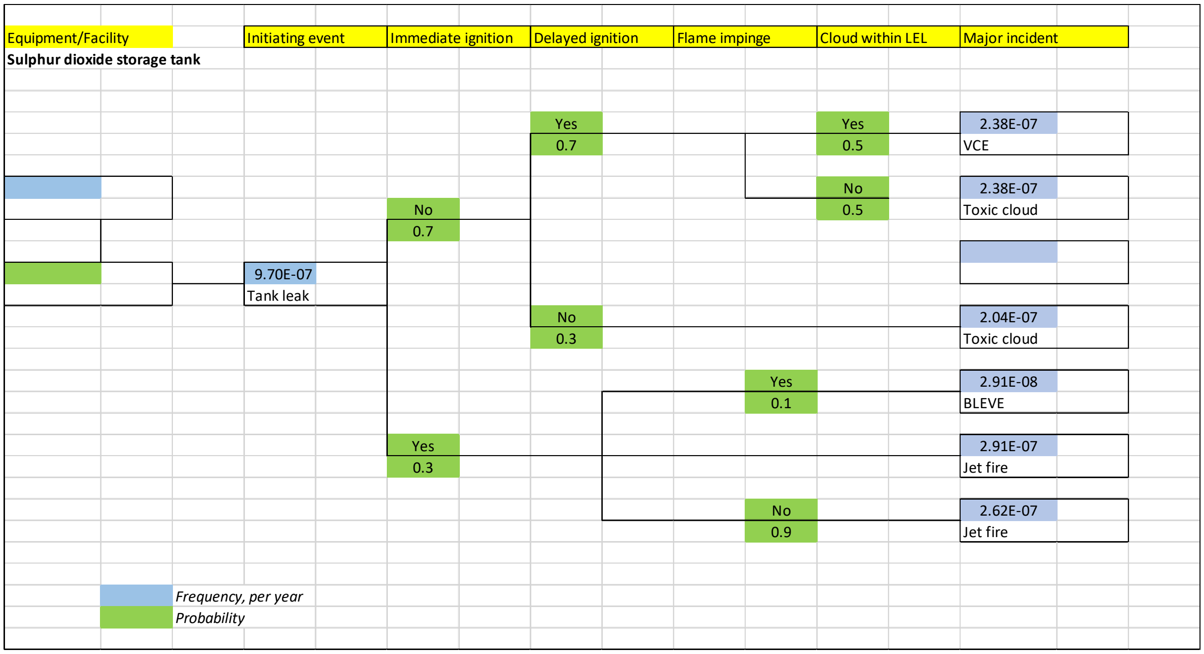
Installation component	**Failure frequency, per year**
Manual valve	1.0 E-4
Remotely controlled shut-off valve	3.0 E-2
Automatic shut-off valve	1.0 E-2
Excess flow valve	1.3 E-2
Flammable warehouse fire	8.8 E-4
Underground LPG tank, instantaneous release	5.0 E-7
Underground storage tank for toxic materials	5.0 E-7
Underground pipeline, rupture	5.0 E-7
Underground pipeline, 20-mm hole	1.5 E-6
Aboveground pipeline, <75 mm diameter, rupture	1.0 E-6
Aboveground pipeline, 75-150 mm diameter, rupture	3.0 E-7
Aboveground pipeline, >150 mm diameter, rupture	1.0 E-7
Aboveground pipeline, <75 mm diameter, 50-mm hole	5.0 E-6
Aboveground pipeline, 75-150 mm diameter, 50-mm hole	2.0 E-6
Aboveground pipeline, >150 mm diameter, 50-mm hole	5.0 E-7
Reciprocating pumps and compressors	4.4 E-3
Heat exchangers	1.0 E-3
Gas road tankers (pressurised; LPG) full release	5.0 E-7
Road tankers with flammable liquid at atmospheric pressure, full release	4.5 E-9
LPG cylinders, catastrophic (HSE)	2N where N = total number of cylinders on site
LPG storage tank aboveground	9.7 E-7

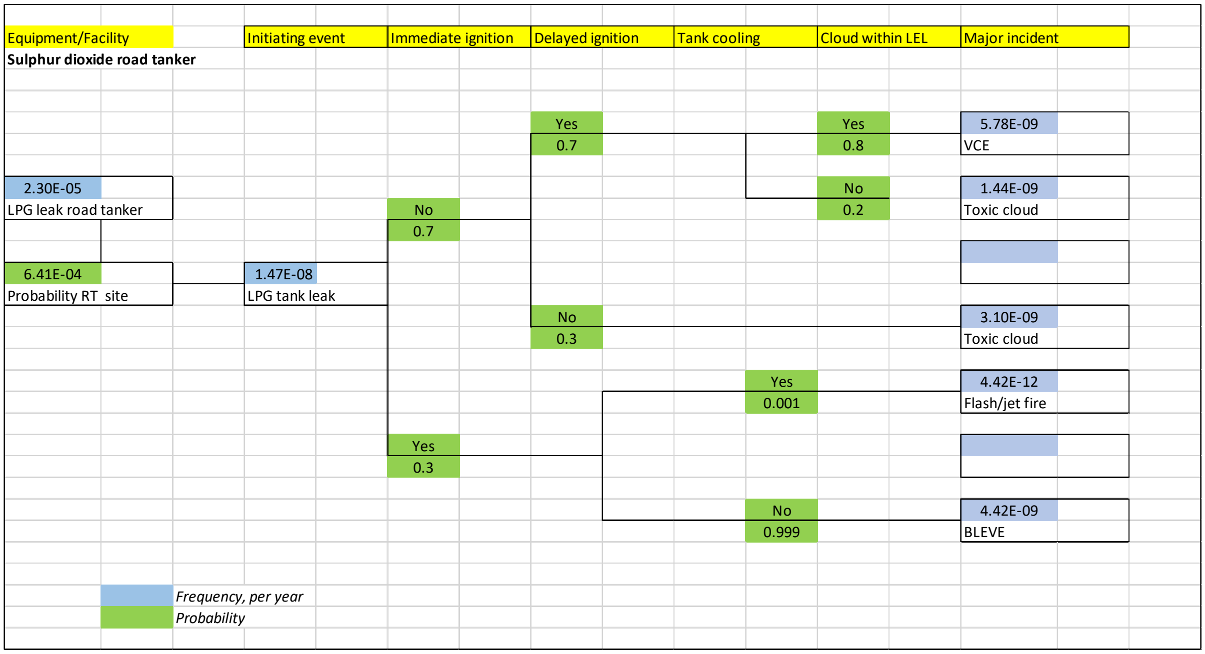
2) Information to determine the final frequency of each failure scenario included in the calculation of risk

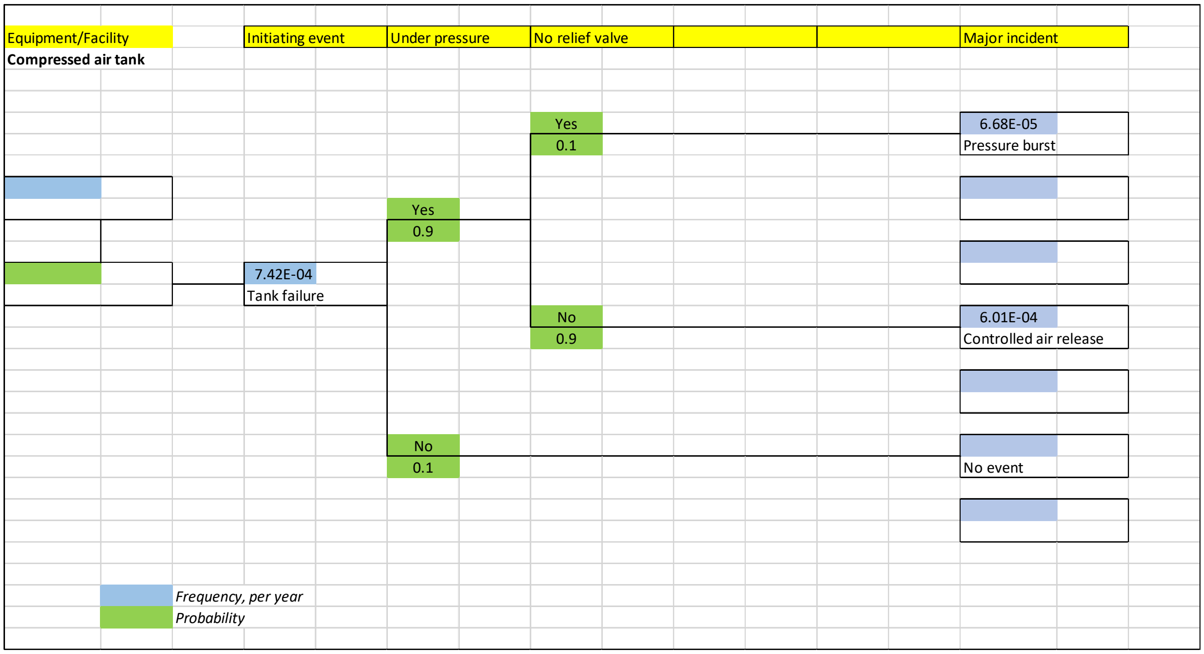


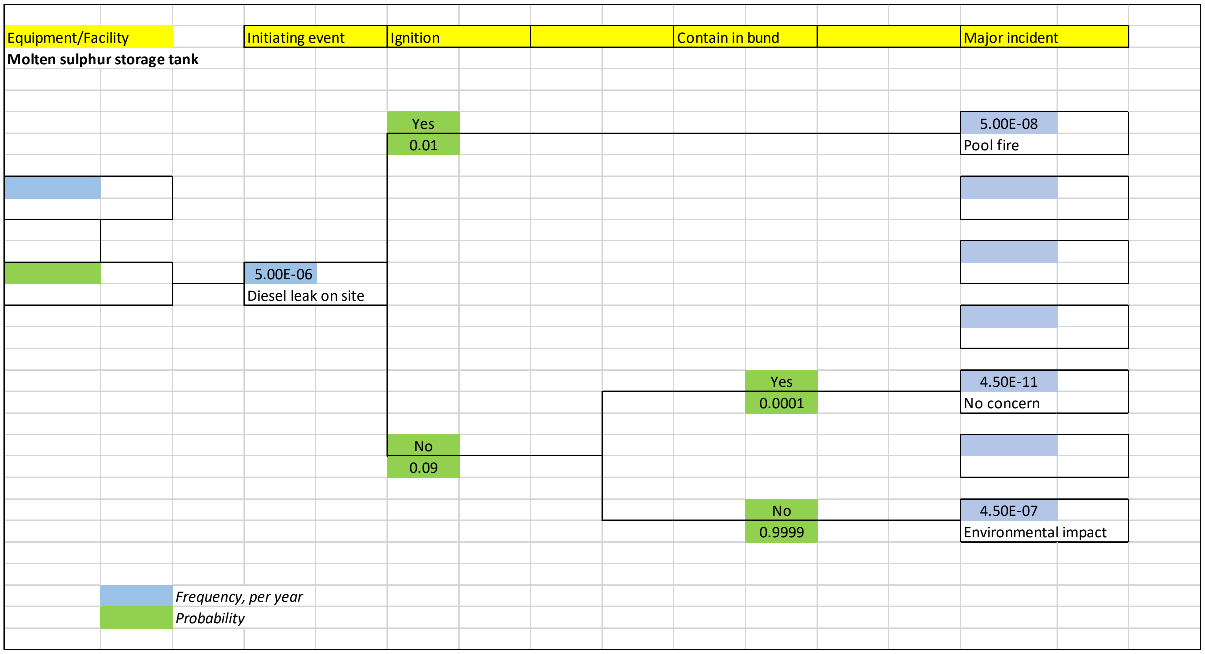


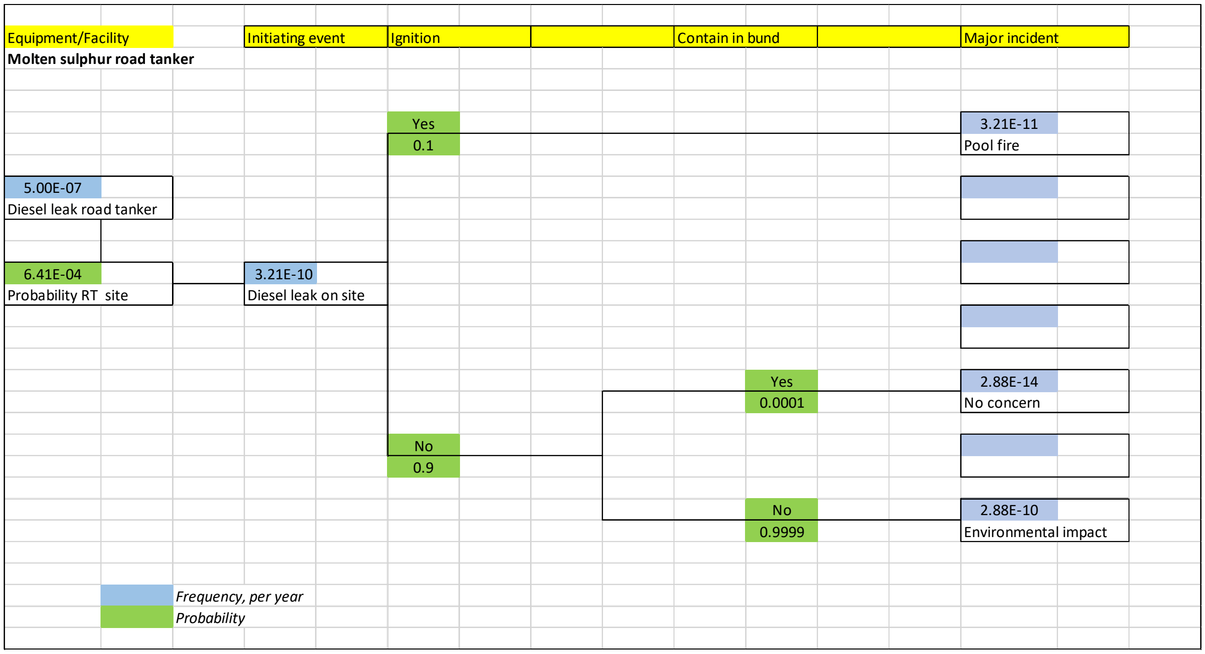

Equipment/Facility
Carbon dioxide tank
Initiating event
Under pressure
No relief valve
Major incident
Yes
0.1
8.73E-08
Pressure burst
Yes
0.9
9.70E-07
Tank failure
No
0.9
7.86E-07
CO2 release
No
0.1
No event
Frequency, per year
Probability

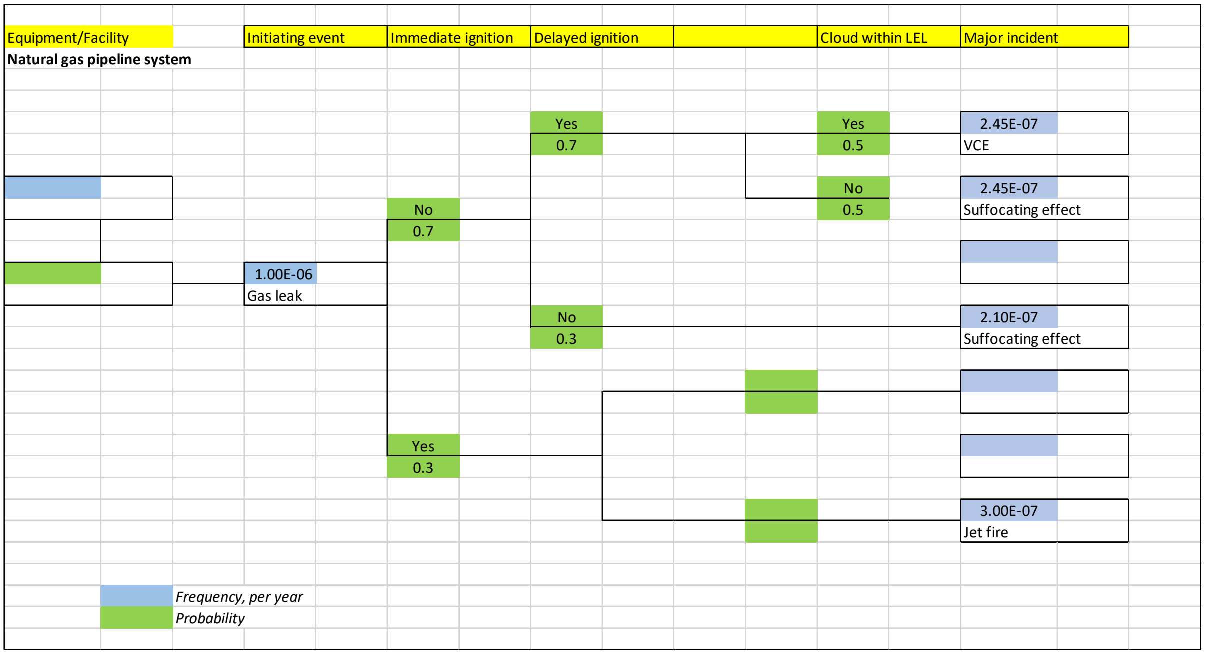

Equipment/Facility
Sulphur dioxide storage tank
Initiating event
Immediate ignition
Delayed ignition
Flame impinge
Cloud within LEL
Major incident
Yes
0.7
Yes
0.5
2.38E-07
VCE
No
0.5
2.38E-07
Toxic cloud
No
0.7
9.70E-07
Tank leak
No
0.3
2.04E-07
Toxic cloud
Yes
0.1
2.91E-08
BLEVE
Yes
0.3
2.91E-07
Jet fire
No
0.9
2.62E-07
Jet fire
Frequency, per year
Probability

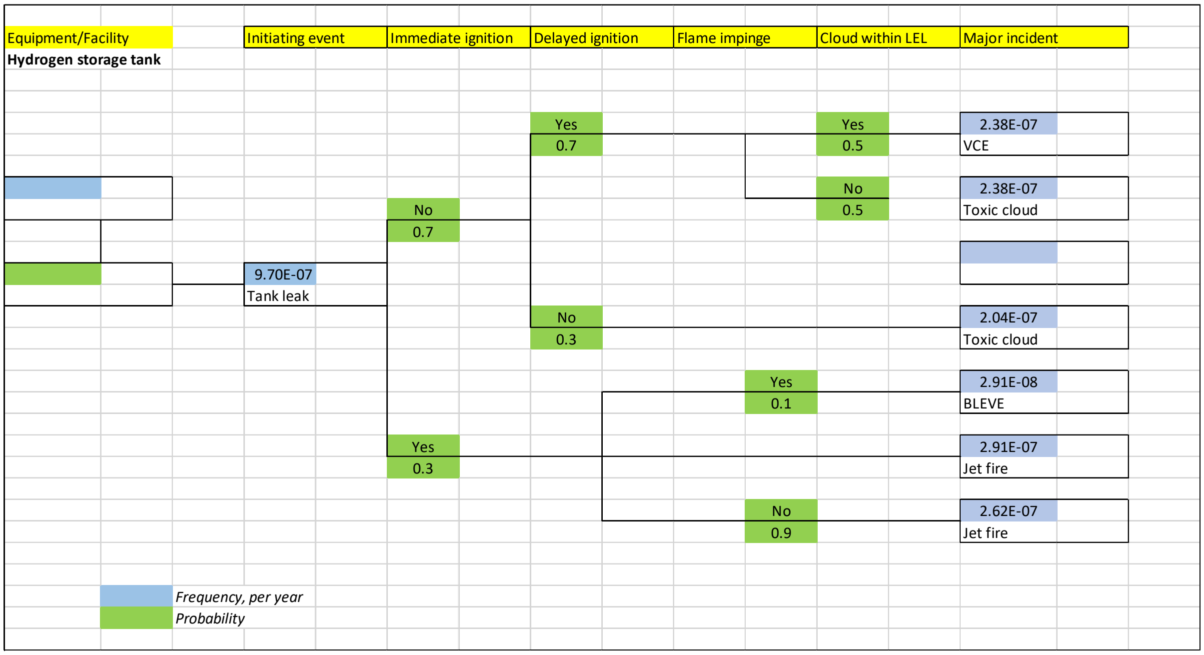

Equipment/Facility
Sulphur dioxide road tanker
Initiating event
Immediate ignition
Delayed ignition
Tank cooling
Cloud within LEL
Major incident
2.30E-05
LPG leak road tanker
6.41E-04
Probability RT site
1.47E-08
LPG tank leak
No
0.7
Yes
0.3
Yes
0.7
No
0.3
Yes
0.001
No
0.999
Yes
0.8
No
0.2
5.78E-09
VCE
1.44E-09
Toxic cloud
3.10E-09
Toxic cloud
4.42E-12
Flash/jet fire
4.42E-09
BLEVE
Frequency, per year
Probability

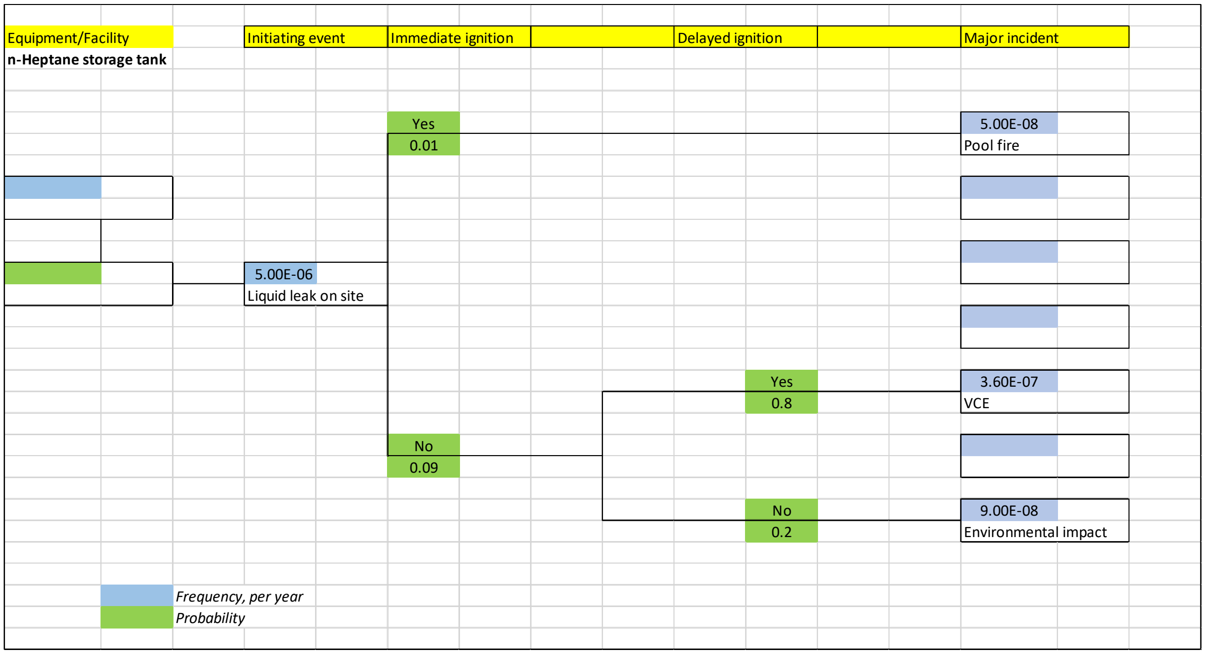

Equipment/Facility
Compressed air tank
Initiating event
Under pressure
No relief valve
Major incident
7.42E-04
Tank failure
Yes
0.9
No
0.1
Yes
0.1
No
0.9
6.68E-05
Pressure burst
6.01E-04
Controlled air release
No event
Frequency, per year
Probability

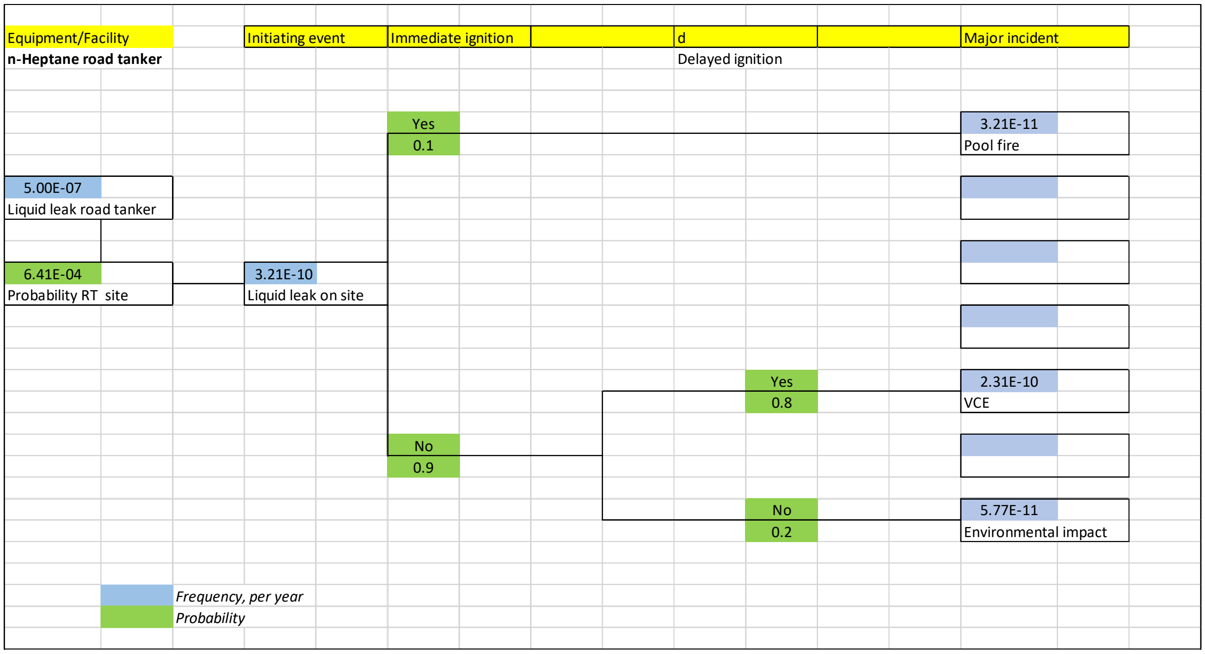

Equipment/Facility
Initiating event
Ignition
Contain in bund
Major incident
Molten sulphur storage tank
Yes
0.01
5.00E-08
Pool fire
5.00E-06
Diesel leak on site
Yes
0.0001
4.50E-11
No concern
No
0.09
No
0.9999
4.50E-07
Environmental impact
Frequency, per year
Probability

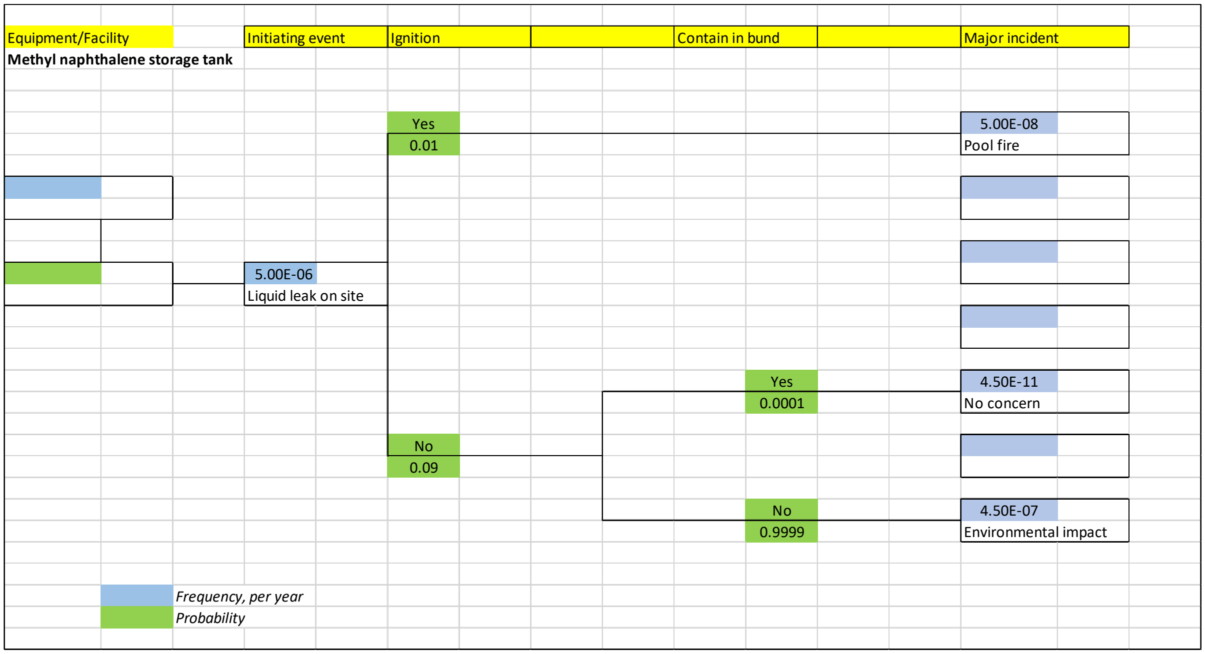

Equipment/Facility
Initiating event
Ignition
Contain in bund
Major incident
Molten sulphur road tanker
Yes
0.1
3.21E-11
Pool fire
5.00E-07
Diesel leak road tanker
6.41E-04
Probability RT site
3.21E-10
Diesel leak on site
Yes
0.0001
2.88E-14
No concern
No
0.9
No
0.9999
2.88E-10
Environmental impact
Frequency, per year
Probability

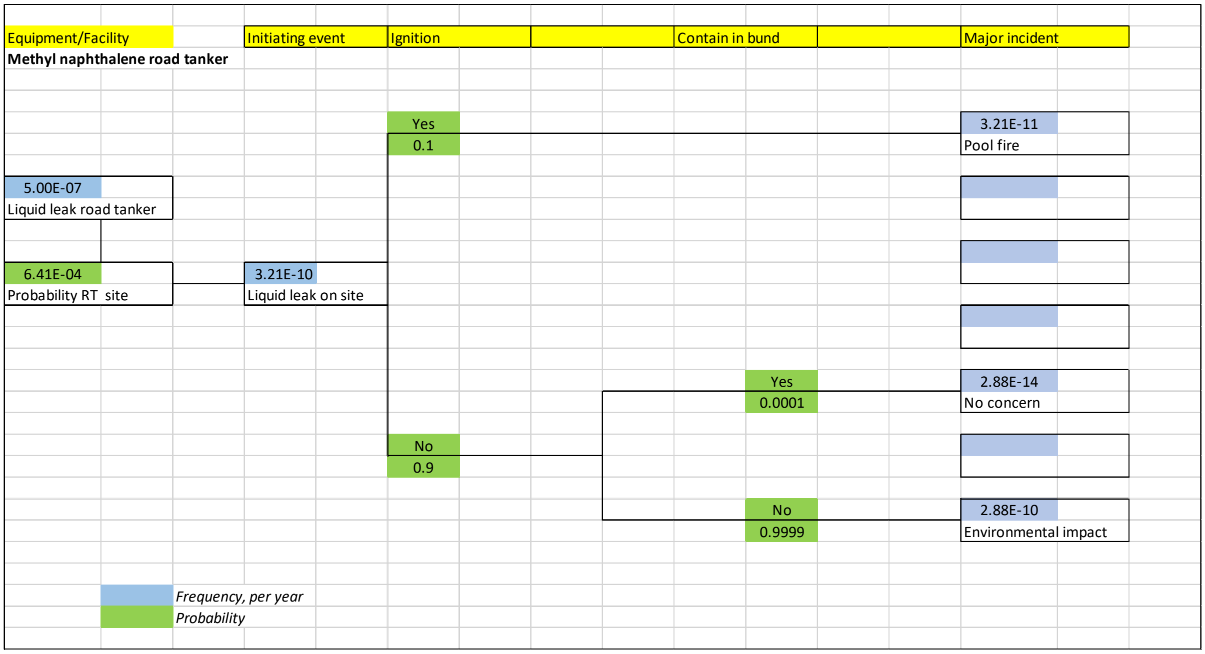

Equipment/Facility
Natural gas pipeline system
Initiating event
Immediate ignition
Delayed ignition
Cloud within LEL
Major incident
1.00E-06
Gas leak
No
0.7
Yes
0.3
Yes
0.7
No
0.3
Yes
0.5
No
0.5
2.45E-07
VCE
2.45E-07
Suffocating effect
2.10E-07
Suffocating effect
3.00E-07
Jet fire
Frequency, per year
Probability


Equipment/Facility
Hydrogen storage tank
Initiating event
Immediate ignition
Delayed ignition
Flame impinge
Cloud within LEL
Major incident
9.70E-07
Tank leak
No
0.7
Yes
0.3
Yes
0.7
No
0.3
Yes
0.5
No
0.5
Yes
0.1
No
0.9
2.38E-07
VCE
2.38E-07
Toxic cloud
2.04E-07
Toxic cloud
2.91E-08
BLEVE
2.91E-07
Jet fire
2.62E-07
Jet fire
Frequency, per year
Probability


Equipment/Facility
n-Heptane storage tank
Initiating event
Immediate ignition
Delayed ignition
Major incident
Yes
0.01
5.00E-08
Pool fire
5.00E-06
Liquid leak on site
Yes
0.8
3.60E-07
VCE
No
0.09
No
0.2
9.00E-08
Environmental impact
Frequency, per year
Probability


Equipment/Facility
n-Heptane road tanker
Initiating event
Immediate ignition
d
Delayed ignition
Major incident
Yes
0.1
3.21E-11
Pool fire
5.00E-07
Liquid leak road tanker
6.41E-04
Probability RT site
3.21E-10
Liquid leak on site
Yes
0.8
2.31E-10
VCE
No
0.9
No
0.2
5.77E-11
Environmental impact
Frequency, per year
Probability


Equipment/Facility
Initiating event
Ignition
Contain in bund
Major incident
Methyl naphthalene storage tank
Yes
0.01
5.00E-08
Pool fire
5.00E-06
Liquid leak on site
Yes
0.0001
4.50E-11
No concern
No
0.09
No
0.9999
4.50E-07
Environmental impact
Frequency, per year
Probability


Equipment/Facility
Initiating event
Ignition
Contain in bund
Major incident
Methyl naphthalene road tanker
Yes
0.1
3.21E-11
Pool fire
5.00E-07
Liquid leak road tanker
6.41E-04
Probability RT site
3.21E-10
Liquid leak on site
Yes
0.0001
2.88E-14
No concern
No
0.9
No
0.9999
2.88E-10
Environmental impact
Frequency, per year
Probability

7. Risk calculations

Location specific societal and individual risk levels:

Colour Code

1 × 10-3 d/p/y – **blue**
1 × 10-4 d/p/y – **red**
1 × 10-5 d/p/y – **orange**
1 × 10-6 d/p/y – **yellow**
1 or 3 × 10-7d/p/y – **green**

Table 7.1: Summary of risks

Public population density	196	Persons/km2
Public population density	0.000196	Persons/m2
Workers on site	150	Workers total, including contractors, peak
Surface area of site	156022	m2
Worker density on site:	0.000961	Workers/m2
Fraction of site within max safe radius	100%	

Major incident	**Consequence**	**Frequency per yr**	**Impact radius m**	**Average N outside site (Public)**	**1% Fatalities N**	**Individual risk contours**		
						Radius m	**Freq, per yr**	**Risk, d/p/yr**
SO2 tank toxic dispersion; full loss	Toxic	1.44E-09	10000	61600	616	4500	1.44E-09	1.44E-09
SO2 tank toxic dispersion; 50-mm hole	Toxic	1.44E-09	681	286	3	681	1.44E-09	2.88E-09
SO2 tank toxic dispersion; 10-mm hole	Toxic	1.44E-09	127	10	0	451	7.87E-07	7.90E-07
Ammonia toxic dispersion; full loss	Toxic	2.70E-08	377	88	1	377	2.70E-08	8.17E-07
Ammonia toxic dispersion; 50-mm hole	Toxic	2.70E-08	94	5	0	215	3.60E-07	1.18E-06
Ammonia toxic dispersion; 10-mm hole	Toxic	2.70E-08	19	0	0	215	2.31E-10	1.18E-06
CO2 toxic; full loss	Toxic	7.87E-07	211	27	0	183	3.21E-11	1.18E-06
CO2 toxic; 50-mm hole	Toxic	7.87E-07	34	1	0	180	3.21E-11	1.18E-06
CO2 toxic; 10-mm hole	Toxic	7.87E-07	10	0	0	127	1.44E-09	1.18E-06
Methane jet fire; 37.5 kW/m2; 50-mm hole	Thermal	3.00E-07	5	0	0	117	3.60E-07	1.54E-06
Methane jet fire; 12.5 kW/m2; 50-mm hole	Thermal	3.00E-07	11	0	0	117	2.31E-10	1.54E-06
Methane jet fire; 37.5 kW/m2; 10-mm hole	Thermal	3.00E-07	1	0	0	106	3.21E-11	1.54E-06
Methane jet fire; 12.5 kW/m2; 10-mm hole	Thermal	3.00E-07	3	0	0	104	3.21E-11	1.54E-06

Boiler pressure burst; 5 psi	Overpressure	6.68E-05	23	0	0	94	2.70E-08	1.57E-06
Boiler pressure burst; 2 psi	Overpressure	6.68E-05	42	1	0	60	3.21E-11	1.57E-06
Compressed air vessel pressure burst; 5 psi	Overpressure	6.68E-05	11	0	0	50	3.60E-07	1.93E-06
Compressed air pressure burst; 2 psi	Overpressure	6.68E-05	21	0	0	50	2.31E-10	1.93E-06
Molten Sulphur storage tank pool fire; 37.5 kW/m2	Thermal	5.00E-08	7	0	0	35	6.68E-05	6.87E-05
Molten Sulphur storage tank pool fire; 12.5 kW/m2	Thermal	5.00E-08	12	0	0	35	3.21E-11	6.87E-05
Molten Sulphur road tanker pool fire; 37.5 kW/m2	Thermal	3.21E-11	69	3	0	34	7.87E-07	6.95E-05
Molten Sulphur road tanker pool fire; 12.5 kW/m2	Thermal	3.21E-11	120	9	0	27	3.60E-07	6.99E-05
m-Naphthalene storage tank pool fire; 37.5 kW/m2	Thermal	5.00E-08	12	0	0	27	2.31E-10	6.99E-05
m-Naphthalene storage tank pool fire; 12.5 kW/m2	Thermal	5.00E-08	20	0	0	21	6.68E-05	1.37E-04
m-Naphthalene road tanker pool fire; 37.5 kW/m2	Thermal	3.21E-11	69	3	0	20	5.00E-08	1.37E-04
m-Naphthalene road tanker pool fire; 12.5 kW/m2	Thermal	3.21E-11	120	9	0	19	2.70E-08	1.37E-04
n-Heptane storage tank pool fire; 37.5 kW/m2	Thermal	5.00E-08	10	0	0	19	6.68E-05	2.04E-04
n-Heptane storage tank pool fire; 12.5 kW/m2	Thermal	5.00E-08	16	0	0	17	3.60E-07	2.04E-04
n-Heptane road tanker pool fire; 37.5 kW/m2	Thermal	3.21E-11	69	3	0	17	2.31E-10	2.04E-04
n-Heptane road tanker pool fire; 12.5 kW/m2	Thermal	3.21E-11	120	9	0	16	5.00E-08	2.04E-04
Hydrogen jet fire; 50-mm hole; 37.5 kW/m2	Thermal	2.91E-07	1	0	0	12	5.00E-08	2.04E-04
Hydrogen jet fire; 50-mm hole; 12.5 kW/m2	Thermal	2.91E-07	1	0	0	12	5.00E-08	2.04E-04
Hydrogen jet fire; 10-mm hole; 37.5 kW/m2	Thermal	2.91E-07	1	0	0	11	3.00E-07	2.04E-04
Hydrogen jet fire; 10-mm hole; 12.5 kW/m2	Thermal	2.91E-07	1	0	0	11	6.68E-05	2.71E-04
Hydrogen full loss VCE; 5 psi	Overpressure	2.38E-07	6	0	0	10	7.87E-07	2.72E-04
Hydrogen full loss VCE; 2 psi	Overpressure	2.38E-07	10	0	0	10	5.00E-08	2.72E-04
n-Heptane storage tank full loss; VCE 5 psi	Overpressure	3.60E-07	117	8	0	10	2.38E-07	2.72E-04
n-Heptane storage tank full loss; VCE 2 psi	Overpressure	3.60E-07	215	28	0	9	3.60E-07	2.73E-04
n-Heptane road tanker full loss; VCE 5 psi	Overpressure	2.31E-10	94	5	0	9	2.31E-10	2.73E-04
n-Heptane road tanker full loss; VCE 2 psi	Overpressure	2.31E-10	170	18	0	7	5.00E-08	2.73E-04
n-Heptane storage tank 50-mm hole; VCE 5 psi	Overpressure	3.60E-07	27	0	0	6	2.38E-07	2.73E-04
n-Heptane storage tank 50-mm hole; VCE 2 psi	Overpressure	3.60E-07	50	2	0	5	3.00E-07	2.73E-04
n-Heptane storage tank 10-mm hole; VCE 5 psi	Overpressure	3.60E-07	9	0	0	3	3.00E-07	2.73E-04
n-Heptane storage tank 10-mm hole; VCE 2 psi	Overpressure	3.60E-07	17	0	0	1	3.00E-07	2.74E-04
n-Heptane road tanker 50-mm hole; VCE 5 psi	Overpressure	2.31E-10	27	0	0	1	2.91E-07	2.74E-04
n-Heptane road tanker 50-mm hole; VCE 2 psi	Overpressure	2.31E-10	50	2	0	1	2.91E-07	2.74E-04
n-Heptane road tanker 10-mm hole; VCE 5 psi	Overpressure	2.31E-10	9	0	0	1	2.91E-07	2.75E-04
n-Heptane road tanker 10-mm hole; VCE 2 psi	Overpressure	2.31E-10	17	0	0	1	2.91E-07	2.75E-04

Individual risk, d/p/yr	2.75E-04

1. Risk levels and ranking at key locations

The risk rankings for the site are as follows:

- First priority: Loss of containment of liquid sulphur dioxide from the storage tank to release a toxic gas cloud.
- Second priority: Loss of containment of ammonia from the compressor station and loop to release a toxic gas cloud.
- Third priority: Pool fire at the molten sulphur storage tank or road tanker.
- Fourth priority: Pool fire at the methyl naphthalene storage tank or road tanker.
- Fifth priority: Loss of containment of n-heptane from the storage tank or road tanker to create a VCE.

2. Societal risks- F-N curve (including on-site populations)

Site graph 🟥

Intolerably high line 🟦

Tolerable with ALARP between blue and orange lines

Acceptably low line 🟨

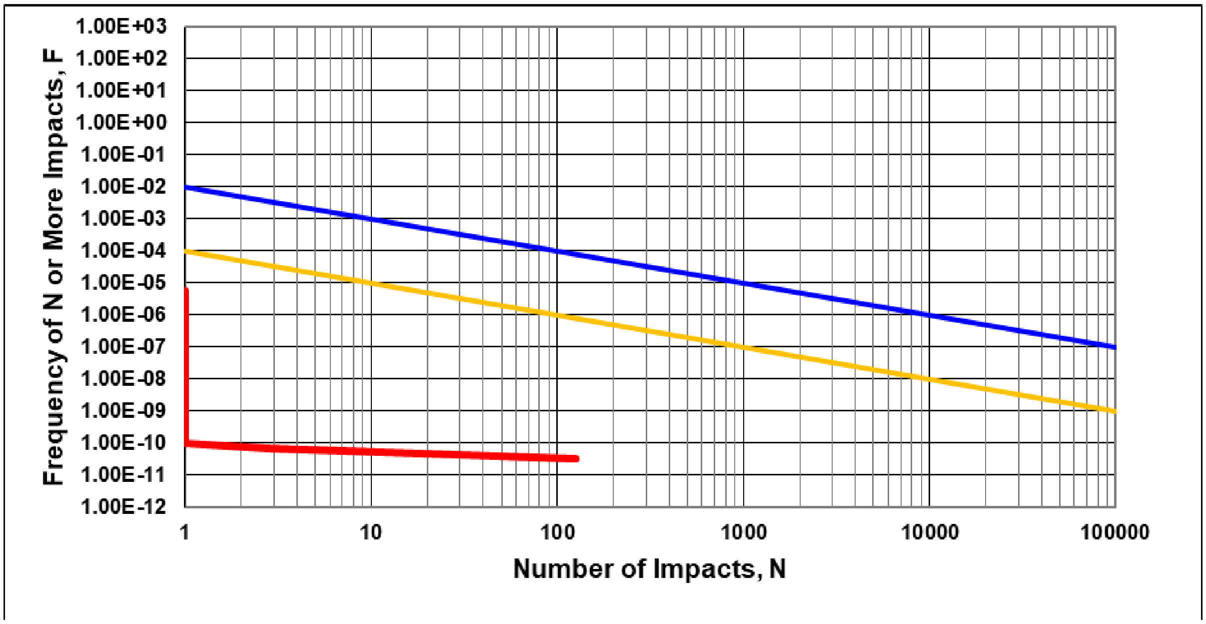


Figure 7.1: FN Curve for societal risk at 1% fatalities

3. Individual risk transect

Site graph —

Tolerable for public - - -

Tolerable for employees —

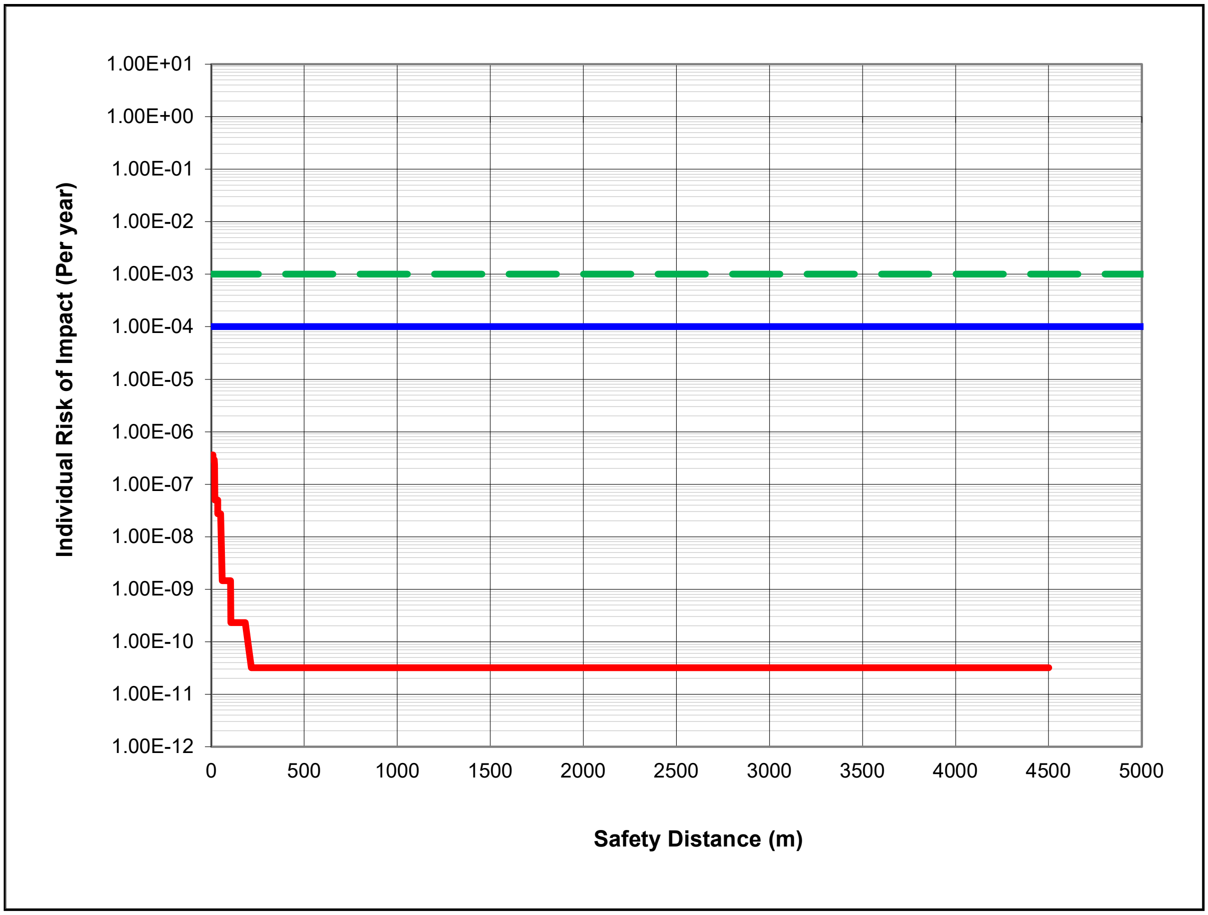


Figure 7.2: Individual risk transect

4. Individual risk contours

Figure 7.2: Individual risk contours

Colour Code

1 × 10-3 d/p/y – **blue**
1 × 10-4 d/p/y – **red**
1 × 10-5 d/p/y – **orange**
1 × 10-6 d/p/y – **yellow**
1 or 3 × 10-7d/p/y – **green**

8 Risk judgement

The risk associated with the operations on this site are judged as follows:

a) The cumulative individual safety risks for the site is 2.75 E-4 d/p/yr.
b) Individual risk at the site is lower than the norm of 1.0 E-3 d/p/yr for the public and for employees on site.
c) Societal safety risks on this site are acceptably low.

Refer to Appendix 8 for societal and individual risk criteria.

9 Risk treatment

1. Risk reduction options including suggested preventative and mitigative measures

   a) The National Chief Inspector of the Department of Employment and Labour must be notified in writing about the outcome of this risk assessment review.
   b) The Provincial Chief Inspector of the Department of Employment and Labour must be notified in writing about the outcome of this risk assessment review.
   c) The Emergency Services of Newcastle Municipality must be notified in writing about the outcome of this risk assessment.
   d) An advertisement must be published in a local community newspaper to inform members of the public about the outcome of this risk assessment, as follows:

NOTIFICATION OF
MAJOR HAZARD INSTALLATION
BROTHER CISA; NEWCASTLE CHEMICAL PARK

Notice is hereby given in accordance with Section 3(b) of the Major Hazard Installation Regulations R.692 of 30 July 2001 that an approved inspection authority conducted a major hazard installation risk assessment on the plant of Brother CISA in Newcastle Chemical Park in Newcastle. The risk assessment report can be obtained in electronic format from the following address:

Nature & Business Alliance Africa (Pty) Ltd
Tel 011-958 2132
E-mail: alfonso@natbus-alliance.co.za

Interested and affected parties have 60 days from the date of publication of this advertisement to submit comments on the major hazard installation to the Head of the Emergency Services of Newcastle or to the Provincial Chief Inspector of the Department of Employment and Labour in KwaZulu-Natal.

   e) A permanent notice must be posted at each entrance to the site, as follows:

BEWARE

MAJOR HAZARD INSTALLATION

f) All safety warning signs on site must be inspected and replaced if faded or worn.

g) The emergency management plan must be updated when personnel changes or contact details occurs, in accordance with the guidelines given in this report.

h) All authorised operators must be trained in the application of the operating procedures applicable to their jobs.

i) The facility must remain under safety and security access control for 24 hours per day. The security guard on duty must comply with the following requirements:
    - The guard must be trained in the potential major incidents that could occur at the site as well as the emergency procedure that must be followed.
    - The guard must be linked via SMS or cellular phone with a responsible standby person at the site.
    - The guard must be able to contact the local Fire Department immediately.

j) Customer and staff parking bays must be located in an area where public vehicles will not cause obstruction to emergency vehicles.

k) Prior to any construction work on site, the local office of the Department of Employment and Labour must be notified in writing, in accordance with the Construction Regulations of the Department of Employment and Labour.

l) No modifications may be made to the facilities on site unless an MHI risk assessment has been done beforehand.

m) The site emergency management plan must be updated in accordance with the findings contained in this risk assessment report.

n) The operating procedures for the Lanxess CISA plant must be updated regularly to include preventative measures against the loss of containment of hazardous chemicals.

o) Ignition sources at the natural gas facilities must be controlled. Guidelines for the control of ignition sources are as follows:
- Use only electrical equipment that is certified to be flameproof and spark proof.
- Control static electricity.
- Ensure that vulnerable equipment is properly bonded to ground.
- Prohibit smoking, open flames and sparks.
- Prevent mechanical sparks and friction.
- Use separator devices to remove foreign materials capable of igniting from process materials.
- Select and use industrial trucks properly.
- Use cartridge activated tools properly.

p) Implement an equipment preventative maintenance programme.

q) The outcome of the risk assessment must be brought to the attention of all the employees and all employees must be fully trained for their jobs, especially plant operators.

r) All gas and liquid pipelines must be protected against corrosion, to prevent leaks.

s) A Maintenance Plan must be maintained for all the equipment used on the plant. The Plan must contain at least the following:
   - List of all gas equipment and facilities on the plant.
   - Maintenance frequency.
   - Particulars of maintenance activities that must be performed on the listed equipment.
   - Responsible person.

t) No waste, especially flammable waste, must be allowed near the natural gas kiln.

u) All gas equipment and facilities on the plant must be inspected on a regular basis (at least once per year) by means of an Inspection Register. The Register must contain at least the following:
   - List of all equipment and facilities on the facility.
   - Equipment items that must be inspected.
   - Facilities that must be inspected.
   - Areas that must be inspected.
   - Inspection findings.
   - Responsible person who carried out the inspection.

v) All authorised operators of plant and equipment must be trained in the application of the operating procedures.

w) The driver of flammable chemical delivery trucks must never reverse or maneuver the truck on site in the plant. Enough space must always be available for the truck to enter and exit the offloading point easily and safely, without any maneuvering.

x) All operating personnel at the plant must be trained to be aware of the dangers involving hazardous chemicals, especially during deliveries by road tanker or rail tank car and to be able to act in case of emergencies.

y) The Emergency Evacuation Procedure aimed at workers as well as the surrounding households must be updated regularly in collaboration with the local fire brigade.

z) The Emergency Management Plan and Emergency Evacuation Procedure of Lanxess CISA plant must be tested at least once every 12 months by means of mock emergencies. The fire brigade must be invited to participate in such tests.

aa) Resident and visitor parking bays must be located in an area where public vehicles will not cause obstruction to emergency vehicles.

bb) The plant must be protected against lightning through a proper earthing system.

cc) Pipelines carrying flammable gas or liquids need special attention as high risk components.

dd) The caustic scrubber system for the sulphur dioxide vents must be inspected regularly and maintained properly to ensure that it remains in good working order.

ee) The hazardous chemicals must be stored safely, separately and must never be allowed to mix.

2. Conclusions on ALARP

It is essential that mitigation measures are applied at this site, as outlined above in this report. The risk criteria in comparison with the site assessment are given in Table 9.1 below.

Table 9.1: Summary of site assessment against risk criteria

Frequency, deaths/person/year		Site assessment
	Public	
Intolerable	>1.0 E-4	🟥
Tolerable	1.0 E-4 to 1.0 E-6	🟧
Broadly acceptable	<1.0 E-6	🟩 X
	Employees	
Intolerable	>1.0 E-3	🟥
Tolerable	1.0 E-3 to 1.0 E-5	🟧
Broadly acceptable	<1.0 E-5	🟩 X
Graph of ALARP		
Intolerable		🟥
Tolerable with mitigation (ALARP)		🟧
Acceptably low		🟩 X

10 Land use planning

1. Restricted development distance

The site is located in an industrial and commercial area, which have been fully developed. Existing facilities around the site may, however, be expanded or redeveloped in future.

2. Plot of three land-use planning zones on a map of the area

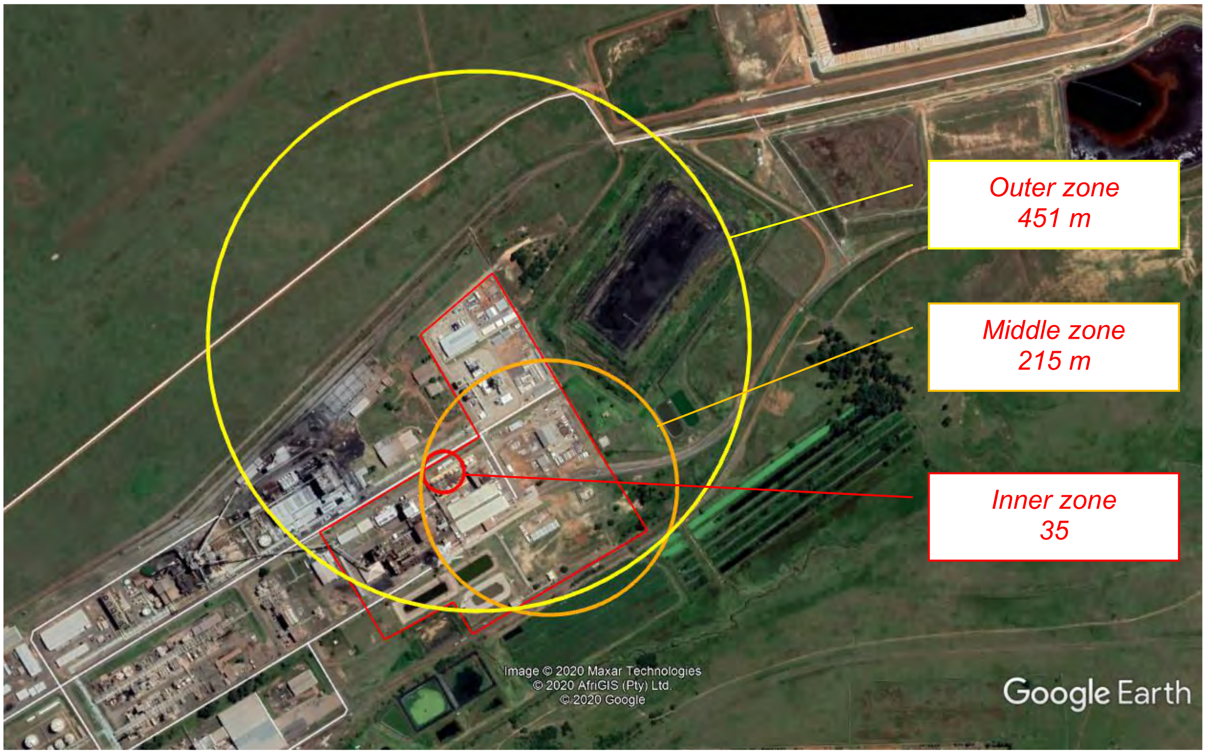


Figure 9.1: Land-use planning zones

Key

Red: Inner zone > 10 chances of a major incident per million per annum (1.0 E-5 per year).

Orange: Middle zone > 1 chance of a major incident per million per annum (1.0 E-6 per year).

Yellow: Outer zone > 0.3 chances of a major incident per million per annum (3.0 E-7 per year).

3. Highlighting of possible land-use planning conflicts for new installations

a) There are no developing conflicts for this site at the time of the risk assessment.
b) To the best knowledge of the risk assessor there are no major hazard installation within reach of a relevant worst-case major incident that can occur at this site.
c) If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

11 Emergency response data

a) The emergency response plan of the site is enclosed in Appendix 4.

b) Evaluation of the suitability of the onsite emergency response plan in terms of the risk assessment results.

A General Requirements	**Is it contained in the Plan?**
The Plan must have a date of compilation	Yes
A clear indication must be given when and how the Plan will be revised.	Yes
Various categories of emergency situations must be defined.	Yes
The Plan must consider all potential natural or man-made emergencies that could disrupt the operation of the MHI facility.	Yes
The Plan must consider all potential internal sources of emergencies that could disrupt the operation of the MHI facility.	Yes
The Plan must consider the impact of all internal and external emergencies on the operation of the MHI facility.	Yes
Response actions must be tailored to the specific MHI facility.	Yes
The Plan must contain a list of key personnel with their responsibilities and contact information.	Yes
The Plan must contain a list of local emergency responders with their contact information.	Yes
The Plan must contain the names, titles, departments and contact numbers of individuals who can be contacted for additional information or an explanation of duties and responsibilities applicable to the Plan.	Yes
The Plan must outline how rescue operations will be performed.	Yes
The Plan must outline how medical assistance will be provided.	Yes
The Plan must state how and where personal information on employees can be obtained in an emergency.	Yes
The Plan must state how affected members of the public will be contacted, who the contact persons are and their contact numbers.	Yes
B Evacuation Procedure	
The Plan must identify the conditions under which an evacuation of people would be necessary.	Yes
The procedure must make provision for the evacuation of employees on site as well as affected members of the public.	Yes
The Plan must outline a clear chain of command and designate a specific person with a standby authorized to order an evacuation or operational shutdown.	Yes
The Plan must address the types of actions expected from different employees for the various categories of emergencies.	Yes
The Plan must identify who will stay behind to shut down critical operations during an evacuation.	Yes
The Plan must show specific evacuation routes for employees and these must be posted at the MHI facility where they are easily accessible to all employees.	Yes

The Plan must show specific evacuation routes for members of the public and these must be easily accessible to the public.	Yes
The Plan must prescribe procedures for assisting people during an evacuation, people with disabilities or those who cannot speak English or read.	Yes
The Plan must show one or more assembly areas where employees will gather.	Yes
The Plan must include a method of accounting for all employees.	Yes
The Plan must explain how visitors will be assisted and accounted for during an evacuation.	Yes
C Reporting of an Emergency Condition	
The Plan must outline the method of reporting fires and other emergencies to the local emergency services.	Yes
The Plan must outline the method of alerting employees, including disabled employees, to evacuate from the MHI site or to take other action.	Yes
D Employee Training and Drills	
The Plan must state how and when employees will be trained with regard to the types of emergencies that may occur, their responsibilities and the actions that they must take.	Yes
The Plan must state how and when retraining of employees will take place.	Yes
The Plan must state how often drills will take place. These drills must involve all employees at the MHI site as well as affected members of the public.	Yes
E Management of the News Media	
The Plan must indicate the person whose responsibility it will be to provide information about the emergency to the news media.	Yes
The Plan must state clear channels for the approval of media releases to journalists.	Yes

12 Conclusions

a) The Occupational Health and Safety Act (Act 85 of 1993) defines a major hazard installation as "*an installation-*
   - *where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or*
   - *where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident*".

   The Explanatory Notes on the Major Hazard Installation Regulations issued in April 2005 by the Chief Directorate of Occupational Health and Safety of the Department of Employment and Labour explains the following:

   "*What is important here is to know that there are two reasons that can determine when an installation is a major hazard installation (MHI). The first reason is when there is more than the prescribed quantity of a substance. The quantities and type of substances are prescribed in the General Machinery Regulation 8 and its Schedule A, on notifiable substances. The second reason is where substances are produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident. The important issue is the potential of an incident and not whether the incident is a major incident or not. The potential will be determined by the risk assessment.*

   A major incident means an occurrence of catastrophic proportions, resulting from the use of plant or machinery, or from activities at a workplace. It is impossible to put a specific value to "catastrophic" because it will always differ from person to person and from place to place. However, when the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident can be seen as catastrophic".

b) The facility is classified as a major hazard installation, because a major incident at the site will impact members of the public outside the boundaries of the premises.
c) Individual risk at the site is tolerable for short effect zones (less than 50 meters) for the public and for employees on site, mainly as a result of a possible boiler rupture or maize dust cloud explosion.
d) The cumulative individual safety risks for the site is 1.1 E+1 deaths per person per year, which is higher than the norm due to possible BLEVEs on the LPG and acetylene cylinders, with effect zones less than 20 meters.
e) Societal safety risks on this site are tolerable and require the implementation of the recommended ALARP mitigation measures.
f) There are no developing conflicts for this site.
g) To the best knowledge of the risk assessor there are no major hazard installation within reach of the worst-case major incident that can occur at this site.
h) If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

13 Proof of competency

Alfonso Niemand is the author of this report.

In terms of the ISO/IEC-17020 standards he has been appointed as Technical Manager of Nature & Business Alliance Africa (Pty) Ltd.

Alfonso holds the following qualifications:

- *Baccalaureus Scientiae (BSc), University of South Africa.*
- *Master's Degree in Business Leadership (MBL), University of South Africa.*
- *PhD, University of the Free State.*
- *Certificate course in the Integration of Safety, Health, Environmental, Risk and Quality Management Systems, University of Potchefstroom, South Africa.*
- *Certificate course in Environmental Management, University of Pretoria, South Africa.*
- *Certificate courses as Safety and Health Representative, Occupational Health and Safety Services and Advantage ACT.*
- *Certificate course in Health and Safety Incident Investigation, Advantage ACT.*
- *Training in Aloha and Cameo software applications for risk incident consequence modelling, University of California, Davis Campus, USA.*

Alfonso Niemand holds the following memberships:

- *International Association for Impact Assessment (IAIA).*
- *South African Right of Way Association (SARWA).*
- *South African Association for Professional Managers (SAAPM, registration 9/2/99)*
- *South African Council for Natural Scientific Professions (SACNASP, registration 200026/04).*
- *SA Institute of Occupational Safety and Health (SAIOSH).*
- *Disaster Management Institute of South Africa (DMISA).*
- *Southern Africa Society for Disaster Reduction (SASDiR).*
- *International Society for Integrated Disaster Risk Management (IDRiM).*

Alfonso Niemand has 40 years' experience in the petrochemical and construction industries in South Africa. He worked with the Environmental Protection Agency of the United States in 1981 for the environmental, safety and health mapping of an oil-from-coal facility in South Africa.

sanas
South African National
Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2)(b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD
Co. Reg. No.: 2003/020335/07
ROODEPOORT

Facility Accreditation Number: **MHI0004**

is a South African National Accreditation System accredited Inspection Body to undertake **TYPE A** inspection provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation, Annexure "A", bearing the above accreditation number for

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:2012

The accreditation demonstrates technical competency for a defined scope and the operation of a management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates

Mr R Josias
Chief Executive Officer

Effective Date: 08 August 2017
Certificate Expires: 07 August 2021

This certificate does not on its own confer authority to act as an Approved Inspection Authority as contemplated in the Major Hazard Installation Regulations. Approval to inspect within the regulatory domain is granted by the Department of Labour.

ANNEXURE A

SCHEDULE OF ACCREDITATION

Facility Number: MHI0004

TYPE A

Permanent Address:
Nature & Business Alliance Africa (Pty) Ltd
No. 13 Sedona Complex
Cnr Flora Haase & Totius Streets
Amorosa
Roodepoort
1725

Tel: (011) 958-2132
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Postal Address:
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Mailroom Suite 16
Strubens Valley
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1735

Issue No.: 09
Date of issue: 08 August 2017
Expiry date: 07 August 2021

Nominated Representative:
Dr A Niemand

Quality Manager:
Ms A Duff

Technical Manager:
Dr A Niemand

Technical Signatory:
Dr A Niemand

Field of Inspection	Service Rendered	Codes and Regulations
Regulatory: The supply of services as an Inspection Authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R 692 of 30 July 2001	Major Hazard Installation Risk Assessments for the following material categories: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. **5 (5) (b)** i) Frequency/Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency planning reviews SANS 31000 SANS 31010 Guidelines for Chemical Process Quantitative Risk Analysis of the Centre for Chemical Process Safety (CCPS), American Institute of Chemical Engineers Areal Locations of Hazardous Atmospheres (ALOHA) Computer Programme developed by the US Environmental Protection Agency (EPA), US National Oceanic and Atmospheric Administration (NOAA), US Chemical Emergency Preparedness and Prevention Office (CEPPO) and US Hazardous Materials Response Division (HMRD)

Original date of accreditation: 08 August 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

labour

Department:
Labour
REPUBLIC OF SOUTH AFRICA

National Department of Labour
Republic of South Africa

APPROVED INSPECTION AUTHORITY

Registered in accordance with the provisions of the Occupational Health and Safety Act, Act 85 of 1993, as amended and the Major Hazard Installation Regulations.

This is to certify that:

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD

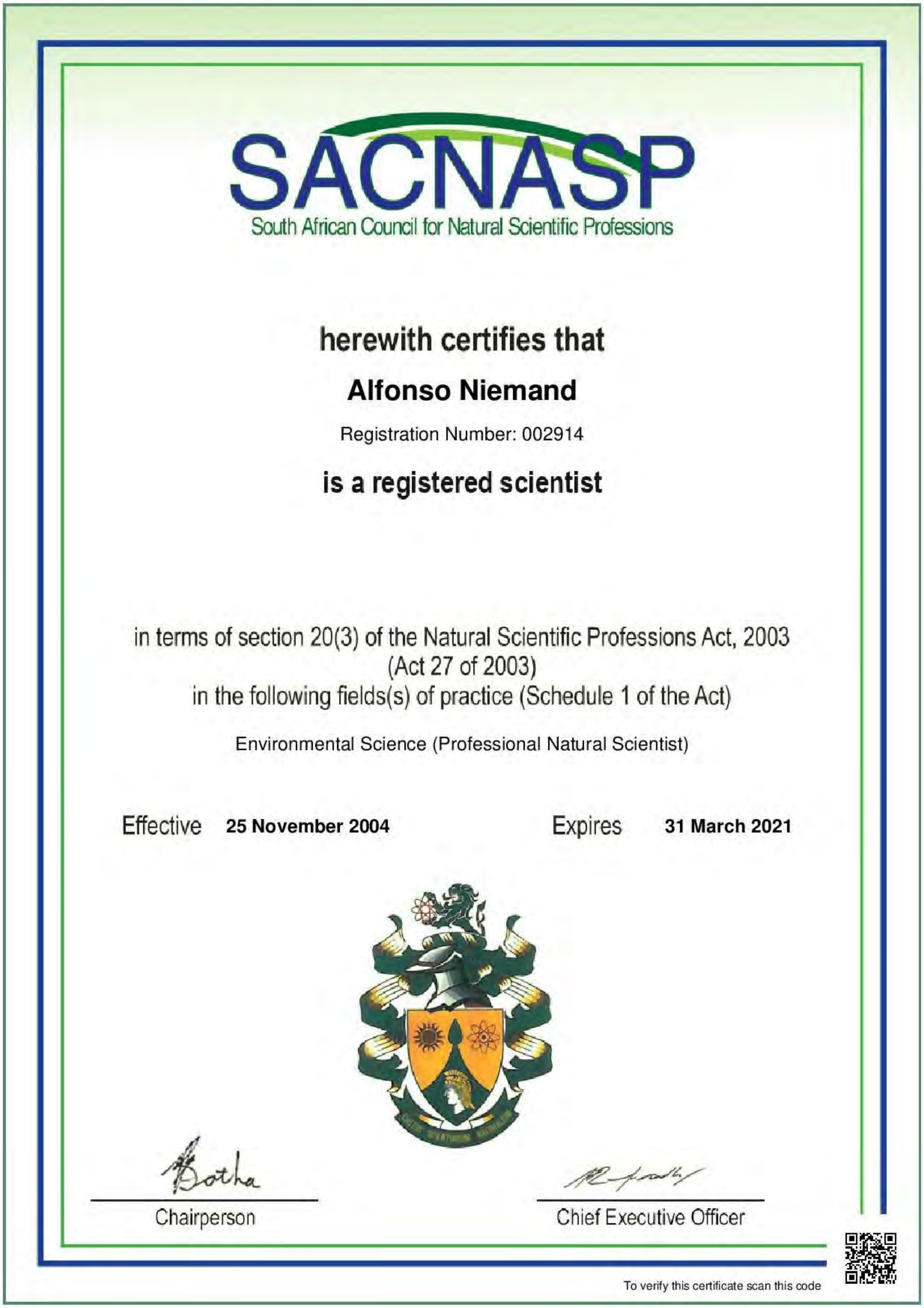
has been registered by the Department of Labour as an Approved Inspection Authority: Type A, to conduct Major Hazard Installation Risk Assessment, in terms of Regulation 5(5)(a), of the Major Hazard Installation Regulations.

CONDITIONS OF REGISTRATION:

- The AIA must at all time comply with the requirements of the Occupational Health and Safety Act, Act 85 of 1993, as amended.
- This registration certificate is not transferable.
- This registration will lapse if there is a name change of the AIA or change in ownership.

CHIEF INSPECTOR

Valid from: **08 August 2017**
Expires: **07 August 2021**
Certificate Number: **CI MHI 0002**



SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Alfonso Niemand

Registration Number: 002914

is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Environmental Science (Professional Natural Scientist)

Effective **25 November 2004** Expires **31 March 2021**

Botha
Chairperson

Chief Executive Officer

To verify this certificate scan this code

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15 Appendices

Appendix 1: Raw data

Brother CISA, Newcastle SA
Site Survey: 23 March 2020
Jacque Hunlun
Dawie van der Merwe

Inventory:

Sulphur dioxide liquid, 60 tons at 6 barg vapour pressure. Design pressure is 10 barg. Always filled only to 80% capacity to allow for expansion. Bund 80 m2.
Anhydrous ammonia, 850 kg. Six top-up cylinders of 61 kg each. One compressor at 12 barg normal operating pressure.
Carbon dioxide, two vessels of 25 m^3 each at 17 barg; one vessel of 100 m^3 (6 tons) at 32 barg.
Natural gas (methane), supplied via pipeline of 150 mm diameter at 6.25 barg, to fuel a kiln and one boiler.
Hydrogen, electrolysis plant produces hydrogen at a continuous rate and stored in a vessel of 37 m^3 at a pressure of 0.5 barg
Boiler, natural gas boiler, 25 m^3. 8 barg operating pressure
Compressed air vessel, three vessels of 5.3 m^3 each, operating pressure is 11 barg

Liquid sulphur storage tank, 10 000 liters
Liquid sulphur road tanker, 5 000 liters
Methyl naphthalene storage tank, 200 000 liters
Methyl naphthalene road tanker, 45 000 liters
n-Heptane storage tank, 50 000 liters
n-Heptane road tanker, 45 000 liters

A Niemand
AIA

No T1 Updated	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	Sulphur dioxide liquid	1079 7446-09-5	2.3	60 m3 (84 000 kg)	80 m2	60 m3 every two weeks	84 000 kg
2	Ammonia liquid	1005 7664-41-7	2.3	850 kg One compressor; 12 barg	-	Closed system	850 kg
3	Carbon dioxide	1013 124-38-9	2	Two tanks of 25 m3; 17 barg	-	Own production and storage	25 m3
4	Methane via pipeline (natural gas)	1971 74-82-8	2.1	150-mm pipeline; 6.25 barg to kiln	-	6 000 nm3 per hour	150-mm hole for 10 minutes
5	Steam boiler	-	-	25 m3; 21 barg	-	-	-
6	Compressed air vessels	-	-	Three tanks of 5.3 m3; each 8 barg	-	-	-
7	Liquid sulphur storage tank (molten)	2448 7704-34-9	4.1	80 000 liters	45 m2	30 tons per day	80 000 liters
8	Liquid sulphur road tanker (molten)	2448 7704-34-9	4.1	20 000 liters	-	30 tons per day	20 000 liters
9	Methyl naphthalene storage tank	1760 91-20-3	4.1	200 000 liters	120 m2	10 tons per day	200 000 liters
10	Methyl naphthalene road tanker	1760 91-20-3	4.1	20 000 liters	-	10 tons per day	20 000 liters
11	n-Heptane storage tank	1206 142-82-5	3	50 000 liters	80 m2	45 000 liters every six months	50 000 liters
12	n-Heptane road tanker	1206 142-82-5	3	20 000 liters	-	20 000 liters every six months	20 000 liters
13	Hydrogen storage tank	1049 1333-74-0		37 m^3 at a pressure of 0.5 barg.	-	3 m3 per day	37 m3

Appendix 2: Case study

Sulphur fire

As a result of trade sanctions against South Africa, the stockpiling of solid sulphur had to be done in South Africa, because sulphur was considered as a strategic raw material in the manufacture of sulphuric acid and fertiliser. In the late 1960s, AECI Ltd began storing sulphur at its Somerset West factory in the Western Cape province. The stockpile comprised 15 000 tons of sulphur in 1967, which was increased to 30 000 tons in 1981. In the beginning housekeeping practices included regular controlled burning around the stockpile for firebreaks, grass cutting and the return of eroded sulphur at the foot of the stockpile. Stockpiling was discontinued in 1988 and the pile was gradually depleted until 1996. Immediately prior to the December 1995 fire the pile contained 15 710 tons of solid sulphur.

Sulphur was stored in nine discrete heaps, three metres high. The stockpile surface area covered about 60 000 square metres and was covered with a sulphur ‘‘blanket’’ about 0.3 metres thick. A road, railroad siding and storm canal bordered the stockpile. Several firebreaks surrounded the property, except on the eastern side, designed to protect explosive magazines and a munitions factory on the nearby Somchem property north of the sulphur stockpile. Firebreaks were ploughed every year. There was no fire protection plan for the sulphur stockpile. The closest water hydrant was one kilometre away, but the water supply was insufficient for proper fire control. Fire-fighting facilities included an internal company fire team of two field personnel, the Stellenbosch fire station 25 kilometres away and the Strand (Somerset West) fire station two kilometres from the stockpile.

On 13 December 1995 the sulphur stockpile was set alight by a veld fire under influence of strong winds. It was estimated that more than 14 000 tons of sulphur dioxide (SO_2) was released into the atmosphere for 20 hours. High and persistent winds, typical of the Western Cape region, significantly reduced the effectiveness of fire-fighting activities and increased the severity of impacts. Adjacent urban and agricultural areas were seriously affected by the toxic sulphur dioxide cloud. Thousands of people were evacuated from the nearby town of Macassar located about four kilometres downwind. Several deaths were caused by the toxic dispersion. Apart from human impacts, severe damage was caused to plants and some animal deaths occurred up to about 30 kilometres from the site. The sulphur dioxide concentration estimated in the community of Macassar reached seriously dangerous levels, exceeding 100 ppm.

The UK Independent newspaper (1996) reported at the time that environmentalists raised fears of a “South African Bhopal” as a result of the sulphur fire. Activists claimed that the AECI company – a subsidiary of the Anglo-American Corporation – was refusing to pay fair compensation to the victims of the disaster. It further reported that the cloud of toxic gas was so thick that it was considered to close down Cape Town International Airport, 22 kilometres away. Vineyards 15 to 20 kilometres away were damaged. Many people thought the smoke was coming from teargas.

One female victim interviewed shortly afterwards said, “I coughed until my chest hurt. I ran to the tap to wash my face, but the smell was too strong to be teargas.”

At the time, the South African Environmental Justice Networking Forum believed that compensation payments from AECI had been “completely arbitrary and unfair”. Claims assessors were apparently offering most victims between R250 and R500 compensation. “There is no independent attempt to put a price on things. They are just offering people money, and because of the poverty and the need for immediate cash, people are taking it ... People are getting totally different pay-outs for the same damage,” a forum spokesman said.

Members of the local community near the disaster area were angry that some farming families had received millions of rand in compensation and accused AECI of racism. AECI said the average pay-out was R700 per affected person and that 4 500 of an expected 8 000 claims had been settled at that stage, which gave an estimated total claim figure of R5.6 million. Most of these claims were for damage to gardens, curtains and carpets, where synthetic fibres reacted chemically with the sulphur dioxide, and for the looting of personal and household goods during the evacuation of homes and workplaces. AECI said there were no arbitrary decisions on claims and that varying degrees of damage and loss required different pay-out amounts. “It is very difficult to generalise when you are dealing with 8 000 claims but there is a pattern,” they said.

Medical compensation became a serious point of contention among affected community members. The community wanted guarantees that their entire medical costs and possible future treatment costs would be paid by AECI. They wanted a medical clinic set up in the township to monitor the long-term effects of the victims’ exposure to sulphur dioxide gas.

The Somerset West sulphur fire was the first disaster in South Africa where a large number of people were exposed to sulphur dioxide fumes in such close proximity. Doctors generally had very little knowledge about the possible long-term consequences of exposure to the gas. The Justice Networking Forum (Independent 1996) said that asthma sufferers were badly affected and many people who had previously been healthy were beginning to develop asthma-like symptoms. There were also fears for the unborn children of pregnant women exposed to the gas. The AECI company had said in a statement that it did not anticipate problems with them paying healthcare cost to victims, but it first wanted to evaluate the results of its health study before it could agree on a compensation figure. The affected community doubted the study, because they had not been consulted and claimed that the study was restrictive with the terms of references set unilaterally by the company. The insurers of AECI expected at the time to pay R25 million for immediate claims.

The Mail & Guardian (1997) reported in South Africa that the Desai Commission of Inquiry had found AECI negligent with regard to the sulphur fire at its Somerset West stockpile. The newspaper reported that the commission noted that from the establishment of the stockpile in 1967 to the time of the fire in December 1995, no steps had been taken by AECI to assess the fire risk and no precautionary measures had been put in place by the company. In his report to the Minister of Environmental Affairs (Desai Commission 1997) Judge Siraj Desai said that, as far as the safety of the stockpile and surrounding communities was concerned, AECI had forgotten about the sulphur pile and had allowed it to contaminate the surrounding area without control.

The commission found that there had been five fires at the stockpile between 13 December and 16 December 1995, with the last four fires caused by re-ignition of hot spots from the previous fires. The final fire on 16 December resulted in the evacuation of the nearby town of Macassar. In that fire 7 250 tons of sulphur was burned, producing about 14 500 tons of toxic sulphur dioxide released into the atmosphere. Several people died after inhaling toxic fumes and local farmers suffered huge crop losses as a result of acid rain.

The question that arises is: What are the long-term health effects of the Somerset West sulphur fire? City Press reported as follows in 2011, 15 years after the disaster:

“Two weeks ago, 52-year-old Magdalene Hess was rushed to the Hottentots Holland Hospital in Somerset West, Western Cape, after suffering a severe attack of asthma. “I could not breathe. I have regular attacks, but this was the worst. I could feel death coming for me,” she said as she lay recovering in the crowded ward. She spent three days in the intensive care unit. Hess had never suffered from asthma before more than 16 000 tons of sulphur, stockpiled at the AECI chemical and explosives - factory in Somerset West, ignited on December 16, 1995.

The blaze was estimated to have emitted 14 500 tons of sulphur dioxide in 21 hours. Thousands of residents of the poor working-class suburb of Macassar were evacuated and reports indicated that two men, both asthma sufferers, died as a - result of the fumes. Fifteen years later, Hess is one of thousands of residents of - Macassar and adjacent Firgrove whose health has significantly deteriorated since the fire. Anecdotal evidence points to an unusually high incidence of respiratory illnesses and skin and eye allergies plaguing residents since the fire.

Exposure to high levels of sulphur dioxide is known to be fatal and the levels of it in Macassar were at times measured at over the Immediately Dangerous to Life or Health (IDLH) level of 100 parts to a million. And yet the affected Macassar residents are still struggling to get compensation from AECI, even though the company is alleged to have paid out millions to affected farmers in the area. Residents say the farmers received immediate pay-outs.

“The farmers easily got R20 million for loss of crops and animals, but AECI’s lawyers struggle to give us R3 000 for the inconvenience. We are just brown people,” said vice-chair of the Macassar Community Forum, Albert Williams.

It would appear AECI moved to minimise compensation claims in the days after the disaster. George Liddle, former chairperson of the now defunct Macassar Disaster Action Committee, said that in the days after the fire, AECI offered compensation to residents who came to its offices. He said pay-outs ranged from R50 to R1 000 and recipients had to sign a waiver that relinquished their rights to submit any future claims. “Most residents were unaware they were signing away their rights,” he said.

“People just accepted cash with no legal advice. Some of these people were illiterate. One father accepted a few hundred rand for his entire household.”

In 1997 the Desai National Commission of Inquiry found AECI had been “casually negligent” as it had not taken any steps to assess the fire risk or establish precautionary measures. The Department of Trade and Industry, which owned the stockpile, was also found to have been negligent.

Liddle said the commission agreed that AECI would pay out a fixed fee of R3 000 to residents for inconvenience. Many are still waiting to receive their money. In July last year, frustrated at the long wait, the Macassar Community Forum approached attorney Rob Green, the founder and chairperson of Family Law Clinics of South Africa. Green said part of the problem might have been that the Macassar Disaster Action Committee had previously approached seven law firms and some residents retained their own lawyers, which might have caused overlaps and confusion. The lawyers he was now approaching for clarity “were not being very cooperative.
The University of Cape Town (UCT) conducted one set of follow-up medical evaluations from 2001 to 2003. Another UCT study published last year indicated that residents who had reported persistent lower and upper respiratory system disease after the fire had experienced significant deterioration in their health (Rajani 2010). Despite the Desai Commission’s request that follow-up evaluations be carried out on the effects of the fire, no known recent follow-up environmental studies had been conducted in the affected areas. Moses Randitsheni, the media liaison officer of the Department of Environmental Affairs, said nobody in the department was familiar with the case.

Asked for comment, Walkers Attorneys Incorporated director John O’ Leary, who acts for AECI and its insurer, said the matter could not be discussed due to legal processes. AECI said it had nothing further to add, and no comment was forthcoming from the Department of Trade and Industry despite repeated requests for information”.

The study by Rajani (2010) was aimed at determining the health-related quality of life in Macassar residents with persistent lower respiratory symptoms (PLRS) and/or asthma, six years after the sulphur stockpile fire disaster in Somerset West. A cross-sectional analysis of responses from affected residents was conducted six years after the incident. Information was obtained from a dataset of 4 000 respondents to an interviewer-administered questionnaire that included medical history, respiratory symptoms and health-related quality of life. The study used information for three different time points: prior to, and one year and six years after the fire and revealed the following:

- A total of 246 records of residents, 74 with PLRS/asthma and 172 without PLRS/asthma, were analysed.
- The mean age of the symptomatic group was 49 years and 47 years in those without symptoms.

- Approximately 60% of the residents were current and ex-smokers in both groups.
- A greater proportion were women (61.3%) and 68% of women reported PLRS/asthma.
- The mean scores were significantly lower for the symptomatic group in the Physical Functioning (24 vs. 39), Role Physical (33 vs. 48) and General Health domain (24 vs. 37).
- Residents with PLRS/asthma were more likely to experience a significant decline in their Role Physical (OR = 1,97; CI 1,09–3,55) and General Health (OR = 7,07; CI 2,88–17,35) at year 1 and General Health (OR = 3,50; CI 1,39–8,79) at year 6, compared to the asymptomatic group.
- Residents with co-morbid RUDS (reactive upper airways dysfunction syndrome) demonstrated even stronger associations for General Health (OR = 7,04; CI 1,61–30,7) at year 1 and at year 6 (OR = 8.58; CI 1,10–65,02).
- The study highlights the long-term adverse impact on health-related quality of life among residents with lower and upper airways disease following a sulphur stockpile fire disaster.
- A major concern in a chemical disaster, whether it be atmospheric dispersion of toxic gases, or soil or water pollution, is delayed deaths and injuries, which are more difficult to assess. These can be quite significant. The public potentially affected by accidents is, most of the time, either inside or adjacent to a major hazard installation site or near transportation routes, which facilitates quick evacuation. However, dispersed populations may be affected through water or food chain contamination (OECD 1996).
- The Code of Practice of the International Labour Organisation for the prevention of major industrial accidents (International Labour Organisation 1991) recognised the risks associated with industrial installations where hazardous substances are produced and stored. Increasing production, storage and use of these substances created a need for control in order to protect employees, the public and the environment. The Code of Practice contains the following eight components, which have a bearing on this research for the formulation of a model for the regulatory management of hazardous installations:
- Definition and identification of major hazard installations in terms of the specific hazardous substances on site and their allowable storage quantities. The substances are classified as very toxic and toxic chemicals, flammable gases and liquids, and explosive substances. The quantum of the hazardous substances handled or stored on site is clearly important, because a major incident involving these substances is a function of its mass. If an analogy is drawn with the Somerset West disaster, the bigger the sulphur stockpile, the higher the risk of a toxic gas cloud formation in case of a fire.
- Information about the installations that includes a safety report, detail about the design and operation of the installation, identified hazards, safety management, precautionary measures and emergency planning.
- Assessment of major hazards such as uncontrolled events that can result in fires, explosions and the release of a toxic substance. The consequence of a major accident must be assessed, including its likelihood (probability) and possible domino effects from one installation to another.
- Control of the causes of major industrial accidents, through good design and operation, maintenance and regular inspections.

- Safe operation of major hazard installations. It should include responsibility for operating and maintenance, training of operators, operating procedures and the recording and analysis of near misses.
- Emergency planning as a collaborative exercise between the operator of the hazardous installation and the competent authorities such as local emergency services, although the emergency response planning function lies with the operator of the installation. The focus must be on the protection of people, both employees and the public around the installation, property and the environment.
- Siting and land-use planning, by ensuring that there is sufficient separation between the hazardous installation, other hazardous installations, residences and facilities such as airports and water reservoirs, which are vulnerable to impacts from the hazardous installation. Proposed developments near major hazard installations should take account of the vulnerability of individuals at the development, for example children, disabled people and elderly people.
- Inspection of major hazard installations by external competent authorities and an internal team composed by the operator of the hazardous installation. The internal safety inspectors must be independent from the production section.

There is a distinct similarity between the Code of Practice of the International Labour Organisation (1991), the UK HSE Comah Regulations (UK Health and Safety Executive. 2010) and the South African Major Hazard Installation Regulations (2001). As far as the vulnerability of surrounding communities is concerned, it is important to note that reference is made only to new land-use developments near existing hazardous installations and new hazardous installations near existing communities. The vulnerability of existing communities near existing hazardous installations, such as the Macassar community near the sulphur stockpile, is not addressed.

BOC Gases (1996) give the following warning statements in its MSDS for sulphur dioxide:

- Corrosive and irritating to the upper and lower respiratory tract and all mucosal tissue.
- Initial symptoms of exposure include nose and throat irritation, becoming steadily worse, suffocating and painful. The irritation extends to the chest causing a cough reflex which may be violent and painful and may include the discharge of blood or vomiting with eventual collapse.
- Other symptoms include headache, general discomfort and anxiety.
- Chemical pneumonitis and pulmonary oedema may result from exposure to the lower respiratory tract and deep lung areas.
- Repeated or prolonged low-level exposures may cause corrosion of the teeth.
- Reproductive toxicity and developmental changes in newborns have been observed in experimental animals exposed to sulphur dioxide.
- Sulphur dioxide is mutagenic in experimental cell assay systems.
- The STEL value of sulphur dioxide is 5 ppm. STEL is the average concentration to which people can be exposed for a short period (15 minutes) without experiencing irritation, long-term or irreversible tissue damage, or reduced alertness. The number of times the concentration reaches the STEL and the amount of time between these occurrences can also be restricted (ACGIH 2016).

Appendix 3: Schedule A of the General Machinery Regulations of 1988

United Nations Organisation Identification Number	Substance	Notifiable Quantity in Tonnage
1001	Acetylene (dissolved)	2
1005	Ammonia (anhydrous, liquified and solutions containing over 50% ammonia)	20
1010	Butadiene	25
1031	Carbon disulphide	20
1017	Chlorine	10
1154	Diethylamine	20
1155	Diethyl Ether	20
1033	Dimethyl Ether	20
1032	Dimethylamine (anhydrous)	20
1220	Dimethylamine (solution)	20
1035	Ethane (compressed)	15
1961	Ethane (refrigerated liquid)	15
1962	Ethylene (compressed)	15
1038	Ethylene (refrigerated liquid)	15
1036	Ethylamine	25
1040	Ethylene oxide	5
1050	Hydrogen Chloride (anhydrous)	10
1051	Hydrogen Cyanide (anhydrous)	10
1052	Hydrogen Fluoride (anhydrous)	10
1969	ISO-Butane	25
1055	ISO-Butylene (Isobutene)	25
1075	LPG (Liquid Petroleum Gas)	25
1971	Methane (compressed)	15
1011	n-Butane	25
1012	n-Butylene (Butene)	25
1076	Phosgene	2
1978	Propane	25
1077	Propylene	25
1079	Sulphur Dioxide (liquified)	15
1829	Sulphur Trioxide (liquified)	15
1083	Trimethylamine (anhydrous)	25
1086	Vinyl Chloride	25

Appendix 4: Site Emergency Response Plan

CISA / KARBOCHEM NEWCASTLE

EMERGENCY PROCEDURES

FOR

FIRES
GAS RELEASES
SERIOUS INJURIES
LOSS OF TOWN WATER
LOSS OF ELECTRICITY
CRISIS COMMUNICATION
EXCESSIVE RAIN
SALVAGE PROCEDURE
SPILLAGES

OPM/30/H&S/48 REV DATE:

THIS DOCUMENT BECOMES AN UNCONTROLLED DOCUMENT WHEN PRINTED

MAIN SIREN

FIRE:	**CONTINUOUS ALARM FOR 60 SECONDS**
GAS RELEASE:	INTERMITTENT ALARM FOR 60 SECONDS
CANCELLATION:	**CONTINUOUS ALARM FOR 15 SECONDS**

The main siren is tested on Wednesday mornings at 10:00 in all three of the modes.

EMERGENCY CONDITION – DEFINITION

An emergency condition is a fire, gas release, a large spillage of any chemical or serious injury on site or any other situation that, in the judgement of the observer, warrants it.

As part of this procedure the handling of, total loss of town water supply, electricity supply, excessive rain and salvage is also outlined.

TO REPORT ANY EMERGENCY CONDITION, PHONE 2333 ON ANY INTERNAL TELEPHONE, FROM ANY TWO-WAY RADIO BASE STATION ON CHANNEL 1 OR REPORTING IT VERBALLY.

PERSON DISCOVERING FIRE

Never try to do too much on your own. Rather get help.

Raise the alarm by phoning 2333 on any telephone.

- Clearly state where the emergency condition is and if possible, what the scope of the problem is;
- Do not endanger yourself or any other person in any way. If unsure of what to do, wait for help to arrive.

PERSON DISCOVERING GAS RELEASE

Always keep wind direction in mind.

Raise the alarm by phoning 2333 on any telephone.

1. Clearly state where the emergency condition is and if possible what gas is being released; or
1.2 Activate a gas hand switch in the affected area.
2. If capable, try to isolate the source of leaking substance eg closing a valve or stopping a pump.
3. If unsure, wait for further help before taking action.
4. Stay upwind of leaking substance and prevent other persons from entering the effected area. (wind direction can be observed by taking note of the windsocks on the plant.)

PERSON DISCOVERING A SERIOUS INJURY

Prompt action can save lives.

1. Raise the alarm by phoning 2333 or 2300 (the latter only during office hours) on any internal telephone.
2 inform Security of where exactly the injured person or persons are to ensure prompt action.
3 Notify the relevant Team Leader of the situation.
4 If trained, apply first aid. Always wear latex gloves when applying first aid
5 If unsure, wait for trained help.
6 Do not try to move a seriously injured person unless this is done to prevent further injuries.
7 Ensure that the area where the incident has occurred remains unhampered, until such time as preliminary investigations have been completed or until authorised by an Inspector of the Dept. of Labour.

PERSON DISCOVERING SPILLAGE

Stay calm and think before acting.

1 Raise the alarm by phoning 2333 on any internal telephone.
2 Inform Security of where the problem is and ask them to implement their actions as set out in the emergency procedures.
3 If possible try to stop the source of the spillage e.g. closing of valves or stopping of pumps.
4 If at all possible, try to prevent the spillage from entering any drains e.g. sand could be used to close drain inlets.
5 Stay upwind of all spillages and keep fire and health risks in mind. Keep persons away from entering the affected area.

GENERAL

1. IF IN DOUBT, REPORT THE MATTER BY PHONING 2333 FROM ANY INTERNAL TELEPHONE

2. Inform Security of your observations and request them to contact the Senior Management standby for further advice.

MAIN ADMINISTRATION BUILDING PERSONNEL (FIRE, GAS RELEASE, SPILLAGE AND SERIOUS INJURY)

1. No specific action, but stay in area of work.
2. No smoking, anywhere in the area during a gas release
3. If Administration emergency procedures are to be implemented, notification will be given via the switchboard operator and the public address system.
4. In case of a gas release, switch off all air conditioners.
5. No information to be given to any outside organisation e.g. newspapers, TV reporters, etc. Refer such people to the CEO or his delegate.

SERIOUS INJURY OR SPILLAGE

1. No specific action, wait for instructions from your floor marshals.
2. If help from Administration employees are needed, specific requests will be made to Heads of Departments via the emergency co-ordinator or appointee. The emergency co-ordinator could ask specific administration personnel to form a team or teams to carry out certain tasks e.g. making of fetching food for teams or driving of vehicles etc.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the CEO or his delegate.

ENGINEERING PERSONNEL - FIRE OR GAS RELEASE

Office hours.

1. On hearing the siren, stop all work in progress and proceed to the workshop Emergency Evacuation Point. Ensure contractors or other non-CISA employees under your control do the same.
2. Always try to stay upwind of area where condition occurred.
3. No smoking allowed on the site during emergencies.
4. Wait at workshop Emergency Evacuation Points and respond to requests from affected area e.g. electricians, riggers, fitters, etc. Such requests will usually come through the emergency co-ordinator or plant Team Leader.
5. After cancellation of emergency condition, engineering personnel can move back to areas of work. Ensure work permits are still valid before starting work. The issuer alone can give this information.

After hours.

1. Respond to call outs as per official CISA procedures.
2. The emergency co-ordinator can call out any help he may need for controlling the emergency condition.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

ENGINEERING PERSONNEL - SERIOUS INJURY OR SPILLAGE

Office hours.

1. No specific action apart from the fact that people not needed in the actual handling of the accident or spillage must leave the area.
2. If help from engineering personnel are needed, specific requests will be made to Heads of Departments, via the emergency co-ordinator. The emergency co-ordinator could ask for the formulation of teams to carry out specific tasks e.g. using heavy machinery to move ground to block water flow or cranes to lift heavy equipment etc.

After hours.

1. Respond to call outs as per official CISA procedures.
2. The emergency co-ordinator can call out any help he may need for controlling the emergency condition.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

AMBULANCE TEAM - FIRE, GAS RELEASE AND INJURY & SPILLAGE.

1 On hearing the main siren, the designated ambulance driver will take the ambulance from the Fire Station and proceed to the area of the emergency condition. In case of gas leaks the wind direction should be kept in mind and the ambulance should not be started if this could be dangerous.
2 On arrival the driver will ascertain if anybody has been injured. If not the ambulance will return to the Fire Station.
3 If injuries have occurred, first aid, appropriate to the type of injury, must be applied.
4 If needed, further treatment can be given at the Medical Station.
5 In cases where more than Medical Station treatment is needed the patient will be transported to the Casualty Section of the Newcastle Private Hospital.
6 The Casualty Section will call out the Company Doctor to attend to the injured.
7 If further transport is needed, such as transfers to other hospitals, this will be done by provincial ambulance.
8 On return to the factory the driver of the ambulance must complete a report, to be handed in at Security Department, giving an outline of who treated the patient, whether the employee has been admitted to hospital etc.
9 The driver should also clearly state in his report whether any further injuries resulted from incidents during transport or not.
10 The assistant should at all times travel in the back of the ambulance with the patient. (See composition of area emergency team members.)

NB: The driver of the ambulance should always keep the wind direction in mind whilst driving on the factory premises.

All traffic rules to be adhered to at all times whilst the ambulance is driven.

The ambulance should be returned to the Fire Station and cleaned, ready for use. If necessary, petrol tank should be filled.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

PERSONNEL NOT DIRECTLY INVOLVED - FIRE OR GAS RELEASE

The less people around, the smaller the chances of an accident.

1. Do not use the telephone system. Keep lines open for emergency calls.
2. Do not use the radio or paging system unless communication is related to the emergency condition.
3. No smoking allowed at any place on site during an emergency condition.
4. People not involved must keep away from the area.
4.1 Office personnel stay at offices.
4.2 Engineering personnel go to the nearest workshop.
4.3 Production areas not involved - man control rooms at all times.
The above will assist the co-ordinator of the emergency to reach people easily if he needs them for different tasks.
5. All employees who have undergone fire training, should be ready to help if emergency co-ordinator should request help. Requests to be made through their supervision or directly where needed.
6. CISA employees responsible for contractors or temporary employees on site shall ensure that such people are informed as to what they shall do.
7. During a fire or gas release, all air conditioners and vehicles shall be switched off to reduce ignition points. A fire can result in a gas release.
8. Keep wind direction in mind and if specific office areas, workshops, etc. seem to be in danger, they could evacuated after the emergency co-ordinator has been informed and he agrees that evacuation is in the best interest for the people in such an area.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

PERSONNEL NOT DIRECTLY INVOLVED - SPILLAGE AND SERIOUS INJURY

Spillage.

1. No specific, action but people not involved in the handling of the spillage, MUST keep away from the area as large spillages could give rise to a fire or vapours.
2. The co-ordinator handling the spillage could ask for help from departments to assist in cleaning up the spillage i.e. front end loaders, chemicals for treatment etc.

Serious injury.

1. No specific action and people not directly involved, MUST keep away from the area.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

SECURITY OFFICER - FIRE OR GAS RELEASES

General points

1. The notification of a fire or gas release can be made by fire/gas hand switch or telephone.
2. Inform the Fire Prevention Officer by two way radio on call sign Foxtrot 2, of what the condition is.
3. Inform the emergency team on the all call paging system 73288 and inform them where the emergency condition is.
4. Activate the main siren to sound for one minute continuously for a fire or one minute intermittent for a gas release.
5. Make a general announcement on the public address system informing people where the emergency condition is. State clearly whether the problem is a fire or a gas release.

6. Inform the switch board operator of the emergency requesting her to announce it over the intercom system within the Admin. Building.
7. Stop entry of vehicles to the Admin. and factory side in case of a fire or a gas release.
8. Keep the road to the factory clear for emergency vehicles.
9. Carry out requests from emergency co-ordinator or other senior personnel during the emergency e.g. calling out ambulances, fire brigades, fitters or other people as needed.
10 All actions taken, instructions received, etc. to be recorded. Entries to be made with a **RED pen** in the occurrence book for later reference.

Additional tasks - office hours.

1. Inform the Senior Management standby about the emergency condition.
2. Inform EH&S Manager on cell phone 083 633 1391 about the emergency condition.

Additional tasks - after hours.

Call out Senior Management standby.
Call out other Standby personnel of the area involved if applicable.
Carry out requests from Plant Team Leader of Fire Prevention Officer for any additional help until emergency co-ordinator takes over co-ordination of the emergency condition.

Cancellation of emergency condition.

1. On receiving information from the Emergency Co-ordinator, Plant Team Leader or Fire Prevention Officer that the emergency condition can be cancelled, activate the "ALL CLEAR" siren. (Siren to be sounded continuously for 15 seconds.)
2. Make a general announcement on the public address system informing everybody that the emergency condition is over.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management standby.

SECURITY OFFICER – SERIOUS INJURY

On notification of an injury the following procedures to be followed:-

Office hours

1. Inform the Medical staff by phoning 2300 and give information as to where the injured person/s can be found.
2. Inform the EH&S Manager on cell phone 083 633 1391 about the incident.
3. Inform Senior Management Standby about the incident.
4. Carry out requests from EH&S Manager, Senior Management Standby or other senior personnel e.g. calling out additional ambulances, notification of doctors or any other instruction as may be deemed necessary.

After Hours

1. Contact the laboratory Team Leader on the internal telephone 2274 and inform him exactly where the ambulance is needed.
2. If the Fire Prevention Officer is not occupied at an emergency condition, also notify him of the situation either by telephone 2373 or by radio on call sign Foxtrot 2.
3. Phone the doctor as requested by the Laboratory Team Leader and inform him that a patient is on his way to the hospital.
4. Notify Senior Management Standby and EH&S Manager if injured person has been admitted to a hospital. Also state the name of the injured person and if available his/her address.

General.

1. All actions taken, instructions received, etc. to be recorded. Entries to be made with a **RED pen** in the occurrence book for later reference.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc.

No information to be given to next of kin of any injured person.
Refer such people to the Senior Management Standby.

SECURITY OFFICER - SPILLAGE

Notification could be by telephone or radio from the affected area or from another source that may notice the spillage first.

Office hours.

1. Contact Fire Prevention Officer (Foxtrot 2) and give details of where the spillage occurred.
2. Contact the following people and inform them accordingly:-
2.1 EH&S Manager
2.2 Senior Management Standby;
3. Carry out requests from Senior Management Standby or any other senior personnel e.g. no outside people to be informed unless management standby requests it.

After hours.

1. Contact Fire Prevention Officer (Foxtrot 2) and give details of where the spillage occurred.
2. Contact the following people by telephone or pager as per standby lists and inform them accordingly:-
2.1 Senior Management standby; and
2.2 EH & S Manager
2.3 Any other person/s as requested by the Senior Management Standby.
3. Carry out requests from Senior Management Standby or any other senior personnel e.g. no outside people to be informed unless management standby requests it.

NB! No information to be given to any outside organisations e.g. newspapers, TV reporters, etc. Refer such people to the Senior Management Standby.

KARBOCHEM FIRE TEAM - FIRE AND GAS RELEASE

1. The Fire Prevention Officer (F.P.O.) will receive an emergency message on his two way radio (foxtrot 2).
2. The main siren will be activated which will confirm the message received.
3. He must immediately proceed to the area of the emergency condition with his equipment.
4. The members of the emergency team, after they have received the emergency call over their pagers, must proceed to the area where the emergency condition is.
5. Both the F.P.O. and the emergency team members must, in a case of a gas release, keep the wind direction in mind as they proceed to the affected area.
6. The emergency team members must report to the F.P.O. at the scene of the emergency and from then until such time that the emergency condition has been called off, such team member/s remains under the supervision of the F.P.O.
7. The F.P.O. must report to the plant Team leader and obtain information regarding the emergency condition.
8. The F.P.O. should start with fire fighting procedures according to experience with fires bearing in mind the type of product that's burning e.g. ensure that no water is sprayed onto carbide and that, where appropriate, hydrogen fires are allowed to continue burning, or procedures to minimise vapors or sources of ignition in case of a gas release, etc.
9. The F.P.O. takes charge of fire fighting activities and should:-work in close co-operation with the plant Team Leader or other senior plant personnel; and should see to the safety of emergency team members.
9.3 Evaluate every emergency condition and decide if additional assistance is needed e.g. municipal fire department or additional help from specific CISA employees e.g. carbide logistics to tow foam tanker to site of emergency etc.
10. During fire fighting activities the F.P.O. must try to reduce all losses or damage to the minimum e.g. take action to reduce water damage to final product etc.
11. The F.P.O. can request assembly of the emergency team members and, If he deems it necessary, requests standby duties on plants.

12. During standby duties it is expected of the F.P.O. to observe all actions and to stop the work if he feels safety precautions are insufficient.
13. Implement plant evacuation procedures if informed that partial or full evacuation is to take place.

TAKE NOTE.

1. Always keep wind direction in mind as wind always plays a role in any emergency condition.
2. After the emergency condition has been cancelled the F.P.O. should:-

   In case of a fire - Check the area for possible re-ignition sources.

   In case of a gas release - Ensure by means of gas tests that no further gas pockets remain in the area.

3. The F.P.O. and the emergency team must ensure that all the used fire fighting equipment is brought back to a working condition before the area is left.
4. Portable fire extinguishers that have been used during the operation, must be taken to the Fire Station for recharging and in the mean time be replaced by some fully charged extinguishers..
5. The F.P.O. must, after every fire or gas release, write a report stating the actions taken and the problems encountered. This report should be written in RED ink in the occurrence book.

FIRE PREVENTION OFFICER – SERIOUS INJURY

1. If not already involved in an emergency condition, the Fire Prevention Officer (F.P.O.) will act as follows where people were injured.
2. He will receive a message by telephone or by radio (Foxtrot 2), informing him about the injury.
3. He will proceed to the area by vehicle and will give assistance in the treatment of any injured person.
4. If injured person needs doctor's treatment, the F.P.O. will:-

4.1 Arrange ambulance transport to the Casualty Section of the Newcastle Private Hospital.

4.2 He will complete a medical request for treatment from to accompany the patient as proof that the patient has been injured whilst on duty.

5. He will inform the person on standby of the injured person's department.
6. The F.P.O. must make an entry in RED INK into his occurrence book regarding the injury and complete an after hours injury report.
7. If the injured person is admitted to a hospital, the F.P.O. must inform the Senior Management Standby accordingly.

FIRE PREVENTION OFFICER - SPILLAGE

1. On notification by radio (Foxtrot 2) of by telephone about a spillage, proceed to the area with the fire equipment. If such a call is received directly from a process area, ensure that Security is also notified.
2. Consult with the plant Team Leader in the area as to what actions to take e.g. covering the spillage with foam to prevent ignition or blocking it in with sand, etc.
3. Call for assembly of emergency fire team members if this is needed to control the condition.
4. Remain on standby in the area and assist the Team Leader until conditions are under control and safe.
5. Make an entry in RED INK into the occurrence book regarding the spillage with specific reference to the steps taken and the problems encountered.
6. The F.P.O. shall ensure that safety precautions are implemented and adhered to during the handling of such spillages. If the required precautions are not followed, the F.P.O. must stop the unsafe practices.

SENIOR MANAGEMENT STANDBY - FIRE, GAS RELEASE OR SPILLAGE

1. The Senior Management Standby will act as co-ordinator of emergency conditions.
2. After having received notification of an emergency condition proceed to the Security control room to cover the tasks of co-ordinating the condition.
3. Request any other employee with special knowledge to assist him in making decisions to control the effects of an emergency condition.
4. The Senior Management Standby will be the CISA contact with outside agencies until a more senior member of management arrives. See crisis communication page.
5. If a decision is taken to evacuate the plant or sections of the plant, the area evacuation procedures must be implemented.

SERIOUS INJURY

Office hours

1. No specific tasks unless involved departments ask for specific assistance or an emergency condition has been declared.

After hours

1. After being informed of any injured employee/s that have been admitted to a hospital, he will be responsible to arrange that the family of the injured employee/s are informed.
   See crisis communication page for handling any outside agencies.

GENERAL

1. Ensure that the area where the emergency condition has occurred remains unhampered, until such time the preliminary investigations have been completed.
2. If an insurance claim may arise from any emergency condition, the Senior Management Standby must arrange for a post investigation to be carried out by the affected departmental manager.

PLANT TEAM LEADER - FIRE AND GAS RELEASE

General points.

1. Confirm that the emergency condition has been reported to Security. The main siren in operation is a good indication.
2. Cease all maintenance and construction work in the area and ensure that people not needed, leave the area. Designate somebody to ensure that visitors and contractors do leave the area. A safe area should be determined before hand.
3. The Team Leader stays in full control of his area of responsibility but should co-operate with other disciplines to ensure effective control of the emergency.
4. The Team Leader must keep the emergency co-ordinator informed about what is happening. He can be contacted at security.

Fire

1. Evaluate the extent of the fire and determine what is burning.
2. Give this information to the Fire Prevention officer to help him make fire-fighting decisions.
3. Inform other plants and areas if the fire may affect them.
4. Ensure that the area affected is shut down according to procedures if needed.
5. See to the closing of roads if needed.
6. Notify Newcastle Fire Department

Gas release

1. Evaluate the extent of the release and determine what substance is involved.
2. Give information to the Fire Prevention Officer so that a plan of action can be formulated to handle the release.
3. Keep wind direction in mind and warn surrounding areas which might be affected.

4. Ensure that the personnel who must remain in the area, are using the correct safety equipment.
5. See to the closing of roads if needed.
6. The Team Leader must keep in mind that any gas release can also give rise to a pollution problem and should act to prevent pollution.
7. Be on the alert for changes in the wind direction.
8. If the plant or sections of the plant needs to be evacuated due to a gas release, the area evacuation procedures must be implemented.

TAKE NOTE

1. After consultation with the emergency co-ordinator and the Fire Prevention Officer, the emergency condition can be called off **ONLY** if all the parties agree to it and are assured that no further danger exists.
2. Inform the Security of this decision.
3. Complete an incident report form and submit the original and yellow copies immediately to the Risk Department.
4. Submit blue copy of incident report form to the respective Plant Manager.
5. All hot work permits on the affected department and all cold work permits in hazardous areas must be cancelled. New permits to be issued after the “ALL CLEAR” siren have been sounded. Cold work in non-hazardous areas of the affected department may carry on without the re-issue of new permits. An affected department resorts under a specific Team Leader.
6. The Team Leader should as soon as possible after the emergency condition, make notes of his observations during the condition for use during later investigations.

PLANT TEAM LEADER - SERIOUS INJURY

1. Confirm that Security has been informed about the incident and that the ambulance driver has been notified. (During an emergency condition the ambulance will arrive as part of the procedure.)
2. See to it that the injured person receives first aid.
3. Ensure that the area is safe for the injured person and for persons helping him.
4. Badly injured persons should not be moved before first aid treatment has been rendered unless danger in the immediate area can cause further injury.
5. Designate a person to accompany the injured person in the back of the ambulance. Preferably someone who has been trained in basic first aid.
6. See to it that the scene of the accident remains unchanged in any way, unless it is done to ensure the safety of the injured person or helpers.
7. Before work is again started, ensure that unsafe conditions are rectified to prevent similar injuries.
8. Complete an accident report stating only the facts and circulate it as spelt out.

PLANT TEAM LEADER - SPILLAGE

PLANT TEAM LEADER.

1. Inform Security .
2. Try to stop the spillage at source.
3. Try to contain the spillage within the plant boundary.
4. Cordon off area,
5. Keep non-essential personnel out of the area.
6. Liase with FPO

AFTER HOURS

1. Confirm that Senior Management Standby has been notified.
2. Consult with Senior Management Standby before:-
   - Contact is made with people and animal owners who are situated down stream and close to outside waterways. If any warnings are issued to prevent use of the water for any purposes, clean drinking water must be supplied.
   - Spillage is treated with neutralising agents.
   - Flushing waterways with large volumes of water.

TAKE NOTE

All communication with outside organisations such as Newspapers, Civil Defence, Dept. of Water Affairs, etc. must be done via the Senior Management Standby.

1. CRISIS COMMUNICATION

Any incident involving CISA which is of such a nature or so sensitive that it is likely to attract public or media attention.

2. AUTHORISED SPOKESMEN.

2.1 CISA CEO or his delegate

3. ACTION TO BE TAKEN IN THE EVENT OF A CRISIS.

3.1 The Chief Executive of CISA will ALWAYS be the person to communicate in time of crisis with higher authorities. In his absence, this task goes down to the next level of Senior Management available but NEVER lower than the Senior Management Standby.

3.1.2 Inform Lanxess Corporate Information Manager on (011) 921 5243(W) or 082 651 9107.

Give the following information:-

* Exact time, location and type of incident.
* Fatalities, injuries or extent of damage.
* Name/s of deceased and/or injured.
* Details of remedial measures being taken.

3.1.3 In the case of major incidents, information may be approximate in the early stages. In such cases, this should be clearly stated.

3.1.6 Keep persons referred to 3.1.2 above, fully briefed throughout the duration of the crisis, particularly about new developments.

SALVAGE/RECOVERY PROCEDURE - PURPOSE

To reduce damage and losses caused by water or theft after a fire or any other emergency on the site.

RESPONSIBILITY FOR IMPLEMENTATION.

Office hours

Responsible manager for the affected area.

After hours

Senior Management Standby.

In all cases, the responsible person can call on all sections for the supply of manpower and equipment to assist in the prevention of further damage or losses.
Emergency telephone numbers are available at the Security Control Room.

CONSIDERATION BEFORE IMPLEMENTATION.

- If the S.A.P.S. might be involved in later investigations, the scene must not be disturbed until such time as to when they have completed their investigation.
- If an insurance claim may arise from the incident, the insurance brokers must be informed as soon as possible. Steps must be taken to prevent further damage to product, plant or equipment.

EQUIPMENT AVAILABILITY.

1. The following internal equipment is available for salvage / recovery actions:-

   - Forklifts - Finishing, Warehouse and Stores.
   - Mobile cranes - Engineering department.
   - Power X bins, Front end loaders, Tractors - Carbide Logistics.
   - L.D.V. - Engineering and Production sections.
   - Portable pumps - Effluent.
   - Tarpaulins, spare pallets - Warehouse.
   - Plastic sheeting - Finishing.
   - Padlocks, Brooms, mops, etc. - Main Stores.
   - Ventilation equipment - Fire Department and Carbide.
   - Drawings of drains - Engineering admin.

   If required, the following external equipment can be asked for through civil defence:-

   1. Tipper trucks.
   2. Portable pumps.
   3. Tractors.
   4. Graders.
   5. Front end loaders.
   6. Large trailers.

WHAT TO DO DURING SALVAGE

The main task of the co-ordinator of any salvage action is the prevention of water damage during and after fire fighting procedures and the securing of the buildings afterwards.

A good example is the Warehouse. Should a fire start s in one area, the person responsible for salvage will see to:-

* The removal of product not involved.
* The covering of product with plastic or tarpaulins.
* The making of ground walls to direct water away from specific areas such as product storage areas drains when needed.
* The securing of the building afterwards to prevent theft.

GENERAL

The sooner action is taken during or after an emergency, the smaller the risk of additional damage caused by water of theft.

PROCEDURE IN CASES OF EXCESSIVE RAIN (FIRE, SECURITY, EFFLUENT AND CARBIDE PERSONNEL)

PURPOSE OF THIS PROCEDURE

To enable us to plan for floods that might be caused by heavy rain falls which may occur within a short period of time. The layout of the site has already handled 120mm of rain within a 24 hour period without any significant damage and as such we are looking at rain which may exceed this total.

AREAS OF CONCERN

- The banks formed by the different levels of plant layout.
- Tailings dams.
- Security fence on the eastern side.
- Areas lower than normal ground level

ACTION IN CASES OF HEAVY RAIN FALL

When rain exceeds 40mm in any one hour or if rain persists for more than 8 hours responsibility for checking all areas of concern have been allocated as set out below. The responsible persons for the areas should ensure inspections of the areas and must check:-

- All banks for mud slides or damage - Fire Department.
- Tailings dams for damage – EH & S Manager/Safety Officer
- Eastern security fence for damage - Security Personnel.
- Areas lower than ground level – Team Leader

ACTION WHEN DANGER IS NOTED.

BANKS

Keep people away from below these banks as well as from the areas at the top of the embankment. Demarcate with hazard tape.

TAILINGS DAMS

Keep people away from the dumps and if danger of possible pollution is noted, notify Security department for implementation of spillage procedures.

SECURITY FENCE

Keep patrols in the area when fence is damaged.

LOW LEVELS AREAS

Keep employees out of these low level areas and if flooding occurs, arrange for pumps to prevent damage to equipment.
Pumps are available at the Effluent plant.

The likelihood of flooding is relatively small, but should be handled in an orderly fashion if it should occur.

EMERGENCY PLANNING FOR TOTAL POWER FAILURE – ELECTRICAL DEPARTMENT.

In the case of a total power failure, the following procedure will apply:-

1. Electrical Team Leader to proceed to Sub 1.
2. Status of trips shall be logged in sub station book.
3. All electricians to go to their respective sub stations.
4. All electricians to check emergency supplies are on.
5. All electricians to check what transformers are off.
6. All electricians to wait at their telephones waiting on instructions.

7. If supervision calls a sub station, the electrician must be able to supply information, as to the condition of incomers (on or off) and transformer numbers information of status of these couplers must be logged in sub station book.
8. All telephone lines must be kept clear, between all sub stations for supervision contact purposes.
9. Unauthorised personnel may not enter any sub station, unless permission has been granted by supervision.
10. No switching may be done by any electrician, unless instructed by supervision to do so.

NB In the case of after hours failure the standby electrician will first proceed to the DA set to check if it has started. There after proceed to Sub 1 to check conditions there. If the fault is on the Municipality side, he must contact them to find out what is wrong. He must then contact the CISA electrical standby Team Leader and inform him accordingly.

EMERGENCY CO-ORDINATOR

This will normally be the Senior Management Standby unless another CISA official is nominated to handle a specific emergency. In such cases the Team Leader of the affected plant will be informed by Security about the change.

AMBULANCE TEAM

Office Hours - Persons either from Risk management or the Medical station.

After Hours - Driver - Laboratory Team Leader
- Ambulance assistant - Laboratory assistant

KARBOCHEM FIRE TEAM

LEADER - Fire Prevention Officer
TEAM MEMBERS (All hours) - Rubber nominee
04/05/06
Carbide nominee
08 nominee
085 Effluent nominee
20 Amines nominee

Office Hours - The above plus :-

Electrical nominee
Mechanical nominee

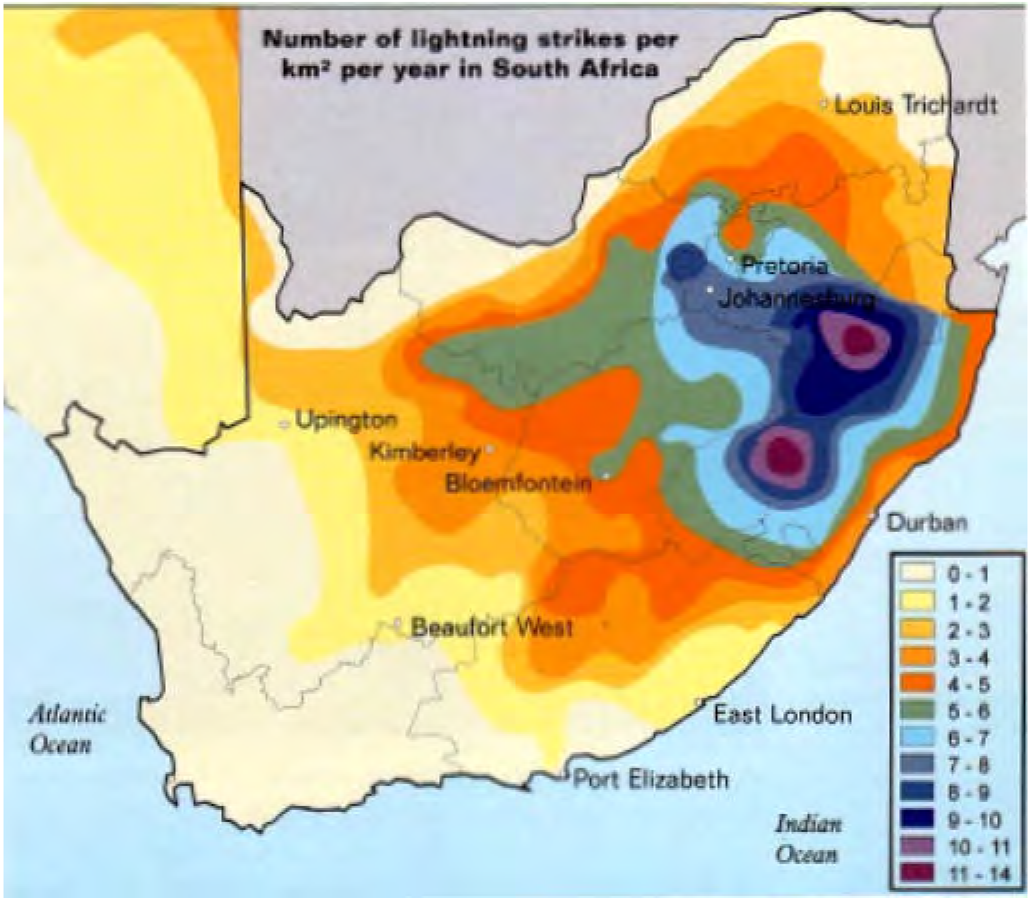
CISA FIRE TEAM

See OPM/30/H&S/0112 for current members

Appendix 5: Average meteorological conditions for South Africa

SA Weather station	Wind direction	Wind speed m/s	Wind calm %	Precipitation mm	Cloud cover %	Ambient temperature ^{0}C
Alexander Bay	S	11	28	<100	50	18-20
Bethlehem	E	10	15	700	10	14-16
Bloemfontein	N	10	20	700	20	16-18
Calvinia	W	10	3	150	5	16-18
Cape Town	S	11	25	500	50	16-18
De Aar	SE	11	3	150	5	14-16
Durban	NE	11	45	1 100	50	18-20
East London	SW	11	15	500	50	16-18
Ermelo	E	6	0.3	700	5	14-16
George	SE	11	30	1 000	30	16-18
Graaff Reinet	S	11	12	300	5	16-18
Johannesburg	N	8	40	500	5	16-18
Kimberley	N	10	28	150	10	16-18
Ladysmith	E	11	15	300	40	14-16
Polokwane	NE	11	39	500	10	18-20
Port Elizabeth	SW	11	20	1 100	50	16-18
Pretoria	NE	6	28	700	20	18-20
Struisbaai	E	11	3	500	50	16-18
Upington	SW	10	26	150	5	18-20
Welkom	NE	10	1	500	5	14-16

Lightning incidence



Appendix 6: Safety data sheets

Print

CAMEO Chemicals

Chemical Datasheet

AMMONIA, ANHYDROUS

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7664-41-7	1005	Non-Flammable Gas (domestic) Inhalation Hazard (Special Provision 13) (domestic) Poison Gas (international) Corrosive (international)	AMA

NIOSH Pocket Guide	International Chem Safety Card
Ammonia	AMMONIA (ANHYDROUS)

NFPA 704

Diamond	Hazard	Value	Description
1 3 0	◆ Health	3	Can cause serious or permanent injury.
	◆ Flammability	1	Must be preheated before ignition can occur.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

Note: The Refrigeration System Classification section of the International Mechanical Code requires a value of 3 for the red quadrant (flammability hazard) for indoor ammonia refrigeration equipment.

(NFPA, 2010)

General Description

A clear colorless gas with a strong odor. Shipped as a liquid under its own vapor pressure. Density (liquid) 6 lb / gal. Contact with the unconfined liquid can cause frostbite. Gas generally regarded as nonflammable but does burn within certain vapor concentration limits and with strong ignition. Fire hazard increases in the presence of oil or other combustible materials. Although gas is lighter than air, vapors from a leak initially hug the ground. Prolonged exposure of containers to fire or heat may cause violent rupturing and rocketing. Long-term inhalation of low concentrations of the vapors or short-term inhalation of high concentrations has adverse health effects. Used as a fertilizer, as a refrigerant, and in the manufacture of other chemicals.

Rate of onset: Immediate

Persistence: Minutes

Odor threshold: 17 ppm

Source/use/other hazard: Explosives manufacture; pesticides; detergents industry.

Hazards

Reactivity Alerts

⚠ Water-Reactive

Air & Water Reactions

Soluble in water with evolution of heat. The amount of heat generated may be large.

Fire Hazard

Mixing of ammonia with several chemicals can cause severe fire hazards and/or explosions. Ammonia in container may explode in heat of fire. Incompatible with many materials including silver and gold salts, halogens, alkali metals, nitrogen trichloride, potassium chlorate, chromyl chloride, oxygen halides, acid vapors, azides, ethylene oxide, picric acid and many other chemicals. Mixing with other chemicals and water. Hazardous polymerization may not occur. (EPA, 1998)

Health Hazard

Vapors cause irritation of eyes and respiratory tract. Liquid will burn skin and eyes. Poisonous; may be fatal if inhaled. Contact may cause burns to skin and eyes. Contact with liquid may cause frostbite. (EPA, 1998)

Reactivity Profile

AMMONIA is a base. Reacts exothermically with all acids. Violent reactions are possible. Readily combines with silver oxide or mercury to form compounds that explode on contact with halogens. When in contact with chlorates it forms explosive ammonium chlorate [Kirk-Othmer, 3rd ed., Vol. 2, 1978, p. 470]. Reacts violently or produces explosive products with fluorine, chlorine, bromine and iodine and some of the interhalogen compounds (bromine pentafluoride, chlorine trifluoride). Mixing of bleaching powder (hypochlorite solution) with ammonia solutions produces toxic/explosive ammonia trichloride vapors. Undergoes potentially violent or explosive reactions on contact with 1,2-dichloroethane (with liquid ammonia), boron halides, ethylene oxide (polymerization), perchlorates or strong oxidants (chromyl chloride, chromium trioxide, chromic acid, nitric acid, hydrogen peroxide, chlorates, fluorine, nitrogen oxide, liquid oxygen). Reacts with silver chloride, silver oxide, silver nitrate or silver azide to form the explosive silver nitride. May react with some heavy metal compounds (mercury, gold(III) chloride) to produce materials that may explode when dry. [Bretherick, 5th ed., 1995, p. 1553].

Belongs to the Following Reactive Group(s)

- Bases, Weak

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 125 [Gases - Corrosive]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

SPILL: See ERG Tables 1 and 3 - Initial Isolation and Protective Action Distances on the UN/NA 1005 datasheet.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2016)

Firefighting

Wear positive pressure breathing apparatus and full protective clothing.

Small fires: dry chemical or carbon dioxide. Large fires: water spray, fog or foam. Apply water gently to the surface. Do not get water inside container. Move container from fire area if you can do it without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire is out. Isolate area until gas has dispersed. (EPA, 1998)

Non-Fire Response

Excerpt from ERG Guide 125 [Gases - Corrosive]:

Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Do not direct water at spill or source of leak. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Isolate area until gas has dispersed. (ERG, 2016)

Protective Clothing

For emergency situations, wear a positive pressure, pressure-demand, full facepiece self-contained breathing apparatus (SCBA) or pressure- demand supplied air respirator with escape SCBA and a fully-encapsulating, chemical resistant suit. (EPA, 1998)

DuPont Tychem® Suit Fabrics

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QS	QC	SL	C3	TF	TP	BR	RC	TK	RF
Ammonia (>95%)	7664-41-7	Vapor		imm.	26	imm.	20	90	133	133	>480	>480
Ammonia (>95%, liquid, < -35°C)	7664-41-7	Liquid				>480		>480			>480	>480
	7664-41-7	Vapor		imm.	26	imm.	20	90	133	133	>480	>480

Chemical	**CAS Number**	**State**	**QS**	**QC**	**SL**	**C3**	**TF**	**TP**	**BR**	**RC**	**TK**	**RF**
Anhydrous ammonia (>95%)												
Anhydrous ammonia (>95%, liquid, < -35°C)	7664-41-7	Liquid				>480		>480			>480	>480

> indicates greater than.
"imm." indicates immediate; having a normalized breakthrough time of 10 minutes or less.
A blank cell indicates the fabric has not been tested. The fabric may or may not offer barrier.

Special Warnings from DuPont

1. Serged and bound seams are degraded by some hazardous liquid chemicals, such as strong acids, and should not be worn when these chemicals are present.

2. CAUTION: This information is based upon technical data that DuPont believes to be reliable. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability...

(DuPont, 2018)

First Aid

Warning: Ammonia is extremely corrosive to the skin, eyes, and mucous membranes. Contact with the liquified gas may cause frostbite. Caution is advised.

Signs and Symptoms of Acute Ammonia Exposure: Inhalation of ammonia may cause irritation and burns of the respiratory tract, laryngitis, dyspnea (shortness of breath), stridor (high-pitched respirations), and chest pain. Pulmonary edema and pneumonia may also result from inhalation. A pink frothy sputum, convulsions, and coma are often seen following exposure to high concentrations. When ammonia is ingested, nausea and vomiting may result; oral, esophageal, and stomach burns are common. If ammonia has contacted the eyes, irritation, pain, conjunctivitis (red, inflamed eyes), lacrimation (tearing), and corneal erosion may occur. Loss of vision is possible. Dermal exposure may result in severe burns and pain.

Emergency Life-Support Procedures: Acute exposure to ammonia may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary.

Inhalation Exposure:
1. Move victims to fresh air. Emergency personnel should avoid self-exposure to ammonia.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Transport to a health care facility.

Dermal/Eye Exposure:
1. Remove victims from exposure. Emergency personnel should avoid self- exposure to ammonia.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.Warning: Do not attempt to neutralize with an acid wash; excessive liberation of heat may result.

3. If eye exposure has occurred, eyes must IMMEDIATELY be flushed with lukewarm water for at least 15 minutes.
4. Remove contaminated clothing as soon as possible.
5. Wash exposed skin areas THOROUGHLY with soap and water.
6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. Transport to a health care facility.

Ingestion Exposure:
1. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
2. DO NOT induce vomiting or attempt to neutralize!
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Activated charcoal does not strongly bind ammonia, and therefore is of little or no value.
5. Give the victims water or milk: children up to 1 year old, 125 mL (4 oz or 1/2 cup); children 1 to 12 years old, 200 mL (6 oz or 3/4 cup); adults, 250 mL (8 oz or 1 cup). Water or milk should be given only if victims are conscious and alert.
6. Transport to a health care facility. (EPA, 1998)

Physical Properties

Chemical Formula: $H3N$

Flash Point: data unavailable

Lower Explosive Limit (LEL): 16 % (EPA, 1998)

Upper Explosive Limit (UEL): 25 % (EPA, 1998)

Autoignition Temperature: 1204 ° F (USCG, 1999)

Melting Point: -107.9 ° F (EPA, 1998)

Vapor Pressure: 400 mm Hg at -49.72 ° F (EPA, 1998)

Vapor Density (Relative to Air): 0.6 (EPA, 1998)

Specific Gravity: 0.6818 at -28.03 ° F (EPA, 1998)

Boiling Point: -28.03 ° F at 760 mm Hg (EPA, 1998)

Molecular Weight: 17.03 (EPA, 1998)

Water Solubility: data unavailable

Ionization Potential: 10.18 eV (NIOSH, 2016)

IDLH: 300 ppm (NIOSH, 2016)

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Ammonia (7664-41-7)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	30 ppm	220 ppm	2700 ppm
30 minutes	30 ppm	220 ppm	1600 ppm
60 minutes	30 ppm	160 ppm	1100 ppm

Exposure Period	**AEGL-1**	**AEGL-2**	**AEGL-3**
4 hours	30 ppm	110 ppm	550 ppm
8 hours	30 ppm	110 ppm	390 ppm

(NAC/NRC, 2017)

ERPGs (Emergency Response Planning Guidelines)

Chemical	**ERPG-1**	**ERPG-2**	**ERPG-3**
Ammonia (7664-41-7)	25 ppm ✪	150 ppm	1500 ppm

✪ indicates that odor should be detectable near ERPG-1.

(AIHA, 2016)

PACs (Protective Action Criteria)

Chemical	**PAC-1**	**PAC-2**	**PAC-3**	
Ammonia (7664-41-7)	30 ppm	160 ppm	1100 ppm	LEL = 150000 ppm

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	**CAS Number/ 313 Category Code**	**EPCRA 302 EHS TPQ**	**EPCRA 304 EHS RQ**	**CERCLA RQ**	**EPCRA 313 TRI**	**RCRA Code**	**CAA 112(r) RMP TQ**
Ammonia	7664-41-7	500 pounds	100 pounds	100 pounds			
Ammonia (anhydrous)	7664-41-7	500 pounds	100 pounds	100 pounds	X		10000 pounds
Ammonia (conc 20% or greater)	7664-41-7			see ammonium hydroxide	X		20000 pounds
Ammonia (includes anhydrous ammonia and aqueous ammonia from water dissociable ammonium salts and other sources; 10 percent of total aqueous ammonia is reportable under this listing)	7664-41-7				313		

"X" indicates that this is a second name for an EPCRA section 313 chemical already included on this consolidated list. May also indicate that the same chemical with the same CAS number appears on another list with a different chemical name.

(EPA List of Lists, 2015)

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			THEFT			SABOTAGE		
Chemical of Interest	**CAS Number**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**
Ammonia (anhydrous)	7664-41-7	1.00 %	10000 pounds	toxic						
Ammonia (conc. 20% or greater)	7664-41-7	20.00 %	20000 pounds	toxic						

(DHS, 2007)

OSHA Process Safety Management (PSM) Standard List

Chemical Name	CAS Number	Threshold Quantity (TQ)
Ammonia solutions (>44% ammonia by weight)	7664-41-7	15000 pounds
Ammonia, Anhydrous	7664-41-7	10000 pounds

(OSHA, 2011)

Alternate Chemical Names

- AM-FOL
- AMMONIA
- AMMONIA (ANHYDROUS)
- AMMONIA (ANHYDROUS) (LIQUEFIED)
- AMMONIA GAS
- AMMONIA SOLUTION, WITH MORE THAN 50% AMMONIA
- AMMONIA, ANHYDROUS
- AMMONIA, ANHYDROUS, LIQUEFIED
- AMMONIA, [ANHYDROUS]
- AMMONIA-14N
- ANHYDROUS AMMONIA
- ANHYDROUS AMMONIA, LIQUEFIED
- AQUA AMMONIA
- AQUEOUS AMMONIA
- LIQUID AMMONIA
- NITRO-SIL
- R 717
- REFRIGERENT R717
- SPIRIT OF HARTSHORN

Print

CAMEO *Chemicals*

Chemical Datasheet

CARBON DIOXIDE

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
124-38-9	1013	Non-Flammable Gas	CDO

NIOSH Pocket Guide	**International Chem Safety Card**
Carbon dioxide	CARBON DIOXIDE

NFPA 704

data unavailable

General Description

A colorless odorless gas at atmospheric temperatures and pressures. Relatively nontoxic and noncombustible. Heavier than air and may asphyxiate by the displacement of air. Soluble in water. Forms carbonic acid, a mild acid. Under prolonged exposure to heat or fire the container may rupture violently and rocket. Used to freeze food, to control chemical reactions, and as a fire extinguishing agent.

Hazards

Reactivity Alerts

none

Air & Water Reactions

Water soluble. Forms carbonic acid, a mild acid in water.

Fire Hazard

Behavior in Fire: Containers may explode when heated. (USCG, 1999)

Health Hazard

Inhalation causes increased respiration rate, headache, subtle physiological changes for up to 5% concentration and prolonged exposure. Higher concentrations can cause unconsciousness and death. Solid can cause cold contact burns. Liquid or cold gas can cause freezing injury to skin or eyes similar to a burn. (USCG, 1999)

Reactivity Profile

Dusts of magnesium, lithium, potassium, sodium, zirconium, titanium, and some magnesium-aluminum alloys, and heated aluminum, chromium, and magnesium when suspended in carbon dioxide are ignitable and explosive. This is especially true in the presence of strong oxidizers, such as peroxides. The presence of carbon dioxide in solutions of aluminum hydride in ether can cause violent decomposition on warming the residue, [J. Amer. Chem. Soc., 1948, 70, 877]. Dangers arising from the use of carbon dioxide in the fire prevention and extinguishing systems of confined volumes of air and flammable vapors are examined. The hazard associated with its use centers around the fact that large electrostatic discharges may be created that initiate explosion, [Quart. Saf. Summ., 1973, 44(1740, 10]. Contact of very cold liquid/solid carbon dioxide with water may result in vigorous or violent boiling of the product and extremely rapid vaporization due to the large temperature differences involved. If the water is hot, there is the possibility that a liquid "superheat" explosion may occur. Pressures may build to dangerous levels if liquid gas contacts water in a closed container. Forms weak carbonic acid in nonhazardous reaction with water.

Belongs to the Following Reactive Group(s)

- Acids, Weak

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 120 [Gases - Inert (Including Refrigerated Liquids)]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 100 meters (330 feet).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Excerpt from ERG Guide 120 [Gases - Inert (Including Refrigerated Liquids)]:

Use extinguishing agent suitable for type of surrounding fire. Move containers from fire area if you can do it without risk. Damaged cylinders should be handled only by specialists.

FIRE INVOLVING TANKS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 120 [Gases - Inert (Including Refrigerated Liquids)]:

Do not touch or walk through spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Allow substance to evaporate. Ventilate the area. CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning. (ERG, 2016)

Protective Clothing

Skin: Wear appropriate personal protective clothing to prevent skin from becoming frozen from contact with the liquid or from contact with vessels containing the liquid.

Eyes: Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: No recommendation is made specifying the need for removing clothing that becomes wet or contaminated.

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. (NIOSH, 2016)

DuPont Tychem® Suit Fabrics

No information available.

First Aid

Eye: If eye tissue is frozen, seek medical attention immediately; if tissue is not frozen, immediately and thoroughly flush the eyes with large amounts of water for at least 15 minutes, occasionally lifting the lower and upper eyelids. If irritation, pain, swelling, lacrimation, or photophobia persist, get medical attention as soon as possible.

Skin: If frostbite has occurred, seek medical attention immediately; do NOT rub the affected areas or flush them with water. In order to prevent further tissue damage, do NOT attempt to remove frozen clothing from frostbitten areas. If frostbite has NOT occurred, immediately and thoroughly wash contaminated skin with soap and water.

Breathing: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible. (NIOSH, 2016)

Physical Properties

Chemical Formula: $CO2$

Flash Point: data unavailable

Lower Explosive Limit (LEL): data unavailable

Upper Explosive Limit (UEL): data unavailable

Autoignition Temperature: data unavailable

Melting Point: -109.3 ° F (USCG, 1999)

Vapor Pressure: 56.5 atm (NIOSH, 2016)

Vapor Density (Relative to Air): data unavailable

Specific Gravity: 1.56 at -110.2 ° F (USCG, 1999)

Boiling Point: Sublimes (NIOSH, 2016)

Molecular Weight: 44 (USCG, 1999)

Water Solubility: 0.2 % at 77° F (NIOSH, 2016)

Ionization Potential: 13.77 eV (NIOSH, 2016)

IDLH: 40000 ppm (NIOSH, 2016)

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

No PAC information available.

Regulatory Information

EPA Consolidated List of Lists

No regulatory information available.

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

No regulatory information available.

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- CARBON DIOXIDE
- CARBON DIOXIDE, COMPRESSED
- CARBON OXIDE (CO2)
- CARBON-12 DIOXIDE
- CARBONIC ACID ANHYDRIDE
- CARBONIC ACID GAS
- CARBONIC ANHYDRIDE
- DRY ICE
- KHLADON 744
- R 744

Print

CAMEO Chemicals

Chemical Datasheet

HYDROGEN

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
1333-74-0	1049	Flammable Gas	HXX

NIOSH Pocket Guide	**International Chem Safety Card**
none	HYDROGEN

NFPA 704

Diamond	Hazard	Value	Description
4 0 0	◆ Health	0	No hazard beyond that of ordinary combustible material.
	◆ Flammability	4	Burns readily. Rapidly or completely vaporizes at atmospheric pressure and normal ambient temperature.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

Hydrogen is a colorless, odorless gas. It is easily ignited. Once ignited it burns with a pale blue, almost invisible flame. The vapors are lighter than air. It is flammable over a wide range of vapor/air concentrations. Hydrogen is not toxic but is a simple asphyxiate by the displacement of oxygen in the air. Under prolonged exposure to fire or intense heat the containers may rupture violently and rocket. Hydrogen is used to make other chemicals and in oxyhydrogen welding and cutting.

Hazards

Reactivity Alerts

⚠ Highly Flammable

Air & Water Reactions

Highly flammable.

Fire Hazard

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

EXTREMELY FLAMMABLE. Will be easily ignited by heat, sparks or flames. Will form explosive mixtures with air. Vapors from liquefied gas are initially heavier than air and spread along ground. CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Methane (UN1971) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.) Vapors may travel to source of ignition and flash back. Cylinders exposed to fire may vent and release flammable gas through pressure relief devices. Containers may explode when heated. Ruptured cylinders may rocket. (ERG, 2016)

Health Hazard

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

Vapors may cause dizziness or asphyxiation without warning. Some may be irritating if inhaled at high concentrations. Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite. Fire may produce irritating and/or toxic gases. (ERG, 2016)

Reactivity Profile

Finely divided platinum and some other metals will cause a mixture of hydrogen and oxygen to explode at ordinary temperatures. If a jet of hydrogen in air impinges on platinum black the metal surface gets hot enough to ignite the gases, [Mellor 1:325(1946-1947)]. Explosive reactions occur upon ignition of mixtures of nitrogen trifluoride with good reducing agents such as ammonia, hydrogen, hydrogen sulfide or methane. Mixtures of hydrogen, carbon monoxide, or methane and oxygen difluoride are exploded when a spark is discharged, [Mellor 2, Supp. 1:192(1956)]. An explosion occurred upon heating 1'-pentol and 1''-pentol under hydrogen pressure. It appears that this acetylenic compound under certain conditions suddenly breaks down to form elemental carbon, hydrogen, and carbon monoxide with the release of sufficient energy to develop pressures in excess of 1000 atmospheres, [AIChE Loss Prevention, p1, (1967)].

Belongs to the Following Reactive Group(s)

- Reducing Agents, Weak

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 800 meters (1/2 mile).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. In fires involving Liquefied Petroleum Gases (LPG) (UN1075); Butane, (UN1011); Butylene, (UN1012); Isobutylene, (UN1055); Propylene, (UN1077); Isobutane, (UN1969); and Propane, (UN1978), also refer to BLEVE - SAFETY PRECAUTIONS (ERG page 368). (ERG, 2016)

Firefighting

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED. CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame. Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.

SMALL FIRE: Dry chemical or CO2.

LARGE FIRE: Water spray or fog. Move containers from fire area if you can do it without risk.

FIRE INVOLVING TANKS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. Prevent spreading of vapors through sewers, ventilation systems and confined areas. Isolate area until gas has dispersed. CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning. (ERG, 2016)

Protective Clothing

Excerpt from GUIDE 115 [Gases - Flammable (Including Refrigerated Liquids)]:

Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection. Always wear thermal protective clothing when handling refrigerated/cryogenic liquids. (ERG, 2016)

DuPont Tychem® Suit Fabrics

No information available.

First Aid

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. Clothing frozen to the skin should be thawed before being removed. In case of contact with liquefied gas, thaw frosted parts with lukewarm water. In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin. Keep victim calm and warm. (ERG, 2016)

Physical Properties

Chemical Formula: H2

Flash Point: data unavailable

Lower Explosive Limit (LEL): 4 % (USCG, 1999)

Upper Explosive Limit (UEL): 75 % (USCG, 1999)

Autoignition Temperature: 1065 ° F (USCG, 1999)

Melting Point: -434 ° F (USCG, 1999)

Vapor Pressure: data unavailable

Vapor Density (Relative to Air): data unavailable

Specific Gravity: 0.071 at -423.4 ° F (USCG, 1999)

Boiling Point: -423 ° F at 760 mm Hg (USCG, 1999)

Molecular Weight: 2 (USCG, 1999)

Water Solubility: data unavailable

Ionization Potential: data unavailable

IDLH: data unavailable

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3	
Hydrogen (1333-74-0)	65000 ppm 🔥🔥🔥	230000 ppm 🔥🔥🔥	400000 ppm 🔥🔥🔥	LEL = 40000 ppm

🔥🔥🔥 indicates value is 100% or more of LEL.

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	CAS Number/ 313 Category Code	EPCRA 302 EHS TPQ	EPCRA 304 EHS RQ	CERCLA RQ	EPCRA 313 TRI	RCRA Code	CAA 112 (r) RMP TQ

Regulatory Name	**CAS Number/ 313 Category Code**	**EPCRA 302 EHS TPQ**	**EPCRA 304 EHS RQ**	**CERCLA RQ**	**EPCRA 313 TRI**	**RCRA Code**	**CAA 112 (r) RMP TQ**
Hydrogen	1333-74-0						10000 pounds

(EPA List of Lists, 2015)

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			**THEFT**			**SABOTAGE**		
Chemical of Interest	**CAS Number**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**
Hydrogen	1333-74-0	1.00 %	10000 pounds	flammable						

(DHS, 2007)

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- DIHYDROGEN
- HYDROGEN
- HYDROGEN (H2)
- HYDROGEN MOLECULE
- HYDROGEN, COMPRESSED
- HYDROGEN, GAS
- MOL. HYDROGEN
- MOLECULAR HYDROGEN
- ORTHOHYDROGEN
- PARAHYDROGEN
- PROTIUM

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CAMEO Chemicals

Chemical Datasheet

NAPHTHALENE, METHYLNAPHTHALENES

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
91-20-3	1760	Corrosive	none

NIOSH Pocket Guide	**International Chem Safety Card**
none	NAPHTHALENE

NFPA 704

Diamond	Hazard	Value	Description
2 2 0	◆ Health	2	Can cause temporary incapacitation or residual injury.
	◆ Flammability	2	Must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

A black liquid with the odor of coal tar. Negligibly soluble in water. Slightly denser than water. Vapors, fumes or direct contact may irritate the eyes. Direct skin contact may produce severe burns. Inhalation may produce mucous irritation, dizziness, loss of coordination, cardiovascular collapse and death.

Hazards

Reactivity Alerts

none

Air & Water Reactions

Negligibly soluble in water.

Fire Hazard

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated. For electric vehicles or equipment, ERG Guide 147 (lithium ion batteries) or ERG Guide 138 (sodium batteries) should also be consulted. (ERG, 2016)

Health Hazard

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

TOXIC; inhalation, ingestion or skin contact with material may cause severe injury or death. Contact with molten substance may cause severe burns to skin and eyes. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. (ERG, 2016)

Reactivity Profile

A mixture containing NAPHTHALENE and METHYLNAPHTHALENES may react vigorously with strong oxidizing agents. Can react exothermically with bases and with diazo compounds. Naphthalene reacts violently with chromic anhydride [Haz. Chem. Data 1967. p 68]. Friedel-Crafts acylation of naphthalene using benzoyl chloride, catalyzed by $AlCl_3$, must be conducted above the melting point of the mixture, or the reaction may be violent [Clar, E. et al., Tetrahedron, 1974, 30, 3296].

Belongs to the Following Reactive Group(s)

- Bases, Strong
- Hydrocarbons, Aromatic

Potentially Incompatible Absorbents

Use caution: Liquids with this reactive group classification have been known to react with the absorbents listed below.

- Cellulose-Based Absorbents
- Mineral-Based & Clay-Based Absorbents

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.

SPILL: Increase, in the downwind direction, as necessary, the isolation distance shown above.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

SMALL FIRE: Dry chemical, CO2 or water spray.

LARGE FIRE: Dry chemical, CO2, alcohol-resistant foam or water spray. Move containers from fire area if you can do it without risk. Dike fire-control water for later disposal; do not scatter the material.

FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS. (ERG, 2016)

Protective Clothing

Excerpt from GUIDE 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible. (ERG, 2016)

DuPont Tychem® Suit Fabrics

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QS	QC	SL	C3	TF	TP	BR	RC	TK	RF
Naphthalene	91-20-3	Solid				>480	>480	>480				
Naphthalene (25% solution in Diethylene glycol dimethyl ether)	91-20-3	Liquid			79	>480	>480		>480	>480	>480	>480

> indicates greater than.
A blank cell indicates the fabric has not been tested. The fabric may or may not offer barrier.

Special Warnings from DuPont

1. Serged and bound seams are degraded by some hazardous liquid chemicals, such as strong acids, and should not be worn when these chemicals are present.

2. CAUTION: This information is based upon technical data that DuPont believes to be reliable. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability...

(DuPont, 2018)

First Aid

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]:

Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim calm and warm. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. (ERG, 2016)

Physical Properties

Chemical Formula: $C_{10}H_8$

Flash Point: 174 ° F (NFPA, 2010)

Lower Explosive Limit (LEL): data unavailable

Upper Explosive Limit (UEL): data unavailable

Autoignition Temperature: data unavailable

Melting Point: data unavailable

Vapor Pressure: data unavailable

Vapor Density (Relative to Air): data unavailable

Specific Gravity: data unavailable

Boiling Point: data unavailable

Molecular Weight: data unavailable

Water Solubility: data unavailable

Ionization Potential: data unavailable

IDLH: data unavailable

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

Chemical	**PAC-1**	**PAC-2**	**PAC-3**	
Naphthalene (91-20-3)	15 ppm	83 ppm	500 ppm	LEL = 9000 ppm

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	**CAS Number/ 313 Category Code**	**EPCRA 302 EHS TPQ**	**EPCRA 304 EHS RQ**	**CERCLA RQ**	**EPCRA 313 TRI**	**RCRA Code**	**CAA 112 (r) RMP TQ**
Naphthalene	91-20-3			100 pounds	313	U165	

(EPA List of Lists, 2015)

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

No regulatory information available.

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- NAPHTHALENE, METHYLNAPHTHALENES

Print

CAMEO Chemicals

Chemical Datasheet

METHANE

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
74-82-8	1971	Flammable Gas	MTH

NIOSH Pocket Guide	**International Chem Safety Card**
none	METHANE

NFPA 704

Diamond	Hazard	Value	Description
4 2 0	◆ Health	2	Can cause temporary incapacitation or residual injury.
	◆ Flammability	4	Burns readily. Rapidly or completely vaporizes at atmospheric pressure and normal ambient temperature.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

Methane is a colorless odorless gas. It is also known as marsh gas or methyl hydride. It is easily ignited. The vapors are lighter than air. Under prolonged exposure to fire or intense heat the containers may rupture violently and rocket. It is used in making other chemicals and as a constituent of the fuel, natural gas.

Hazards

Reactivity Alerts

- ⚠ Highly Flammable
- ⚠ Strong Reducing Agent

Air & Water Reactions

Highly flammable.

Fire Hazard

Special Hazards of Combustion Products: None (USCG, 1999)

Health Hazard

High concentrations may cause asphyxiation. No systemic effects, even at 5% concentration in air. (USCG, 1999)

Reactivity Profile

METHANE is a reducing agent, it is involved in many explosions when combined with especially powerful oxidizers such as bromine pentafluoride, chlorine trifluoride, chlorine, iodine, heptafluoride, dioxygenyl tetrafluoroborate, dioxygen difluoride, trioxygen difluoride and liquid oxygen. Other violent reactions include, chlorine dioxide and nitrogen trifluoride. Liquid oxygen gives an explosive mixture when combined with liquid methane [NFPA 1991]. Contact of very cold liquefied gas with water may result in vigorous or violent boiling of the product and extremely rapid vaporization due to the large temperature differences involved. If the water is hot, there is the possibility that a liquid "superheat" explosion may occur. Pressures may build to dangerous levels if liquid gas contacts water in a closed container [Handling Chemicals Safely 1980].

Belongs to the Following Reactive Group(s)

- Hydrocarbons, Aliphatic Saturated

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 800 meters (1/2 mile).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. In fires involving Liquefied Petroleum Gases (LPG) (UN1075); Butane, (UN1011); Butylene, (UN1012); Isobutylene, (UN1055); Propylene, (UN1077); Isobutane, (UN1969); and Propane, (UN1978), also refer to BLEVE - SAFETY PRECAUTIONS (ERG page 368). (ERG, 2016)

Firefighting

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED. CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame. Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.

SMALL FIRE: Dry chemical or CO2.

LARGE FIRE: Water spray or fog. Move containers from fire area if you can do it without risk.

FIRE INVOLVING TANKS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. Prevent spreading of vapors through sewers, ventilation systems and confined areas. Isolate area until gas has dispersed. CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning. (ERG, 2016)

Protective Clothing

Self-contained breathing apparatus for high concentrations; protective clothing if exposed to liquid. (USCG, 1999)

DuPont Tychem® Suit Fabrics

No information available.

First Aid

EYES: First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician. IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop.

SKIN: CAUTION: Exposure of skin to compressed gases may result in freezing of the skin. Treatment for frostbite may be necessary. Remove the victim from the source of contamination. IMMEDIATELY wash affected areas gently with COLD water (and soap, if necessary) while removing and isolating all contaminated clothing. Dry carefully with clean, soft towels. If symptoms such as inflammation or irritation develop, IMMEDIATELY call a physician or go to a hospital for treatment.

INHALATION: IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. If symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop, call a physician and be prepared to transport the victim to a hospital. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Protective Clothing.

INGESTION: This compound is a gas, therefore inhalation is the first route of exposure. (NTP, 1992)

Physical Properties

Chemical Formula: CH_4

Flash Point: -306 ° F (NTP, 1992)

Lower Explosive Limit (LEL): 5 % (NTP, 1992)

Upper Explosive Limit (UEL): 15 % (NTP, 1992)

Autoignition Temperature: 1004 ° F (USCG, 1999)

Melting Point: -296.5 ° F (NTP, 1992)

Vapor Pressure: 258574 mm Hg at 100 ° F ; 760 mm Hg at -258.7° F (NTP, 1992)

Vapor Density (Relative to Air): 0.55 (NTP, 1992)

Specific Gravity: 0.422 at -256 ° F (USCG, 1999)

Boiling Point: -258.7 ° F at 760 mm Hg (NTP, 1992)

Molecular Weight: 16.04 (NTP, 1992)

Water Solubility: 3.5 mL/100 mL at 63° F (NTP, 1992)

Ionization Potential: data unavailable

IDLH: data unavailable

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

Chemical	**PAC-1**	**PAC-2**	**PAC-3**	
Methane (74-82-8)	65000 ppm 🔥🔥🔥	230000 ppm 🔥🔥🔥	400000 ppm 🔥🔥🔥	LEL = 50000 ppm

🔥🔥🔥 indicates value is 100% or more of LEL.

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	**CAS Number/ 313 Category Code**	**EPCRA 302 EHS TPQ**	**EPCRA 304 EHS RQ**	**CERCLA RQ**	**EPCRA 313 TRI**	**RCRA Code**	**CAA 112 (r) RMP TQ**
Methane	74-82-8						10000 pounds

(EPA List of Lists, 2015)

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			THEFT			SABOTAGE		
Chemical of Interest	**CAS Number**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**	**Min Conc**	**STQ**	**Security Issue**
Methane	74-82-8	1.00 %	10000 pounds	flammable						

(DHS, 2007)

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- BIOGAS
- FIRE DAMP
- MARSH GAS
- METHANE
- METHANE, COMPRESSED
- METHANE, REFRIGERATED LIQUID
- METHYL HYDRIDE
- NATURAL GAS
- R 50
- R 50 (REFRIGERANT)

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CAMEO *Chemicals*

Chemical Datasheet

SULFUR DIOXIDE

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
7446-09-5	1079	Poison Gas Corrosive	SFD

NIOSH Pocket Guide	International Chem Safety Card
Sulfur dioxide	SULPHUR DIOXIDE

NFPA 704

Diamond	Hazard	Value	Description
0 3 0	🟦 Health	3	Can cause serious or permanent injury.
	🟥 Flammability	0	Will not burn under typical fire conditions.
	🟨 Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

A colorless gas with a choking or suffocating odor. Boiling point -10°C. Heavier than air. Very toxic by inhalation and may irritate the eyes and mucous membranes. Under prolonged exposure to fire or heat the containers may rupture violently and rocket. Used to manufacture chemicals, in paper pulping, in metal and food processing.

Rate of onset: Immediate & Delayed

Persistence: Minutes to hours

Odor threshold: 1 ppm

Source/use/other hazard: Disinfectant and preserving in breweries and food/canning; textile industry; batteries.

Hazards

Reactivity Alerts

- ⚠ Water-Reactive

Air & Water Reactions

Dissolves in water to form sulfurous acid, a corrosive liquid. Moist sulfur dioxide is very corrosive due to the slow formation of sulfuric acid [Handling Chemicals Safely 1980 p. 876].

Fire Hazard

Containers may explode in heat of fire or they may rupture and release irritating toxic sulfur dioxide. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. When the liquid is heated it may release irritating, toxic sulfur dioxide gas. Avoid ammonia, monocesium or monopotassium acetylide; dicesium monoxide; iron (II) oxide; tin oxide; lead (IV) oxide; chromium; manganese; molten sodium, powder aluminum and rubidium. Sulfur dioxide has explosive properties when it comes in contact with sodium hydride; potassium chlorate at elevated temperatures; ethanol; ether; zinc ethylsulfurinate at very cool temperatures (-15C); fluorine; chlorine trifluoride and chlorates. It will react with water or steam to produce toxic and corrosive fumes. Hazardous polymerization may not occur. (EPA, 1998)

Health Hazard

It may cause death or permanent injury after very short exposure to small quantities. 1,000 ppm causes death in from 10 minutes to several hours by respiratory depression. It is an eye and respiratory tract irritant. Persons with asthma, subnormal pulmonary functions or cardiovascular disease are at a greater risk. (EPA, 1998)

Reactivity Profile

SULFUR DIOXIDE is acidic. Reacts exothermically with bases such as amines, amides, metal oxides, and hydroxides. Frequently used as a reducing agent although it is not a powerful one. Acts as a reducing bleach to decolorize many materials. Can act as an oxidizing agent. Supports combustion of powdered aluminum [Mellor 5:209-212 1946-47]. Reacts explosively with fluorine [Mellor 2:1 1946-47]. Supports burning of manganese [Mellor 12:187 1946-47]. Readily liquefied by compression. Contact between the liquid and water may result in vigorous or violent boiling and extremely rapid vaporization. If the water is hot an explosion may occur. Pressures may build to dangerous levels if the liquid contacts water in a closed container [Handling Chemicals Safely 1980]. Supports incandescent combustion of monocesium acetylide, monopotassium acetylide, cesium oxide, iron(II) oxide, tin oxide, and lead oxide [Mellor]. Ethylene oxide and SO_2 can react violently in pyridine solution with pressurization if ethylene oxide is in excess (Nolan, 1983, Case History 51).

Belongs to the Following Reactive Group(s)

- Acids, Strong Non-oxidizing
- Reducing Agents, Weak

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 125 [Gases - Corrosive]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

SPILL: See ERG Tables 1 and 3 - Initial Isolation and Protective Action Distances on the UN/NA 1079 datasheet.

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2016)

Firefighting

Wear self-contained breathing apparatus and full protective clothing. Move container from fire area. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after the fire is out. Isolate area until gas has dispersed. Keep unnecessary people away.

Not flammable. Extinguish fires with dry chemical, carbon dioxide, water spray, fog or foam. (EPA, 1998)

Non-Fire Response

Excerpt from ERG Guide 125 [Gases - Corrosive]:

Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Do not direct water at spill or source of leak. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Isolate area until gas has dispersed. (ERG, 2016)

Protective Clothing

Skin: Wear appropriate personal protective clothing to prevent skin from becoming frozen from contact with the liquid or from contact with vessels containing the liquid.

Eyes: Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: If chemical is in liquid form, work clothing that becomes wet or significantly contaminated should be removed and replaced.

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. (NIOSH, 2016)

DuPont Tychem® Suit Fabrics

Normalized Breakthrough Times (in Minutes)

Chemical	CAS Number	State	QS	QC	SL	C3	TF	TP	BR	RC	TK	RF
Sulfur dioxide (>95%)	7446-09-5	Vapor		imm.	>480		38*	38*	>480	>480	>480	>480

> indicates greater than.
"imm." indicates immediate; having a normalized breakthrough time of 10 minutes or less.
* indicates actual breakthrough time; normalized breakthrough time is not available.
A blank cell indicates the fabric has not been tested. The fabric may or may not offer barrier.

Special Warnings from DuPont

1. Serged and bound seams are degraded by some hazardous liquid chemicals, such as strong acids, and should not be worn when these chemicals are present.

2. CAUTION: This information is based upon technical data that DuPont believes to be reliable. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability...

(DuPont, 2018)

First Aid

Note: Persons with asthma, subnormal pulmonary function, or cardiovascular disease are at greater risk.

Signs and Symptoms of Acute Sulfur Dioxide Exposure: Sulfur dioxide may irritate the eyes and respiratory tract. Signs and symptoms of acute exposure to sulfur dioxide may be severe and include coughing, choking, dyspnea (shortness of breath), sneezing, wheezing, and chest discomfort. Upper airway edema (swelling) or obstruction, bronchoconstriction, pneumonia, pulmonary edema, and respiratory paralysis may occur. Fatigue may be noted. Gastrointestinal effects may include nausea, vomiting, and abdominal pain. Cyanosis (blue tint to skin and mucous membranes) may be noted following exposure to sulfur dioxide.

Emergency Life-Support Procedures: Acute exposure to sulfur dioxide may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Rescue vehicles should carry supplies such as plastic sheeting and disposable plastic bags to assist in preventing spread of contamination.

Inhalation Exposure:
1. Move victims to fresh air. Emergency personnel should avoid self-exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
4. Transport to a health care facility.

Dermal/Eye Exposure:
1. Remove victims from exposure. Emergency personnel should avoid self- exposure to sulfur dioxide.
2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.
3. Remove contaminated clothing as soon as possible.
4. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 minutes.
5. Wash exposed skin areas with soap and water.

6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures.
7. Transport to a health care facility.

Ingestion Exposure: No information is available. (EPA, 1998)

Physical Properties

Chemical Formula: SO2

Flash Point: data unavailable

Lower Explosive Limit (LEL): data unavailable

Upper Explosive Limit (UEL): data unavailable

Autoignition Temperature: Not flammable (USCG, 1999)

Melting Point: -98.9 ° F (EPA, 1998)

Vapor Pressure: 2432 mm Hg at 68 ° F (EPA, 1998)

Vapor Density (Relative to Air): 2.26 (EPA, 1998)

Specific Gravity: 1.434 (EPA, 1998)

Boiling Point: 14 ° F at 760 mm Hg (EPA, 1998)

Molecular Weight: 64.07 (EPA, 1998)

Water Solubility: 10 % (NIOSH, 2016)

Ionization Potential: 12.30 eV (NIOSH, 2016)

IDLH: 100 ppm (NIOSH, 2016)

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Sulfur Dioxide (7446-09-5)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	0.2 ppm	0.75 ppm	30 ppm
30 minutes	0.2 ppm	0.75 ppm	30 ppm
60 minutes	0.2 ppm	0.75 ppm	30 ppm
4 hours	0.2 ppm	0.75 ppm	19 ppm
8 hours	0.2 ppm	0.75 ppm	9.6 ppm

(NAC/NRC, 2017)

ERPGs (Emergency Response Planning Guidelines)

Chemical	ERPG-1	ERPG-2	ERPG-3
Sulfur Dioxide (7446-09-5)	0.3 ppm ✪	3 ppm	25 ppm

✪ indicates that odor should be detectable near ERPG-1.

(AIHA, 2016)

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3
Sulfur dioxide (7446-09-5)	0.2 ppm	0.75 ppm	30 ppm

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

Regulatory Name	CAS Number/ 313 Category Code	EPCRA 302 EHS TPQ	EPCRA 304 EHS RQ	CERCLA RQ	EPCRA 313 TRI	RCRA Code	CAA 112 (r) RMP TQ
Sulfur dioxide	7446-09-5	500 pounds	500 pounds				
Sulfur dioxide (anhydrous)	7446-09-5	500 pounds	500 pounds				5000 pounds

(EPA List of Lists, 2015)

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

		RELEASE			THEFT			SABOTAGE		
Chemical of Interest	CAS Number	Min Conc	STQ	Security Issue	Min Conc	STQ	Security Issue	Min Conc	STQ	Security Issue
Sulfur dioxide (anhydrous)	7446-09-5	1.00 %	5000 pounds	toxic	84.00 %	500 pounds	WME			

WME = weapons of mass effect.

(DHS, 2007)

OSHA Process Safety Management (PSM) Standard List

Chemical Name	CAS Number	Threshold Quantity (TQ)
Sulfur Dioxide (liquid)	7446-09-5	1000 pounds

(OSHA, 2011)

Alternate Chemical Names

- FERMENTICIDE LIQUID
- SULFUR DIOXIDE
- SULFUR DIOXIDE (ANHYDROUS)
- SULFUR DIOXIDE (SO2)
- SULFUR DIOXIDE, LIQUEFIED
- SULFUR OXIDE
- SULFUR OXIDE (SO2)
- SULFUR SUPEROXIDE
- SULFUROUS ACID ANHYDRIDE
- SULFUROUS ANHYDRIDE
- SULFUROUS OXIDE

Print

CAMEO Chemicals

Chemical Datasheet

SULFUR, MOLTEN

Chemical Identifiers

CAS Number	**UN/NA Number**	**DOT Hazard Label**	**USCG CHRIS Code**
7704-34-9	2448	Flammable Solid (international) Class 9 (domestic)	SXX

NIOSH Pocket Guide	**International Chem Safety Card**
none	SULFUR

NFPA 704

Diamond	Hazard	Value	Description
1 2 0	◆ Health	2	Can cause temporary incapacitation or residual injury.
	◆ Flammability	1	Must be preheated before ignition can occur.
	◆ Instability	0	Normally stable, even under fire conditions.
	◇ Special		

(NFPA, 2010)

General Description

A pale yellow crystalline solid with a faint odor of rotten eggs. Insoluble in water. A fire and explosion risk above 450° F. Transported as a yellow to red liquid. Handled at elevated temperature (typically 290°F) to prevent solidification and makes transfers easier. Hot enough that plastic or rubber may melt or lose strength. Causes thermal burns to skin on contact. Cools rapidly and solidifies if released. Equipment designed to protect against ordinary chemical exposure is ineffective against the thermal hazard. Exercise caution walking on the surface of a spill to avoid breakthrough into pockets of molten sulfur below the crust. Do not attempt to remove sulfur impregnated clothing because of the danger of tearing flesh if a burn has resulted. May be irritatin to skin, eyes and mucous membranes. Used in sulfuric acid production, petroleum refining, and pulp and paper manufacturing.

Hazards

Reactivity Alerts

⚠ Highly Flammable
⚠ Strong Reducing Agent

Air & Water Reactions

Flammable. Insoluble in water.

Fire Hazard

Special Hazards of Combustion Products: Produces toxic sulfur dioxide gas.

Behavior in Fire: Burns with a pale blue flame that may be difficult to see in daylight. (USCG, 1999)

Health Hazard

Can cause eye irritation; may rarely irritate skin. If recovered sulfur, refer to hydrogen sulfide.* (USCG, 1999)

Reactivity Profile

SULFUR reacts violently with strong oxidizing agents causing fire and explosion hazards [Handling Chemicals Safely 1980 p. 871]. Reacts with iron to give pyrophoric compounds. Attacks copper, silver and mercury. Reacts with bromine trifluoride, even at 10°C [Mellor 2:113. 1946-47]. Ignites in fluorine gas at ordinary temperatures [Mellor 2:11-13 1946-47]. Reacts to incandescence with heated with thorium [Mellor 7:208 1946-47]. Can react with ammonia to form explosive sulfur nitride. Reacts with calcium phosphide incandescently at about 300°C. Reacts violently with phosphorus trioxide [Chem. Eng. News 27:2144 1949]. Mixtures with ammonium nitrate or with metal powders can be exploded by shock [Kirk and Othmer 8:644]. Combinations of finely divided sulfur with finely divided bromates, chlorates, or iodates of barium, calcium, magnesium, potassium, sodium, or zinc can explode with heat, friction, percussion, and sometimes light [Mellor 2 Supp.1:763. 1956]. A mixture with barium carbide heated to 150°C becomes incandescent. Reacts incandescently with calcium carbide or strontium carbide at 500°C. Attacks heated lithium, or heated selenium carbide with incandescence [Mellor 5:862 1946-47]. Reacts explosively if warmed with powdered zinc [Mellor 4:476. 1946-47]. Reacts vigorously with tin [Mellor 7:328. 1946-47]. A mixture with potassium nitrate and arsenic trisulfide is a known pyrotechnic formulation [Ellern 1968 p. 135]. Mixtures with any perchlorate can explode on impact [ACS 146:211-212]. A mixture of damp sulfur and calcium hypochlorite produces a brilliant crimson flash with scatter of molten sulfur [Chem. Eng. News 46(28):9 1968]. Takes fire spontaneously in chlorine dioxide and may produce an explosion [Mellor 2:289 (1946-47)]. Ignites if heated with chromic anhydride ignite and can explode, [Mellor 10:102 (1946-47)]. Even small percentages of hydrocarbons in contact with molten sulfur generate hydrogen sulfide and carbon disulfide, which may accumulate in explosive concentrations. Sulfur reacts with Group I metal nitrides to form flammable mixtures, evolving flammable and toxic NH3 and H2S gases if water is present (Mellor, 1940, Vol. 8, 99).

Belongs to the Following Reactive Group(s)

- Reducing Agents, Strong

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 133 [Flammable Solids]:

As an immediate precautionary measure, isolate spill or leak area for at least 25 meters (75 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 100 meters (330 feet).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

Firefighting

Excerpt from ERG Guide 133 [Flammable Solids]:

SMALL FIRE: Dry chemical, CO2, sand, earth, water spray or regular foam.

LARGE FIRE: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Fire Involving Metal Pigments or Pastes (e.g. "Aluminum Paste") Aluminum Paste fires should be treated as a combustible metal fire. Use DRY sand, graphite powder, dry sodium chloride-based extinguishers, G-1® or Met-L-X® powder. Also, see ERG Guide 170.

FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: Cool containers with flooding quantities of water until well after fire is out. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 133 [Flammable Solids]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch or walk through spilled material.

SMALL DRY SPILL: With clean shovel, place material into clean, dry container and cover loosely; move containers from spill area.

LARGE SPILL: Wet down with water and dike for later disposal. Prevent entry into waterways, sewers, basements or confined areas. (ERG, 2016)

Protective Clothing

Safety goggles with side shields; approved respirator; heat-resistant gloves; leather heat-resistant clothing. If recovered sulfur, refer to hydrogen sulfide.* (USCG, 1999)

DuPont Tychem® Suit Fabrics

No information available.

First Aid

EYES: wash eyes carefully for at least 15 min.

SKIN: Treat molten sulfur burns with petroleum jelly or mineral oil. If recovered sulfur, treat as for hydrogen sulfide.* (USCG, 1999)

Physical Properties

Chemical Formula: S

Flash Point: 405 ° F (USCG, 1999)

Lower Explosive Limit (LEL): data unavailable

Upper Explosive Limit (UEL): data unavailable

Autoignition Temperature: 450 ° F (USCG, 1999)

Melting Point: 251 ° F (USCG, 1999)

Vapor Pressure: data unavailable

Vapor Density (Relative to Air): data unavailable

Specific Gravity: 1.8 at 248 ° F (USCG, 1999)

Boiling Point: 832.3 ° F at 760 mm Hg (USCG, 1999)

Molecular Weight: 256.51 (USCG, 1999)

Water Solubility: data unavailable

Ionization Potential: data unavailable

IDLH: data unavailable

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

No PAC information available.

Regulatory Information

EPA Consolidated List of Lists

No regulatory information available.

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

No regulatory information available.

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- BRIMSTONE
- SULFUR
- SULFUR, DRY
- SULFUR, MOLTEN
- SULFUR, [MOLTEN]
- SULFUR, [SOLID]
- SULPHUR

- SULPHUR, MOLTEN

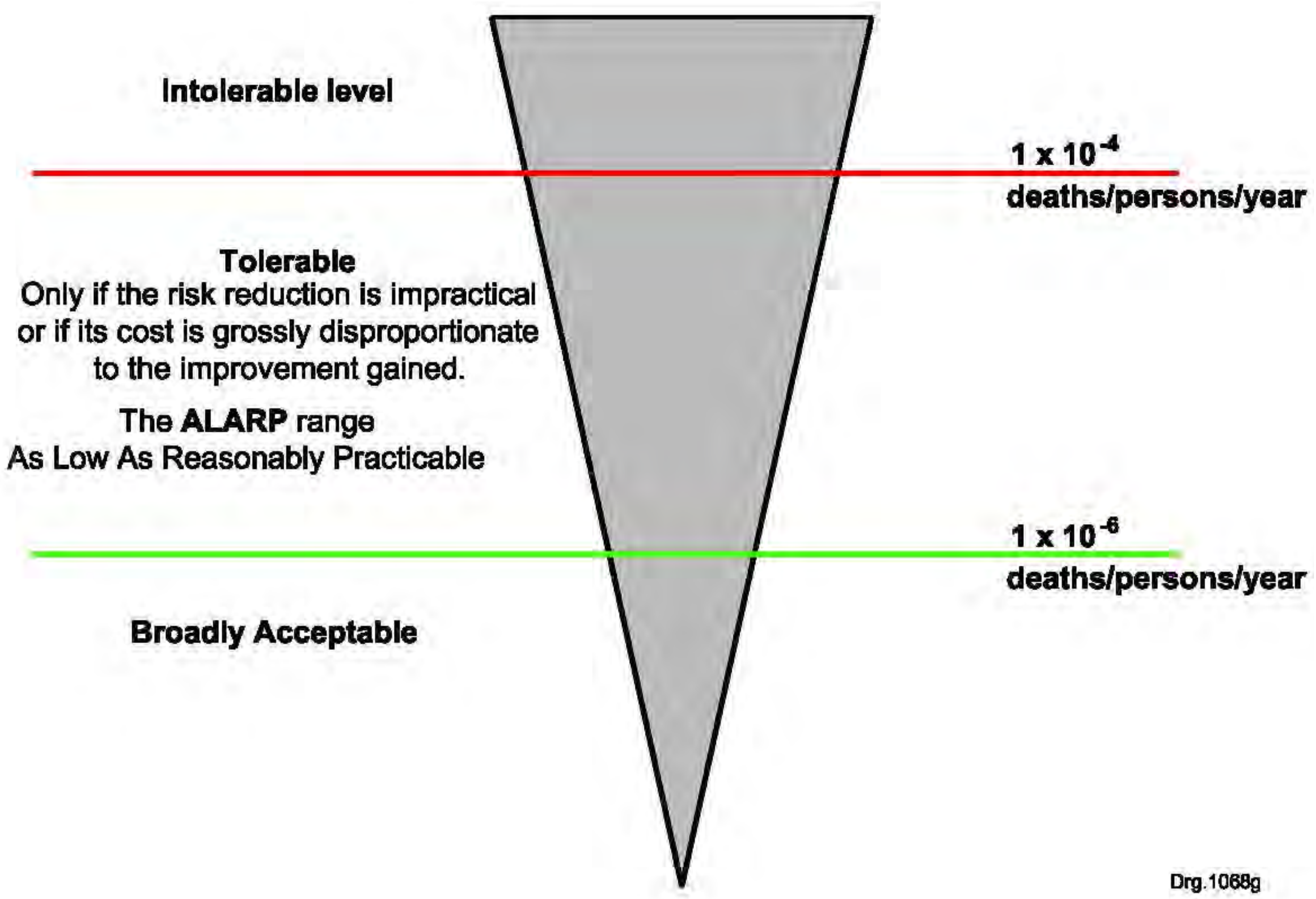
Appendix 7: Generic inspection protocol

Gas and liquid containment systems

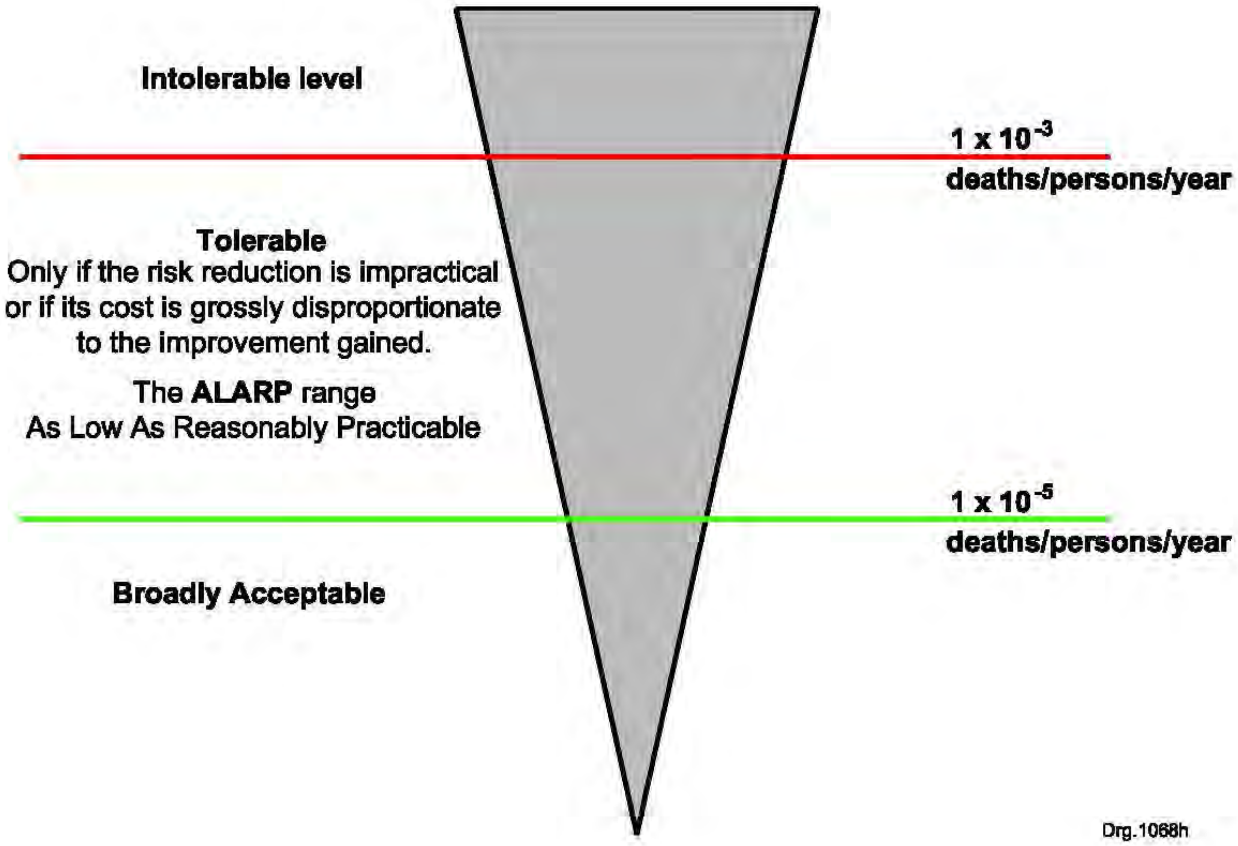
1. Pressure relief valve setting
2. Locality of emergency vent point to atmosphere
3. Flanges discharge side
4. Flanges intake side
5. Pipe nipples
6. Compressor oil drain points
7. Compressor lock-out procedure
8. Compressor shaft seals
9. Drive belts
10. Noticeable excessive vibration on compressor
11. Elbow connections on pipes
12. Valves on pipelines
13. Ammonia detectors
14. Detectors set point
15. Detectors testing
16. Audio alarm
17. Strobe alarm
18. Alarm linked to security office
19. Emergency contacts external
20. Emergency contacts internal
21. Wind sock fitted
22. Wind sock condition
23. Compressor mountings
24. Ammonia smell
25. Ventilation in engine room
26. Emergency switch for compressor shutdown
27. Length of reticulation piping
28. Pressure test certificates for receiver tank
29. Ammonia replenishment mode
30. Availability of self-contained breathing apparatus
31. Availability of full-face cartridge masks
32. Availability of resistant chemical suits
33. Emergency shower
34. Notice outside engine room with ammonia inventory
35. Availability of water source for ammonia vapour deluge
36. Classification of ammonia engine room: Zone 2
37. Flameproof and spark-proof electrical connections on compressors
38. Training of operators on engine room
39. Emergency training of staff
40. Identification of emergency assembly area
41. Identification of surrounding communities
42. Communication with neighbouring communities
43. Nameplate
44. Heat expansion relief valves on pipelines
45. Water drain valve

46. Intake flange
47. Outlet flange
48. Tank isolation valve
49. Tank isolation valve flanges
50. All Gaskets
51. Cylinder filling pump
52. Electrical connections
53. Area classification Zone 2
54. Tank mountings and plinth
55. Deluge system installed
56. Testing of deluge system
57. Scales
58. Filling platform LPG detectors
59. Flammables certificate
60. Road tanker connection
61. Road tanker filling coupling, dry
62. Road tanker no reverse
63. Isolation valves
64. Isolation valve flanges
65. Earth connections
66. Bund around liquid storage tanks
67. Bund drain valve
68. Tank leaks
69. Tank overfill protection.
70. Alarm systems.
71. Deluge systems.
72. Maintenance schedule.
73. Internal inspection registers.

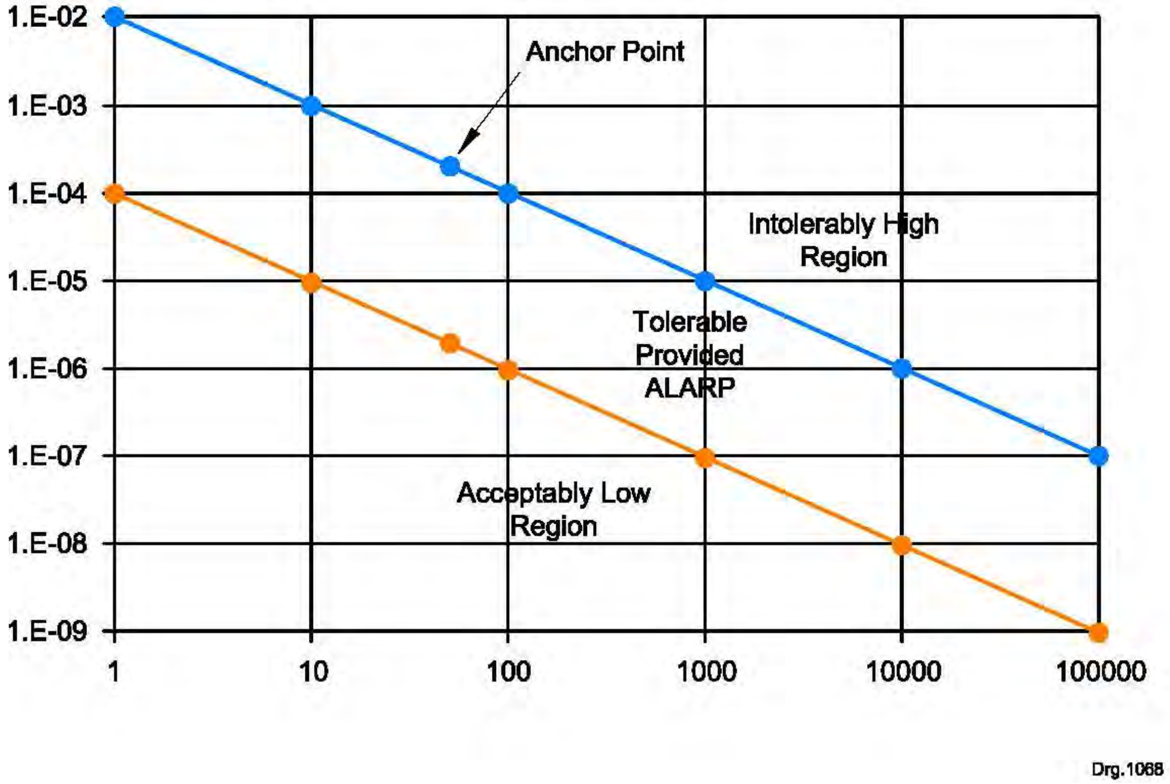
Appendix 8: Risk criteria



The public ALARP risk decision-making framework



The employee ALARP risk decision-making framework



Societal risk F-N criteria graph used in decision-making

APPENDIX 4.5 AVIATION IMPACT ASSESSMENT

NEWCASTLE AIRPORT
AVIATION IMPACT ASSESSMENT
FOR BROTHER CISA (PTY) LIMITED

AVIATION ASSESSMENT REPORT

PRESENTED BY

GWI
Aviation Advisory

JULY 2020

NEWCASTLE AIRPORT
AVIATION IMPACT ASSESSMENT FOR
BROTHER CISA (PTY) LIMITED

Revision History

REV	DATE	DESCRIPTION	AFFECTED PAGES	ORIGINATOR
00	9 July 2020	Draft Report issued for review	All	Jon Heeger
01				
02				

Core Review Team

NAME	DESIGNATION	COMPANY
Basil Karstadt	Project Director	GWI
Jon Heeger	Aviation Planner	GWI
Sam Leyde	Director	EScience Associates

Glossary

This report makes of acronyms and specific terminology unique to the aviation industry. A glossary of such terminology and definitions is attached as Annex A.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

Brother CISA (Pty) Ltd operates a chrome chemicals production facility at the Newcastle Chemical Park, in KwaZulu Natal. The facility produces various chrome chemicals and by-products. Brother CISA proposes to expand its existing product range to include chrome tanning salts (CTS) and synthetic vitamin K. The proposed expansion requires Environmental Authorisation in terms of National Environmental Management Act (Act 107 of 1998). EScience has been commissioned as an independent Environmental Assessment Practitioner (EAP), to conduct an Environmental Impact Assessment (EIA) process for Environmental Authorisation.

This report flows from a requirement for the impact of the proposed expansion on the adjoining Newcastle Airport (FANC) to be assessed by way of an Aviation Impact Assessment, and consultation with the Newcastle Municipality as airport owner and the SA Civil Aviation Authority (SACAA) as regulator, who are two key interested and affected parties (I&APs).

The Department of Environment, Forestry and Fisheries online screening tool identifies the site as having a ‘high’ aviation sensitivity due to proximity of the Newcastle airport. Accordingly, a specialist assessment and “civil aviation compliance statement” is required.

2 STUDY SCOPE

2.1 BACKGROUND

The agreed study scope is set out below:

1. Submit relevant credentials of ‘expert’ status, including cv’s, letters of reference and project experience.

2. Confirm the SACAA licensing and operational status of Newcastle Airport (FANC)

3. Confirm the current Aeronautical Information Publication (AIP) status of FANC

4. Report on the potential ICAO Annex 14 or SACAA CARS/CATS impacts of the proposed Brother CISA project, which would encompass:
    a. Approach surfaces
    b. Take-off climb surfaces
    c. Inner horizontal surface
    d. Inner transitional surface
    e. Conical surface
    f. Radar, communications or navigational systems interference
    g. Any other issues raised by SACAA (as an I&AP)

5. Report on any potential impacts arising from the AIP or any NOTAMs currently in play, which are likely to be limited to potential dust/smoke plume impacts and any other H&S issues, which might more detailed assessment of prevailing wind direction and risk of particulates drifting into the path of aircraft (requires client input on air quality issues)

6. Noise impact assessment (of the proposed project on the airport) is not an issue and is excluded.

7. The study is a desk-top study.

8. The study is limited to the impact of the proposed Brother CISA development on Newcastle Aerodrome and does not address possible existing non-compliances of the aerodrome with CAA licence conditions.

2.2 PROGRESS TO DATE

Item 1 of the Scope was achieved during the Proposal Submission stage, but relevant documents attached hereto as Appendix D. This report addresses the remaining aspects of the scope.

3 LOCATION

The site is in the Newcastle Chemical Park, immediately south of the Newcastle Airport. Fig 1 illustrates the location of the proposed development site relative to existing airport infrastructure, GA developments and the FANC terminal, with the following key features noted:

- Runway orientation is essentially east-west (RWY 11/29) with RWY 29 dominant.
- Road access to the airport is from the north, off the Provincial road linking Newcastle to Madadeni
- The apron, passenger terminal and General Aviation (GA) areas are located north of the runway
- The Brother CISA site is **746m** south of the runway centreline
- The ground level of the nearest corner of the Brother CISA site is 9 m lower than the runway centreline.
- The gravel crosswind runway is no longer in use

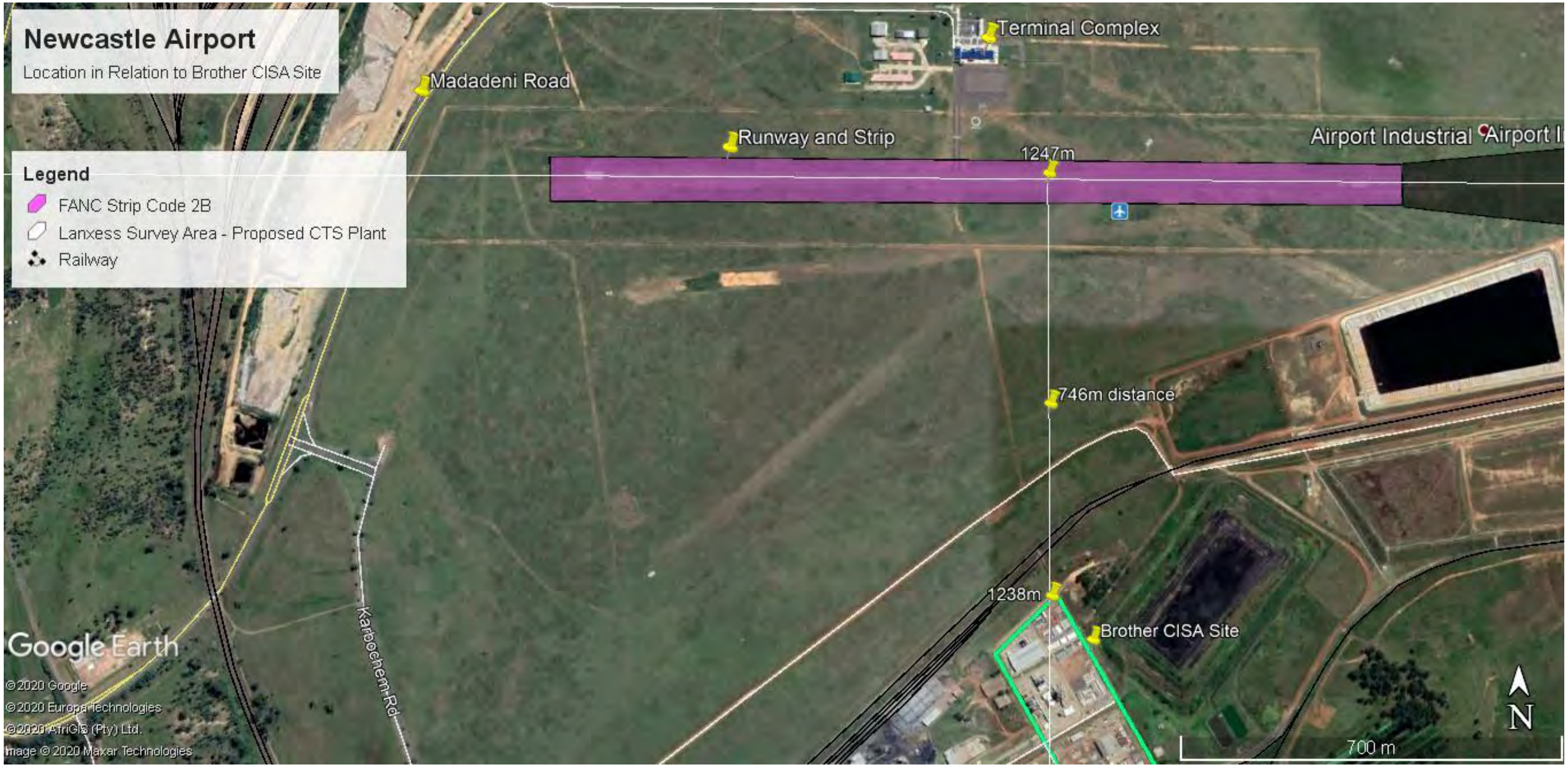


Figure1: Context of FANC and the Proposed Development Site

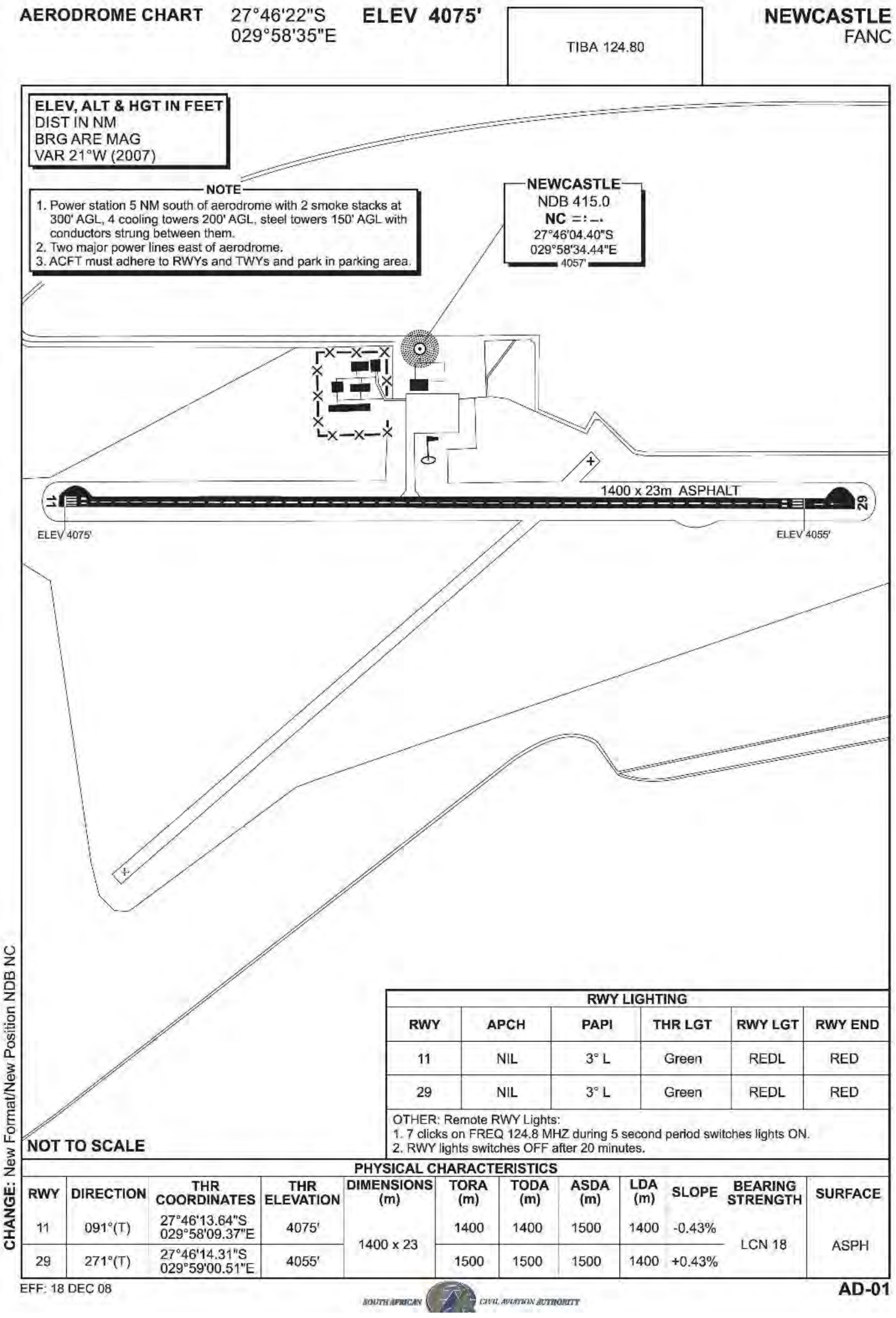
4 SUMMARY OF FANC INFRASTRUCTURE

4.1 AVIATION INFRASTRUCTURE

Newcastle Aerodrome is included in the consolidated Aeronautical Information Publication published by the SACAA and attached as Appendix B. The relevant provisions of the AIP are summarised below.

4.1.1 RUNWAY

FANC is an unmanned airfield with asphalt-surfaced runway of 1420x23 m at reference elevation 4 075 ft AMSL. The runway is an ICAO Code 2B non-instrument runway, which permits the use by Code 2B aircraft of up to ACN 18 under Visual Meteorological Conditions (VMC), as summarised in the Aerodrome Chart issued by the SACAA.



AERODROME CHART 27°46'22"S 029°58'35"E **ELEV 4075'**

TIBA 124.80

NEWCASTLE
FANC

ELEV, ALT & HGT IN FEET
DIST IN NM
BRG ARE MAG
VAR 21°W (2007)

NOTE
1. Power station 5 NM south of aerodrome with 2 smoke stacks at 300' AGL, 4 cooling towers 200' AGL, steel towers 150' AGL with conductors strung between them.
2. Two major power lines east of aerodrome.
3. ACFT must adhere to RWYs and TWYs and park in parking area.

RWY LIGHTING					
RWY	APCH	PAPI	THR LGT	RWY LGT	RWY END
11	NIL	3° L	Green	REDL	RED
29	NIL	3° L	Green	REDL	RED

OTHER: Remote RWY Lights:
1. 7 clicks on FREQ 124.8 MHZ during 5 second period switches lights ON.
2. RWY lights switches OFF after 20 minutes.

PHYSICAL CHARACTERISTICS

RWY	DIRECTION	THR COORDINATES	THR ELEVATION	DIMENSIONS (m)	TORA (m)	TODA (m)	ASDA (m)	LDA (m)	SLOPE	BEARING STRENGTH	SURFACE
11	091°(T)	27°46'13.64"S 029°58'09.37"E	4075'	1400 x 23	1400	1400	1500	1400	-0.43%	LCN 18	ASPH
29	271°(T)	27°46'14.31"S 029°59'00.51"E	4055'		1500	1500	1500	1400	+0.43%		

EFF: 18 DEC 08

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

AD-01

Fig 2: FANC Aerodrome Chart

The largest aircraft currently utilising the airport is the Code 2 Pilatus PC-12, although it is known that the introduction of scheduled services to Newcastle is being considered, in larger aircraft such as the Beech B1900-D or BaE Jetstream 41 types.

4.1.2 TAXIWAYS

A single link taxiway is provided from approximately the midpoint of the runway, accessing the main apron near it's south western corner, with taxi-lanes on the southern and western edges of the apron linking to a fuel facility and the GA area respectively. Aircraft wingspans are generally limited to 16m, although 18m wingspan aircraft can be accommodated.

4.1.3 APRON, TERMINAL AND SUPPORT FACILITIES

The apron can accommodate up to 3 x Code B aircraft to ICAO Annex 14 standards, parked at pilot-in-charge discretion.

The terminal was upgraded in 2015 utilising Provincial funding, and provides a peak hour passenger handing capacity of up to 100 2-way passengers per hour, at IATA Level of Service (LOS) C. Simultaneously with the terminal upgrade, the initial phase of a future 'Technohub' was developed in a new building linked to the passenger terminal, a new parking area built and a new security perimeter to SACAA standards installed.

4.1.4 FIRE AND RESCUE & FUEL

Fire & rescue facilities are provided *ad hoc* by the Newcastle Municipality at ICAO Cat 3, and both Jet A-1 and Avgas are available adjacent to the main apron. The contractual arrangements for the dispensing of fuel as between Council, the oil companies and intermediary service providers are not known.

4.1.5 ROADS, PARKING AND SUPPORT FACILITIES

A single 2-lane road access from the north-west leads to the public parking area and terminal, with one-way circulation around the parking area for approximately 50 vehicles. Additional (remote) long-term parking for approximately 50 vehicles is also provided, with provision for a drop-off lane and holding areas for PTO's and taxis close to the terminal.

4.1.6 SANITATION

Connections to a local septic tank and French drain system are provided, discharging partially treated effluent at agreed quality into existing water courses to the north.

4.1.7 SOLID WASTE MANAGEMENT

The municipality provides refuse removal services, which can be expanded to service new airfield development, hazardous waste excepted.

4.1.8 POWER SUPPLY

An Eskom MV supply to the airport is provided.

4.1.9 OBSTACLES

The Ingagane Power Station 5nm south of the aerodrome and Eskom HV powerlines approximately 0,5 nm to the east are noted in the AIP. No other obstacles are recorded.

4.1.10 GA AREA

GA traffic utilises the public apron, with taxiway links to a separate GA area west of the public apron, where private hangars are provided.

4.1.11 WEATHER

While the aerodrome has a weather station, no 'live' meteorological information is currently provided to pilots and no Aeronautical Flight Information Service (AFIS) is provided.

4.1.12 MASTER PLAN AND FUTURE EXPANSION

Airport and Precinct Master Planning (PMP) was undertaken by Council during the period 2012-2015 with the view of reserving certain surplus land in the northern airport precinct for future commercial uses and expanding the GA area.

5 IMPACTS OF THE PROPOSED BROTHER CISA FACILITY

After analysis of the layout of the FANC site and assessment of capacity, access and infrastructural constraints, the following summarises the potential impact of the proposed Brother CISA development to the south.

Fig 2 illustrates:

Figure 2: Development Site Locality in relation to Aerodrome OLS

5.1 ICAO ANNEX 14 COMPLIANCE ANALYSIS

5.1.1 KEY OBSTACLE LIMITATION SURFACES (OLS)

Fig 2 shows the key OLSs as defined in ICAO Annex 14 for the applicable Aerodrome Code (2B) likely to be influenced by the proposed development being:

a. **Approach and Take-Off Climb Surfaces**
Given the distance of the facility from the runway centreline, the aerodrome approach and take-off climb surfaces are not impacted.

b. **Inner horizontal surface**
The inner horizonal surface extends over the proposed development site, imposing a height limitation of 45m above the runway refence level of 1 247 m i.e. 1 292 m AMSL. To comply with this restriction, any new structures will need to be restricted to **54m** in height.

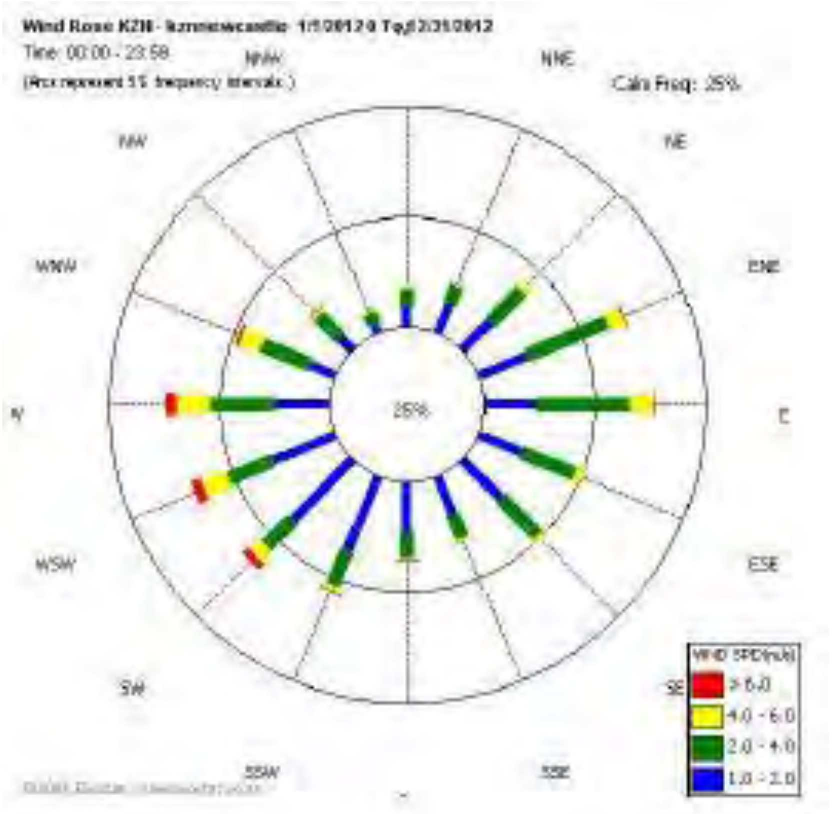
c. **Inner transitional surface**
The inner transitional surface does not impact the proposed development site.

d. **Conical surface**
The conical surface is superseded by the Inner Horizontal surface.

e. **Radar, communications or navigational systems interference**
The aerodrome is equipped with radio communications equipment located in the terminal building, which is used to communicate with aircraft and to enable remote operation of runway edge lights for night-time emergency operations. In addition, a non-directional beacon (NDB) is positioned north of the terminal complex. The infrastructure is a minimum of 1 000m from the proposed development site, which imposes a low risk of interference. In any event, standard operating procedures would require pilots to abort any movements in the event of communications failures and to divert, if necessary, to nearby airports such as Ladysmith.

f. **Wind and Air Quality**
In the absence of detailed wind data from the aerodrome itself, the potential of impacts on aircraft operations arising from dust or smoke plumes was referenced to anecdotal wind data sourced from the DAEA Ambient Air Quality Monitoring Network Report (2012) (Appendix C), subject to updated data being source by the Environmental Consultants.

The wind rose data for Newcastle confirms anecdotal data provided by the runway users, that predominant winds are westerly and south westerly, with a calm frequency of 1,0 – 2,0m/s, and wind speed in excess of 6 m/s only moderately likely. The attached wind rose illustrates.



In terms of impact on the aerodrome, the positioning of the proposed development is such that any new plumes will have low impact on the airfield within the landing zone. It is also likely that, because of the distance from the facility and height differential, any potential impact of visibility on approaches to RWY 29 will have dispersed, and not materially affect runway usability.

6 CONCLUSIONS AND COMPLIANCE STATEMENT

The analysis in accordance with ICAO Annex 14 and relevant SACAA standards indicates a low likelihood of any material impacts of the proposed development on operations at Newcastle Aerodrome, and the sensitivity of the site is thus low.

It is recommended therefore that the development be supported, subject to a height restriction of 54m above natural ground level within the development site.

7 APPENDICES

A: GLOSSARY OF TERMS

The acronyms listed below have been used in this document. Definitions have been taken from Wikipedia, where applicable, or accord with industry norms.

TERM	ACRONYM	DEFINITION
Aircraft Classification Number	CAN	An indication of runway strength requirements of aircraft, which must not exceed the corresponding Pavement Classification Number (PCN) of the airfield
Airfield Ground Lighting	AGL	Lighting systems on runway, taxiways and apron.
Aeronautical Information Publication	AIP	Publication issued from time to time by the SACAA summarising essential technical characteristics and operational parameters of an aerodrome
Civil Aviation Regulations	CARS	A national aviation authority or civil aviation authority is a government statutory authority in each country that maintains an aircraft register and oversees the approval and regulation of civil aviation.
Fire and Rescue classification category	CAT	The requirements for fire-fighting and rescue facilities required in terms of ICAO Annex 14, based on generally on aircraft length and cabin diameter.
Civil Aviation Technical Standards	CATS	Technical compliance standards applied by the CAA, generally parallel with ICAO Annex 14 requirements but in some cases adapted to local conditions.
Code	CODE	A two- letter code e.g. 2B designating the classification of an aircraft by ICAO in accordance with runway length (numeric code) required at mean sea level under standard temperature conditions, and wingspan (alpha code).
Calculated Take-off Time	CTOT	A time ‘slot’ issued by Air Traffic Control (or ACSA in the case of ad hoc slots) providing a planned take-off time in response to a filed flight plan. At slot-coordinated airports (ORTIA, KSIA, CTIA and PEIA), these need to be filed at least 24 hours in advance.
General Aviation	GA	Private, recreational, pilot training and non-scheduled commercial air services
Global Navigational Satellite System	GNSS	Satellite based aircraft navigational systems relying on GPS technology, regarded by the CAA as non-precision approaches.
Integrated Development Plan	IDP	An Integrated Development Plan is a plan for an area that gives an overall framework for development. It aims to co-ordinate the work of local and other spheres of government in a coherent plan to improve the quality of life for all the people living in an area.
International Civil Aviation Organisation	ICAO	The International Civil Aviation Organization is a specialized agency of the United Nations. It regulates the principles and techniques of international civil aviation infrastructure and air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.
International Air Transport Association	IATA	The International Air Transport Association is a trade association of the world’s airlines. Consisting of 290 airlines, primarily major carriers, representing 117 countries, the IATA's member airlines account for approximately 82% of total available seat miles air traffic.
Level of Service	LOS	Level of service to passengers as defined in IATA reference documents

Newcastle Airport	FANC	CAA acronym/reference for Newcastle (Municipal) Airport
Passengers	PAX	Number of passengers
Non-directional Beacon	NDB	Ground-based radio beacon that transmits a radio signal allowing pilots to establish positional (not directional) information relative to an aerodrome
Notice to Airmen	NOTAM	Ad hoc information issued from time to time by the SACAA advising pilots of short-term or new on-site issues at airports likely to affect safety or flight operations.
Performance Based Navigation	PBN	ICAO recommended policy to improve air traffic management through increased reliance on satellite-based navigation systems and thereby reduce aircraft-based carbon footprint through reduction in approach and 'hold' times of arriving aircraft and reliance on ground-based navigational infrastructure.
Precinct Master Plan	PMP	Precinct Master Plan for Pietermaritzburg Airport and linked Airport Master Plan as prepared by Messrs Royal HaskoningDHV and Delta BEC Consultants between 2012 and 2015.
Runway	RWY	According to ICAO, a runway is a rectangular area on a land aerodrome prepared for the take-off and landing manoeuvres of aircraft".
South African Civil Aviation Authority	SACAA	The South African Civil Aviation Authority is the South African national aviation regulating authority, overseeing civil aviation and governing investigations of aviation accidents and incidents.
Safety Health and Environment	SHE	Safety Health and Environment
Request for Proposal	RFP	A request for proposal is a document that solicits proposal, often made through a bidding process, by an agency or company interested in procurement of a commodity, service, or valuable asset, to potential suppliers to submit business proposals.
Remote Navigation	RNAV	Satellite based navigation systems, similar to GNSS.
Taxiway	TWY	According to the ICAO, a taxiway generally is a prepared area on a land aerodrome prepared for the taxi manoeuvres aircraft".
Visual Flight Rules	VFR	Visual flight rules are a set of regulations under which a pilot operates an aircraft in weather conditions generally clear enough to allow the pilot to see where the aircraft is going, within prescribed parameters.
Very high frequency omnidirectional radio antenna	VFOR	Radio antenna that provides position and directional vectoring capability to aircraft.
Visual Meteorological Conditions	VMC	Meteorological conditions under which visual sight distances (per SACAA rules) allow flight operations to proceed under VFR, without the necessity to resort to instrument procedures (IMC).

B: SACAA IAP

C: DAEA AIR QUALITY REPORT 2012

D: CREDENTIALS AND PROOF OF EXPERIENCE

E: STATEMENT OF INDEPENDENCE

Summary Resume of Jon Heeger and outline of Relevant Experience: October 2019

Jon Heeger is a civil engineer (BSc – Eng, Wits, 1977), with post graduate qualifications in project management (GDE, 1985) and business administration (MBA, 1985).

He was active in infrastructure development for 25 years before joining Airports Company SA (ACSA) in 1995 as Group Manager (Projects). In this capacity he chaired the King Shaka International Airport Ministerial Steering Committee (1996), sat on the ACSA Property and Capex Sub-Committees and was a member of the National Tender Board.

Jon has 24 years' experience on over 50 airports in over 10 countries in Africa, and in China, Brazil and Europe, where he has been involved on aviation projects across the spectrum of strategy development, forecasting and feasibility studies, airline route and network planning and operational management. He has proven knowledge of international aviation structures including ICAO/IATA.

Since 2004 Jon has been an independent aviation specialist, locally and in Africa, working in various capacities at airports like Roberts International Airport, Monrovia, Liberia (2005); Murtala II, Lagos, Nigeria; Aeroporto du Mozambique, Maputo (2007); Maun, Botswana (2006-2010); Klerksdorp (2011); Plettenberg Bay (2011); and six (6) municipal airports in KZN (2012-2017). More recently he was involved in network assessment for the National Tourism Strategy for the Republic of Kenya (2017), the Provincial Airlift Strategy for Mpumalanga (2018/9), the proposed redevelopment of Grand Central Airport (2019) and (currently) precinct strategies for ACSA at Port Elizabeth and East London, proposed new airports in Takoradi, Ghana and Postmasburg (Anglo American).

Other work includes route development and facilitation of negotiations with operators on routes to destinations such as KMIA, Maun, Gaborone, Mthatha, Grahamstown, Newcastle, Ulundi, Margate, Pietermaritzburg, Plettenberg Bay and Mkhuse.

Jon has interacted with all significant stakeholders in the aviation/route development industry in South Africa and internationally, including:

- National Department of Transport (DoT), SA.
- The SACAA and equivalent bodies in Africa
- Air Traffic and Navigation Services Corporation (ATNS)
- Commercial Airlines, both directly and through the Airline Association of South Africa (AASA) and the Board of Airline Representatives of SA (BARSA). Airline relationships include SAA, SA Express Airlines, SA Airlink, Mango, Federal Air, Cemair, Kenya Airways, Air Botswana and BA/Comair.
- Other industry bodies such as the AeroClub of SA, CAASA and others
- Counterpart organisations in Africa, namely KCAA and KAA (Kenya) and equivalents in Rwanda, Ghana, Nigeria and Mozambique.

Curriculum Vitae (CV): JBC Heeger

1	PROPOSED POSITION FOR THIS PROJECT	*Aviation and Airport Specialist*			
2	NAME OF PERSON	*Heeger, Jon*			
3	DATE OF BIRTH	*2 May 1955*			
4	NATIONALITY	*South African*			
5	MEMBERSHIP IN PROFESSIONAL SOCIETIES	*Member, Engineering Council of South Africa -ECSA No. 820365 (1982 - 2008)*			
6	EDUCATION	*MBA (Construction Management), University of the Witwatersrand, 1985* *GDE (Construction Management), University of the Witwatersrand, 1985* *BSc. Civil Engineering, University of the Witwatersrand, 1977* *BCom modules (part time): Micro and Transport Economics, UNISA 1978-1980*			
7	OTHER TRAINING	*ACSA/IATA/ICAO- Internal Training & Development programmes (1994-2000)* *Presentor/Attendee at various Aviation Conferences/Seminars (Aviadev, ATNS, BARSA)*			
8	LANGUAGES & DEGREE OF PROFICIENCY	Language	Speaking	Reading	Writing
		English	*Excellent*	*Excellent*	*Excellent*
		Afrikaans	*Good*	*Excellent*	*Good*
9	COUNTRIES OF WORK EXPERIENCE	South Africa, Botswana, Ghana, Mozambique, Nigeria, Liberia, China, Kenya, Brazil and Rwanda.			
10	EMPLOYMENT RECORD				
	Independent Expert/Consultant: Airport Planning and development	FROM: *2000*	TO: *2019*		
	Asset Management Division - Airports Company South Africa Position: Group Manager – Airport developments	FROM: *1996*	TO: *1999*		
	RMB Group (now Eris Properties) Position: General Manager: Developments	FROM: *1984*	TO: *1996*		
	SA Transport Services Position: Civil Engineer - Infrastructure	FROM: *1977*	TO: *1983*		
11	WORK UNDERTAKEN THAT BEST ILLUSTRATES YOUR CAPABILITY TO HANDLE THIS ASSIGNMENT				
		2019/2020: Airport Specialist *Pre-Feasibility Study for Proposed Ghana Airports Company Limited Regional Airport, Takoradi, Ghana.(Glad Africa)* Airport catchment area determination, traffic forecasting and route/frequency assessment. Engagement with GACL on Airport Master Plan and critical aircraft determination. Data gathering including meteorological/wind, runway length calculations and specification, obstacle limitation surface assessment, assessment of land use options for airport precinct, Airport Master plan including assessment of growth potential for aeronautical and JIT freight revenues. Terminal planning including peak hour assessment. Feasibility Study for integrated airport precinct.			
		2019/2020 Airport Specialist *Redevelopment Options for Tommy's Field Airport, Postmasburg (Anglo American, SMEC Engineers)* Traffic forecasting and route/frequency assessment with airline/charter operators. Assessment and			

		agreement of critical aircraft (ERJ 140), runway and terminal planning to ICAO Annex 14, IATA and client service levels standards/policies (security, health and safety) for three site options; commercial land use options for airport precinct, Airport Master Plan including assessment of growth potential for aeronautical and commercial revenues. Assessment of airspace class and options development for navigational and ATC protocols. Input into EIA and noise footprint; Feasibility Study for integrated airport precinct. Reference: Mr D DuPlessis (SMEC) – 082 495 0304
		Airport Specialist and Business Analyst *Revitalization Options for Ulundi Airport, South Africa. Zululand District Municipality. (2017)* Land use options for airport precinct, update of the Airport Master plan including traffic analysis and assessment of growth potential for aeronautical and freight revenues. Feasibility Study for integrated airport precinct. Reference: Ms Thembi Hadebe - 082 902 6029
		Commercial/Airport Specialist *Precinct Planning of Port Elizabeth and East London Airports, ACSA (2018/2020)* Advise on commercial land use options for airport precinct, assessment of current traffic in relation to previous forecasts insofar as this may impact on commercial and cargo potential/growth. Assessment of other exogenous developments that may impact growth at both airports (e.g. Coega and ELIDZ). Reference: Mr L Tilana (ACSA)
		Airport Specialist and Business Analyst *Redevelopment Options for Grand Central Airport, Midrand. Ivora Capital (2018/9)* Land use options for airport precinct, update of the Airport Master plan including traffic analysis and assessment of growth potential for aeronautical and non-aeronautical revenues. Pre-Feasibility Study for integrated airport precinct and potential for use of drones for fast-moving commodity delivery. Reference: Mr C Duminy - 083 633 6909
		Aviation Specialist *Republic of Kenya National Tourism Strategy (2017)* Analysis of existing route networks and traffic distribution and associated potential for international and domestic traffic/freight. Alignment of tourism priorities with airport and airlift strategies as between Ministry of Tourism, KAA, KCAA and stakeholder airlines including Kenya Airways, Fly540, Kenya Express and many non-scheduled operators. Assessment of likely impact of early adoption of SAATM on traffic within Kenya. Ref: Hon Najib Balala, Cabinet Secretary, Tourism
		Airport Specialist and Business Analyst *Richards Bay Airport Master Plan, South Africa. City of uMhlathuze (Richards Bay). (2009, 2017)*

		Site assessment, land use options and Airport Master plan including traffic forecast, critical aircraft determination and assessment of growth potential for aeronautical, freight and non-aeronautical revenues. Pre-Feasibility Study for new airport. Reference: Ms B Strachan – strachanb@umhlathuze.gov.za
		Airport Specialist and Business Analyst *Redevelopment Options for PC Pelser AIrport, Klerksdorp. Matlosana Municipality (2011,2017-19)* Land use options for airport precinct, update of the Airport Master plan including traffic analysis and assessment of growth potential for aeronautical and non-aeronautical revenues. Pre-Feasibility Study for integrated airport precinct. Reference: Mr A Khutlhwayo - 062 692 0590
		Aviation/Airport Specialist and Business Analyst *KZN Treasury Crack Team. KZN Treasury. (2012 – 2013).* Airport Master planning including traffic forecasts and assessment of growth potential for aeronautical and non-aeronautical revenues; Pietermaritzburg, Margate, Newcastle, Ladysmith, Ulundi and Richards Bay Airports. Reference: Mr F Alberts – 082 802 0382
		Airport Specialist and Business Analyst *Proposed New Mkuze Airport. Umhlosinga Development Agency. (2008 to 2013).* To conduct a feasibility study for the Mkuze Regional Airport as a catalyst for socio-economic upliftment of the Umkhanyakude District, including potential for local airfreight of agricultural produce.
		Business/Aviation Specialist *Maun Airport Expansion. Botswana Civil Aviation Authority. (2005-2010).* Preparation and validation of traffic forecasts, developing a business model, scenario planning and economic cost-benefit analysis for period 2005-2030. Development of new terminal concept designs and detailed landside Master planning including parking areas and non-scheduled operator FBOs
		Consultant Team Leader *Development of new Passenger Terminals and Cargo Facilities at Maputo. Aeroporto du Mozambique. (2007-2012).* Design review and construction supervision consultant for the new Domestic and International Terminals at Maputo International Airport. Review of contractor-produced traffic forecast, design brief and design proposals, level-of-service analysis and value management. Reference: Mr A Tuendue, CEO, ADM
		Summary of other airport assignments pre 2007. (1980-2007).

		• *Team leader – Kruger Mpumalanga International Airport:* Commercialisation Study Proposal. • *Lead Joint Venture partner - Mafikeng Airport IDZ (NW Provincial Government):* Proposed Minerals Cluster and commercial development. • *Team leader – Ghana Civil Aviation Authority*: Accra and Kumasi International airport Master Plans; air platform and non-aeronautical commercialisation (proposal). • *Joint Venture consultant – Ghana Civil Aviation Authority:* Implementation of parking equipment and systems, Kotoka International Airport, Accra, Ghana. • *Transport Economist/Business Analyst – World Bank - Monrovia, Liberia:* Assessment of emergency works required at Roberts International Airport. Validation of traffic forecast, development of business model, scenario planning and economic cost-benefit analysis. • *Team Leader – Department of Civil Aviation, Gaborone, Botswana:* Design review and development of alternate designs for new passenger terminal, including development and validation of traffic forecasts and preparation of facilities/ architectural design brief. • *Aviation Specialist – Bi Courtney Consortium, Lagos, Nigeria: Preparation of Master Plan proposals for expansion of domestic terminal* ***As Client Development Team Leader*** • *International Terminal Retail Project – ORTIA Johannesburg (1997)* • *Design Team Leader – Domestic terminal ORTIA (1997)* • *4 300 bay Multi-storey parkade, ORTIA (1996)* • *Chairman, Airport Steering Committee, La Mercy Airport (1997)* • *General Aviation Centre, East London (1998)* • *Terminal upgrades, East London & Port Elizabeth (1998)* • *Refrigerated cargo facility, Cape Town (1997)* • *Precious Commodities handling facility, JIA (1997)* • *In-flight catering facility, Cape Town (1997)*

CERTIFICATION
I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience. I understand that any wilful misstatement described herein may lead to my disqualification or dismissal, if engaged.

[Signature of staff member or authorized representative of the staff]

Date: 17/03/2020
Day/Month/Year

Full name of authorized representative: JONATHAN BARRY CLIVE HEEGER

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Ref: 14/6/1/R   Enq: PM Manqele   Email: mmanqele@zululand.org.za   Date: 2019/02/26

TO WHOM IT MAY CONCERN

This serves to acknowledge that GWI Aviation Advisory has been appointed to provide Professional advice, guidance and support to the Municipality regarding revitalization of Prince Mangosuthu Buthelezi Airport.

GWI conducted a well-structured and informative desk top study of the current situation and sustainability models for the airport. This Service Provider then developed a comprehensive Final Report on proposed Institutional Structures Options for Revitalization of the Airport. The document provides guidelines on what needs to be done to successfully work with an interested private party, such that the optimum potential of the Airport would be unleashed at minimal or no expense to the Municipality.

GWI developed unique options that look at circumventing disadvantages of most similar collaborations that have failed in the past, well within the ambits of all relevant legislation.

These are supported by the Provincial Treasury as well as Economic Development, Tourism and Environmental Affairs Departments.

GWI's work is undoubtedly given an A Rating.

A Rating: Excellent service provided
B Rating: Good service provided
C Rating: Average service provided
D Rating: Poor service provided

Yours Faithfully

pp   26-02-2019

RN HLONGWA
ACTING MUNICIPAL MANAGER

NEWCASTLE
SOUTH AFRICA

My Verw.:
My Ref.: ED 13/15/17

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2940

21 June 2017

To whom it may Concern

We hereby confirm that GWI Project Managers were appointed to provide project management services that would include an urban design and architectural concept layout for our airport and our Techno Hub Project in Newcastle.

Following their appointment, the planning has been completed, approved and we have secured R36, 560,000.00 inclusive of 14% VAT for the implementation of Phase 1 of the Techno Hub project. This project integrates with the upgrading of the Newcastle Airport in terms of the South African Civil Aviation Authority and it includes the construction of a new fence, provision of infrastructure, refurbishment to the airport terminal building and a new administration building for the Techno Hub.

GWI have provided project management services, together with specialized aviation compliance and recommendations, for the implementation of this project. The project is currently under construction and will be completed early in 2018.

We would give GWI A Rating on their services.

A Rating: Excellent services provided
B Rating: Good services provided
C Rating: Average services provided
D Rating: Poor services provided

Should you require any additional information please do not hesitate to contact me

Yours faithfully

F. Alberts
Director: Economic Development

DECLARATION OF INDEPENDENCE

I, Jonathan Barry Clive Heeger, as principal of GWI Aviation Advisory, hereby confirm my independence as a specialist and declare that I do not have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which EScience Associates (Pty) Ltd was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the application for Environmental Authorisation for expansion of Brother CISA operations in Newcastle, KZN. I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in my specialist report.

Signature

Dated: 10th July 2020