Appendix G.6

MHI REPORT

Public

MHI RISK ASSESSMENT
R- BAY PROPERTIES
PIETERMARITZBURG
2023

REPORT:	**MAJOR HAZARD INSTALLATION RISK ASSESSMENT FOR R-BAY PROPERTIES PIETERMARITZBURG NEW FACILITY**
ASSIGNMENT NO:	J3285M
INSPECTION DATE:	30 January 2023
REPORT ISSUE DATE:	25 April 2023
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CK 99/29022/23 VAT 4800182422

REPORT ADMINISTRATIVE RECORD

LIST OF ASSESSMENTS

Assessment	Rev. No.	Date	Description
Original	0	March 2023	J3285M - DRAFT MHI Risk assessment report issued by Ishecon.
Original	0	March 2023	J3285M - FINAL MHI Risk assessment report issued by Ishecon.

CONTRIBUTORS

The validity, results and conclusions of this assessment are based on the expertise, skills and information provided by the following contributing team members who are responsible for the design, operation and maintenance of the plant and equipment:

NAME	ORGANISATION	DISCIPLINE
Anri Scheepers	WSP Africa for R-Bay Properties	Principal associate
Martin	R-Bay Properties	CEO

NOTIFICATIONS

(Notifications to be done by client in terms of regulation 3)

NAME OR DESIGNATION	ORGANISATION
Chief Fire Officer	Msunduzi Municipality Fire & Rescue Emergencies 333 Church St, Pietermaritzburg, 3201 Tel: 033 845 5911
Provincial Inspector: Mr Edward Khambula	Department of Labour (Durban) PO Box 940, Durban, 4000 Tel: 031 366 2201/031 366 2203 Cell: 060 985 9286 Email: Edward.Khambua@labour.gov.za Sandile Kubeka (Specialist) Cell: 060 994 2436
Specialist Major Hazard Installations - Rachel Aphane	Chief Inspector – Major Hazard Installations Department of Labour Private Bag X117, Pretoria, 0001

MHI CLASSIFICATION

Under the MHI Regulations of 2001 and the MHI Regulations of 2022, the R- Bay warehouse site in Pietermaritzburg should as a precaution be classified as a Major Hazard Installation. Under the 2022 Regulation the facility should be considered a Low Level Major Hazard Establishment.

DISCLAIMER

Although every effort has been made by ISHECON to obtain the correct information and to carry out an appropriate, independent, impartial and competent study, it remains the facility's responsibility to ensure suitable Process Safety Measures are in place. ISHECON cannot be held liable for any accident or incident, due to negligence by the owner/operator, which directly or indirectly relates to the plant, equipment, facilities and systems analysed in this document and which may have an effect on the client or any other third party.

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I*SHE*CON will keep all information, results and findings confidential, and will not pass these on to other parties without the permission of the Client. However, I*SHE*CON has legal accreditation obligations toward SANAS and the Chief Inspector of the Department of Employment and Labour, which include monthly notifications to them of completed Risk Assessments, as well as presenting Risk Assessments for auditing purposes on request. These obligations will be complied with under legal confidentiality arrangements with SANAS and Department of Employment and Labour, without notifying the Client. As Approved Inspection Authorities for Department of Employment and Labour, I*SHE*CON is also under legal obligation to the Department of Employment and Labour to report any obvious violations of the OHS Act during site inspections.

RISK ASSESSMENT APPROVAL

This report is approved for issue by the undersigned Technical Signatory as per the ISHECON - Approved Inspection Authority – Appendix 2.1.

NAME	CAPACITY	REPORT DATE	SIGNATURE
S. Kachikira	Site visit, Calculations Report preparation:	April 2023	
D.C. Mitchell	Technical signatory:	April 2023	

EXECUTIVE SUMMARY

Richbay is a chemical distribution company in South Africa. The company imports chemicals in 1000L IBCs and 200L drums through the Richards Bay port, and bulk breaks at their distribution centres in Richards Bay, Pietermaritzburg and Gauteng into smaller Polycans for clients.
Due to the current import delays and challenges, Richbay chemicals is proposing to build a warehouse to be used as buffer storage for the imported chemicals. The warehouse will be able to supply its distribution centres with the chemicals to ensure the business keeps running.

The chemicals that will be stored at the R-Bay warehouse will be 500t hydrochloric acid, 150t sulphuric acid, 20t phosphoric acid, 20t Nitric acid, 30t sodium hypochlorite, 100t sodium hydroxide solution, 3t formaldehyde, 15t ammonium solution, 5t acetic acid, 15t sodium chlorite and 5t sodium metabisulphite powder, 150t sodium hydroxide flakes.

Ishecon has been contracted by WSP Africa to carry out a Major Hazard Installation risk assessment for the proposed facility as a requirement for the Scoping and Environmental Impact Reporting Process for chemical storage warehouses in Pietermaritzburg. This document therefore, summarizes the Major Hazard Installation Risk Assessment 2023.
This MHI risk assessment and report was conducted by a Department of Labour Approved Inspection Authority and complies with the requirements of SANS 1461:2018.

2. FINDINGS

Consequence Analysis and MHI Classification

- Due to the presence of certain hazardous materials, their associated offsite effects and the fact that some may be stored in IBCs (not drums) thereby exceeding the 2022 MHI Regulation Threshold, the R-Bay Properties Pietermaritzburg site should as a precaution be classified as a Low-Level Major Hazard Establishment.

- The following materials within the R-Bay Properties Pietermaritzburg have the following impact distances:

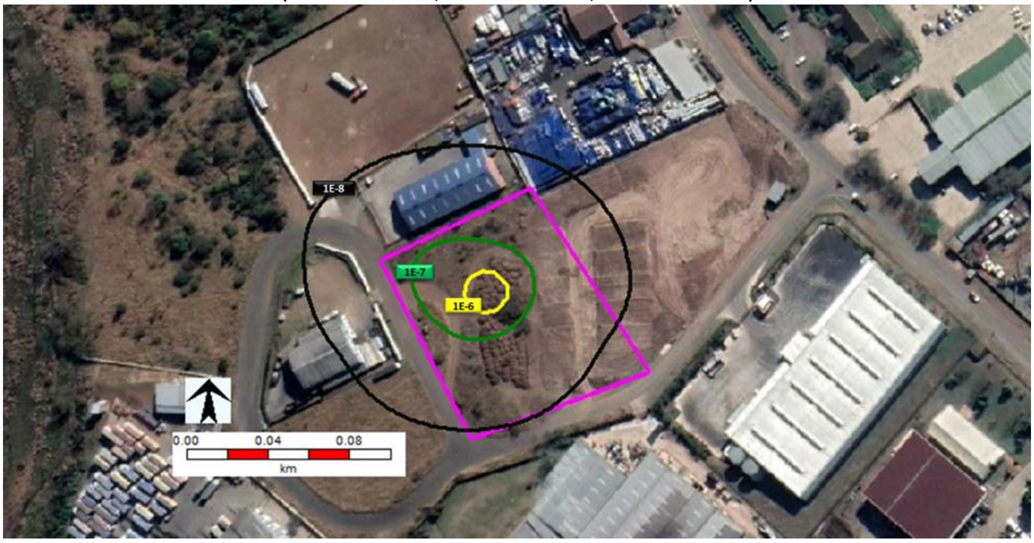
Installation	Worst case incident	Distance to 1% lethality
33% Hydrochloric acid	Catastrophic rupture – one pallet with four drums	200m
25% Ammonium hydroxide solution	Catastrophic rupture – one pallet with four drums	100m
60% Nitric acid	Catastrophic rupture – one pallet with four drums	35m
Acetic acid	Catastrophic rupture – one pallet with four drums	30m

- There are no known other declared Major Hazard Installations in the vicinity. Domino effect range of worst-case events does not go offsite (35m), therefore offsite domino effects are not a possibility.

Risks

- Risk levels to individuals near the facility can be summarised as follows:

Individual Risk Isopleths for the R-Bay Properties Pietermaritzburg Installation
(Yellow=1E-6, Green=3E-7, Black = 1E-8)



<u>Onsite risk (employee risk</u>
Acceptably low (i.e. Risk<$1*10^{-5}$ deaths/person/year). Risk to employees is highest at the offloading area
<u>Offsite risk at the site boundary (risk to neighbours):</u>
Acceptably low (i.e. Risk<$1*10^{-6}$ deaths/person/year). Risk to the public is highest at the site boundary with Buhle recycling.
<u>Risk to the nearest residences/sensitive receptors:</u>
Broadly acceptable (i.e. Risk<$1*10^{-6}$ deaths/person/year).

- Risks are acceptably low beyond ±0m from the site boundary.

- R-Bay Properties could consider implementing the following organisational measures:

Aspect	Review evaluation & Recommendation
Operator reliability - Major hazard awareness	– Ensure that operators are well informed of the impacts of toxic releases that have been included in this assessment. The training programmes should enable them to understand how to respond after an incident i.e. emergency planning and training – Forklift drivers must be licenced and well trained to minimise the likelihood of forklift accidents when carrying toxic chemicals.

- Risk reduction should always be explored. R-Bay Properties could consider the following technical risk reduction suggestions have been made in section 9 of this report:

Plant Area	Risk mitigated	Risk reduction suggestion
Offloading area.	Toxic release	Consider having curbing with drain to sump/ collection pit in the chemical offloading area to reduce the impact of toxic release from spills after a drum / pallet with drums has ruptured while offloading. A spill management schedule must be in place to prevent any incompatible chemicals ending up in the same pit.
Warehouse	Toxic release	Ensure product segregation as per SANS 10263. Ensure secondary containment as per SANS 10263 and the National Buildings Regulations. Ensure suitable ventilation through the warehouse.

- Societal risks **are acceptably low.** The maximum number of fatalities for a worst-case scenario could be up to 12 persons. The likelihood of this is less than once in ten million years.

Emergency Plan

- There are Emergency Procedures for the R-Bay group and the procedure has been reviewed against the requirements of SANS 1514 and suggestions made in Appendix 11. The plan needs to be adjusted to suite the hazards assessed for the R- bay warehouse in Pietermaritzburg.

- In terms of the regulations, off-site emergency planning is the responsibility of the local authorities, with involvement from the operating personnel at the facility when developing the plan.

- Annual Emergency drills are required.

Land Use Planning

- Since there could be offsite effects Town Planning should be made aware of which areas could be affected, in order to manage the approval of new developments in the vicinity of this MHI.
- The following land use planning restrictions have been suggested in section 10 of this report:

Development Type	Description	Suggested separation distance
Industrial use	Workplaces with buildings with <100 occupants and <3 storeys per building.	No land-use planning restrictions
	Workplaces containing buildings with >100 occupants and 3 or more storeys per building.	Not within the **Inner Zone** (0 m from site boundary)
Residential	Any housing developments, even those with less than 30 dwellings per hectare, except small infill projects of one or two units which could be allowed.	Not within the **Inner Zone** (0 m from site boundary)
	High density developments such as large blocks of flats, informal housing, etc.	Not within the **Middle Zone** (0 m from site boundary)
Other	Hospitals, old-age homes, crèches, schools, large outdoor entertainment facilities (theme parks, sports stadia), etc.	Not within the **Outer Zone** (0 m from site boundary)

3 RECOMMENDATIONS

The following recommendations have been made:

1. Under both the MHI Regulations of 2001 and the MHI Regulations of 2022, the R- Bay warehouse site in Pietermaritzburg should as a precaution be classified as a Low-Level Major Hazard Establishment.

2. The MHI Regulations of 2002 (regulation 3) requires that a person be appointed as responsible for the MHI. In addition, there are various other administrative requirements such as training, neighbourhood communications, reporting of incidents etc. Refer to regulations 3, 5, 9, 16, 17 and 18 specifically. R-Bay should ensure compliance with these requirements. Note that regulations 11, 12 and 13 do not apply to this installation.

3. A copy of this risk assessment should be available on the site at all times for inspection by the authorities.

4. Prior to commencement of construction, the relevant authorities (i.e. local Fire and Emergency services, Provincial Department of Employment and Labour and National Department of Labour) should be notified as per the requirements of regulation 4 of the MHI Regulations of 2022. R-Bay Properties should retain proof of notifications. See section 5.3.2.

5. Prior to commencement of construction, public notifications should be undertaken as per the requirements of Regulation 4 of the MHI Regs of 2022. R-Bay Properties should retain proof of notifications. See section 5.3.2.

6. R-Bay Properties Pietermaritzburg should inform their Health and Safety Committee of the results of this risk assessment.

7. There are Emergency Response Procedures (ERP) for the R-Bay group, The procedure has been reviewed against the requirements of SANS 1514 and suggestions made in appendix 11. The plan needs to be adjusted to suite the hazards assessed for the R- bay warehouse in Pietermaritzburg. R-Bay need to ensure compliance with the requirements of regulation 15 of the 2022 MHI Regulations, e.g. the ERP plan needs to be signed off by the local authorities.

8. R-Bay Properties Pietermaritzburg should confirm that the local emergency services have an off-site emergency plan in place.

9. The proposed design presents acceptably low risk levels. Risk reduction measures should always be explored and implemented to ensure continuous improvement. Some possible improvements have been suggested in section 9.

10. The R-Bay Properties Pietermaritzburg facility is unlikely to affect land-use planning in the area. Land use planning restrictions need not apply outside the site boundary. See section 10.

11. This MHI facility should be reassessed 5-yearly, (i.e. due 2028), or earlier if major modifications are made, the installations are expanded, or a major incident occurs.

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APPENDICES

GLOSSARY OF SOME TERMS USED IN THIS REPORT

List of units, acronyms and abbreviations used in this report	Definition
AIA	Approved Inspection Authority
ALARP	As Low As Reasonably Practicable
ASOV	Automated Shut-Off Valve
CAS number	A unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature
d/p/y	Deaths per persons per year
EFV	Excess Flow Valve
ERPG	Emergency Response Planning Guideline
E-stop	Emergency stop button
F-N curve	Frequency of N+ fatalities curve (graph)
G-room	Gas escape room
GMR	General Machinery Regulations
H/HH/HHH	High/High high/High high high, usually referring to operating parameters e.g. temperature/pressure
HAZOP	Hazard and Operability Study
IBC	Intermediate Bulk Container, usually 1000 litre capacity
kW	Kilowatts
kPa	Kilopascal
m	Metres
m^2	Metres squared
m^3	Metres cubed
MHI	Major Hazard Installation
ppm	Parts Per Million
PRV	Pressure Relief Valve
RA	Risk Assessment
ROSOV	Remotely Operated Shut-Off Valve
SANS	South African National Standards
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
XV	On/Off valve, usually operated by a solenoid when linked to an E-stop

1. INTRODUCTION

1.1 SCOPE OF ASSESSMENT

A Quantified Risk Assessment suitable as a Major Hazard Installation risk assessment for the proposed R-Bay Properties new development to be used as a chemical warehouse. The facility is located in Pietermaritzburg. The following chemicals will be stored in the warehouse and will be considered in this risk assessment study:

- Hydrochloric Acid
- Acetic Acid
- Sodium Hypochlorite
- Sulphuric Acid
- Caustic Soda (Solid)
- Caustic Soda Liquid
- Phosphoric Acid
- Nitric Acid
- Sodium Metabisulphite (Solid)
- Formaldehyde
- Ammonium 25%
- Sodium Chlorite 25-31%
- No other materials were listed by R-Bay Properties. Storage of other materials may change the classification of the facility as and MHI as well as the risks posed by the facility.

Several sections of the report necessitate substantiating information, which can be found in the appendices. The structure of the report is such that the numbering of the appendix will correspond with the numbering of the relevant section in the body of the report. Thus, should one want to look up further information regarding the weather data in section 2.2, the appendix with the corresponding information will be numbered as appendix 2.2.

Although this assessment is based on the best available information and expertise, ISHECON cc cannot be held liable for any incident that may occur on this installation and associated equipment which directly or indirectly relate to the work in this report.

1.2 MHI REGULATION SCOPE OF APPLICATION

This risk assessment was conducted to comply with the Major Hazard Installation Regulations under the (Occupational Health and Safety Act Nr. 85 of 1993, revised June 2001). Refer to Appendix 1.2 for further details of the regulation requirements.

It should be noted that between the time of the site inspection (30 January 2023) and issuing the report, the new MHI Regulations were promulgated on 31st January 2023. Due to clause 26 in the new regulations, there is some uncertainty as to whether the new regulation is currently in effect.

As a result, this assessment will look at the classification of the facility in terms of both the old and the new MHI Regulations.

1.3 PHILOSOPHY FOR CLASSIFICATION AS AN MHI

Two criteria define a site as an MHI:

1. Under the 2001 MHI Regulations the General Machinery Regulations* and under the New MHI Regulations ANNEXURE A - contains a list of hazardous materials with qualifying quantities for each. A site that stores more than the prescribed quantity of any of these materials is classified as an MHI. Under the new regulations there are three quantity thresholds for low, medium and high hazard installations.

OR

2. An installation that could cause a major incident that will affect the public is also classified as an MHI. MHI risk assessments consider only sites with materials that could lead to catastrophic fires, explosions or toxic releases.

Refer to Appendix 1.3 for details.
*(of the Occupational Health and Safety Act Nr. 85 of 1993, revised June 2001)

1.4 RISK ASSESSMENT METHODOLOGY

Risk is made up of two components:

- The probability of a certain magnitude of hazardous event occurring.
- The severity of the consequences of the hazardous event.

The risk assessment therefore includes the following:

- Identifying the likely major hazards expected to be associated with the operation of the installation including the causes, consequences and effects.
- Quantifying the hazards in terms of their magnitude (release rate and duration).
- Quantifying the consequences of the hazards and the severity of the effects using dispersion, radiation and explosion modelling.
- Determining the lethality of the effects of the hazardous consequences.
- Quantifying the likely frequency of the hazardous events.
- Estimating the individual risks[1] by combining the severity (lethality) and the likelihood of the various hazards.
- Estimating the societal risk[2] by taking the surrounding population into account.
- Comparing risks with international acceptability criteria[3].
- Reviewing the suitability of the emergency plan and organisational measures in terms of the risks.
- Proposing measures to reduce or eliminate the risk where necessary

Competencies:

- The MHI regulations require that a risk assessment should be carried out by a Department of Labour Approved Inspection Authority (AIA) to comply with the South African standard SANS 1461.2018 Edition 1.
- Refer to Appendix 1.3 for AIA approval certification for details of risk assessment procedures and Certification.

[1]The frequency at which an individual may be expected to sustain a given level of harm from the realisation of specified hazards.
[2] This is the relationship between the frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards.
[3]A standard or a norm.

2. DESCRIPTIONS

2.1 ORGANISATION, SITE LOCATION AND SURROUNDING AREAS

2.1.1 ORGANIZATION

R- Bay properties is a division of the Richbay Chemicals group.

2.1.2 LOCATION AND PHYSICAL ADDRESS

The installation's physical address is:

Physical Address: 0 Yarborough Road, Shortts Retreat no. 1208, Pietermaritzburg, 3201 *GPS co-ordinates:* 29° 39' 40.26 "S 30°24'51.49"E

2.1.3 DESCRIPTION OF SITE AND SURROUNDINGS

On **Figure 2.1.2** the border of R-Bay Properties Pietermaritzburg site (defined as the Major Hazard Installation Premises) is marked in pink. All persons outside this area are considered to be members of the public.

The following nearby locations are relevant:

Location	Details	Approximate Distance from proposed boundary (m)
Neighbouring industrial sites	Richbay chemicals Kingsley drinks Buhle waste management company Eco cycle waste management company Truda foods	<20m <20m <20m <20m 50m
Nearby MHIs and possible MHIs	None known	Na
Residential areas	Informal settlement Cleland Bisley	400m 1500m 1500m
Busy main roads, highways or rail lines	R103	1200
Sensitive receptors	None known	Na

Figure 2.1.1 is a map of South Africa showing the location of R-Bay Properties Pietermaritzburg.
Figure 2.1.2 shows the location of the site and surrounding area in more detail.
Figure 2.1.3 The location of the site and neighbouring industries
Figure 2.1.4 is a layout of the R-Bay Properties Pietermaritzburg site.

Figure 2.1.1 - Map showing the location of R-Bay Properties Pietermaritzburg

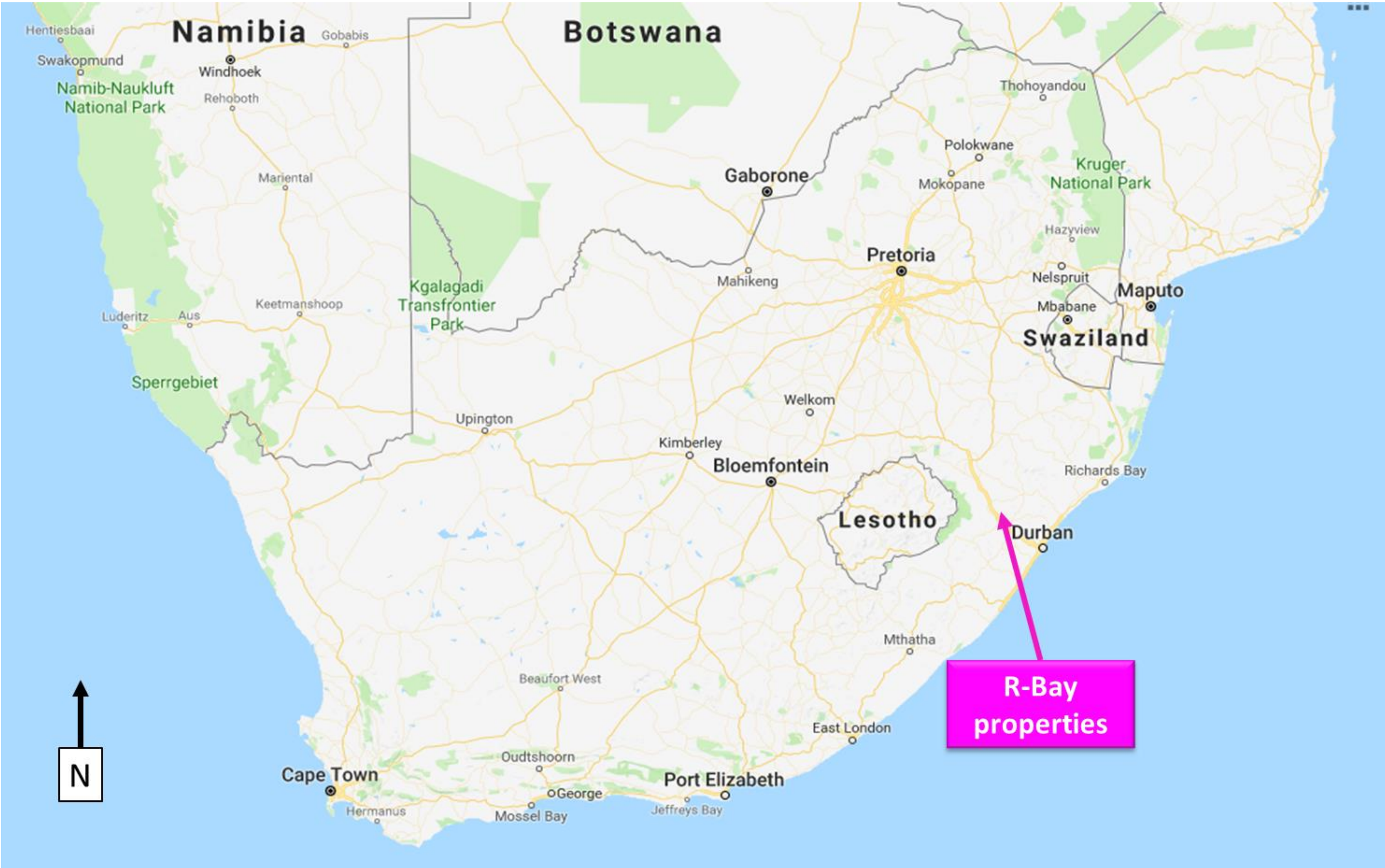
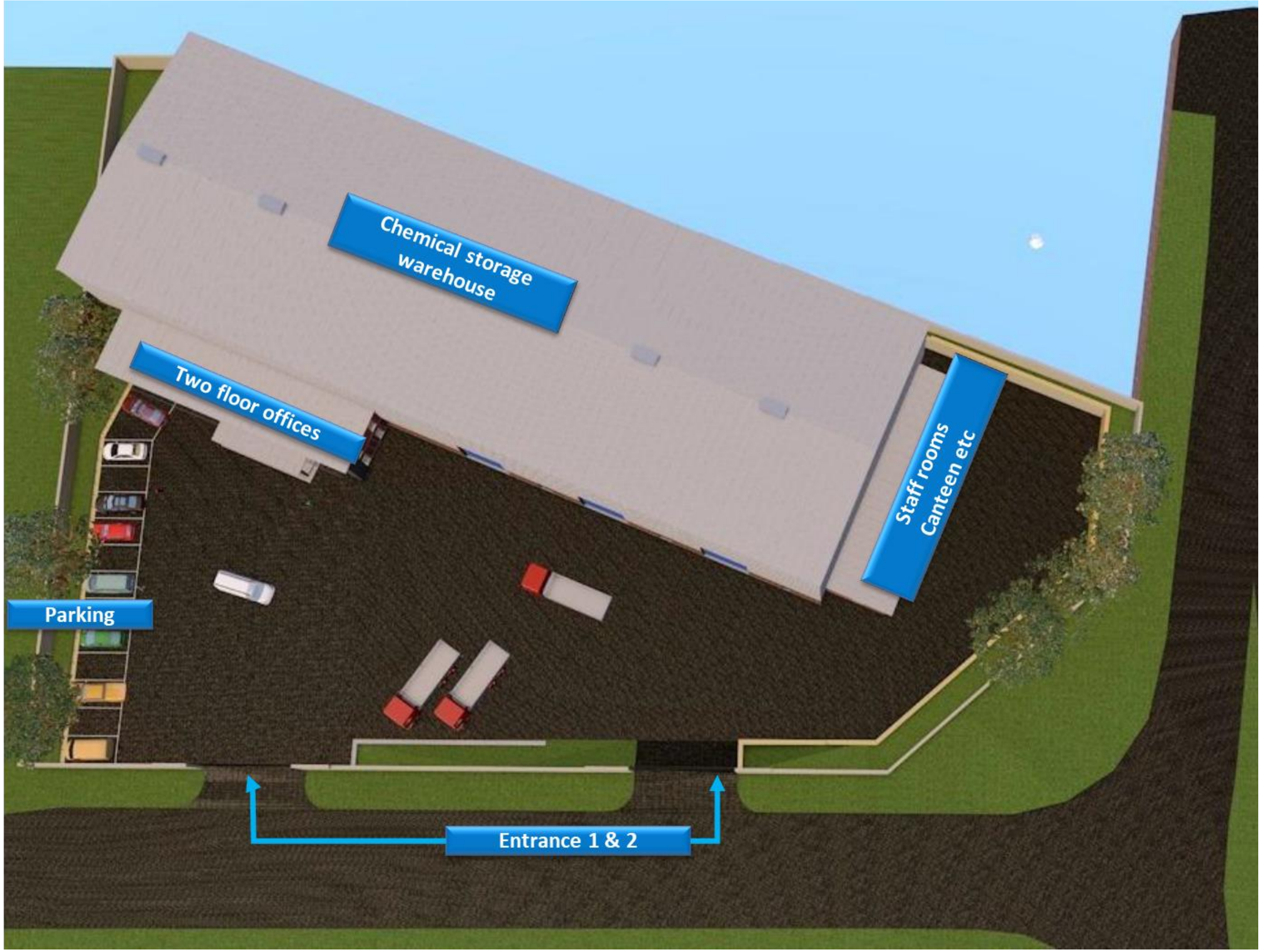


Figure 2.1.2 - The location of the site and surrounding area

Figure 2.1.3 The location of the site and neighbouring industries

Figure 2.1.4 is a proposed layout of the R-Bay Properties warehouse Pietermaritzburg site.



2.2 TOPOGRAPHY AND METEOROLOGY

2.2.1 TOPOGRAPHY

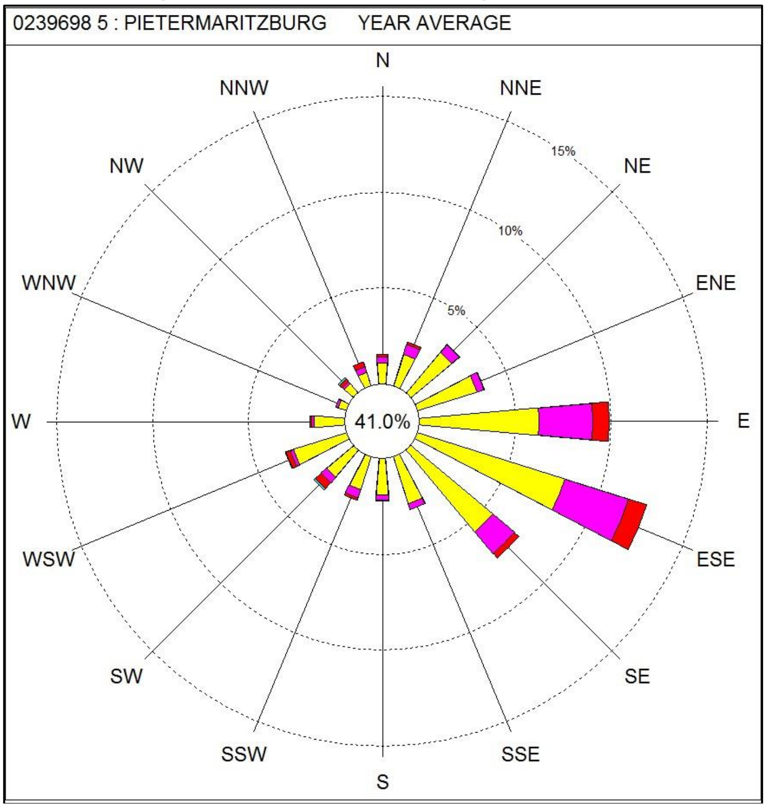
The proposed warehouse will be built in a relatively flat industrial area. There is Mkhondeni river south of the proposed site and Blackborough spruit northwest of proposed site.
The risk assessment software (SAFETI 8.7), does not take into account topography such as hills and valleys, nor local thermal conditions (upward currents due to heat generated by industries). However, the surrounding land is classified according to its “surface roughness” which influences dispersion modelling. (Refer to Appendix 2.2).

Across South Africa seismic activity is conceivable with Gauteng (man-made activity) the Western Cape (natural activity) being relatively higher risk areas. However, compared with aspects such as corrosion, human error etc. seismic activity is not usually a highly likely MHI risk factor, refer to SANS 10160:2011, part 4. [Ref 24]. To date there have been no seismic events that have impacted on the installation.

2.2.2 METEOROLOGY

Weather data for Pietermaritzburg was applied to the site.

Figure 2.2.2 Pietermaritzburg wind rose:



The dominant wind directions are from southeast. Refer to Appendix 2.2 for detailed weather information used.
Across South Africa, lightning strikes are conceivable as a source of ignition of major hazards, refer to SANS10313:2012 lightning strike density table. However, generally ignition from on-plant sources is much more likely than lightning and the frequency data need therefore not be specifically adjusted.

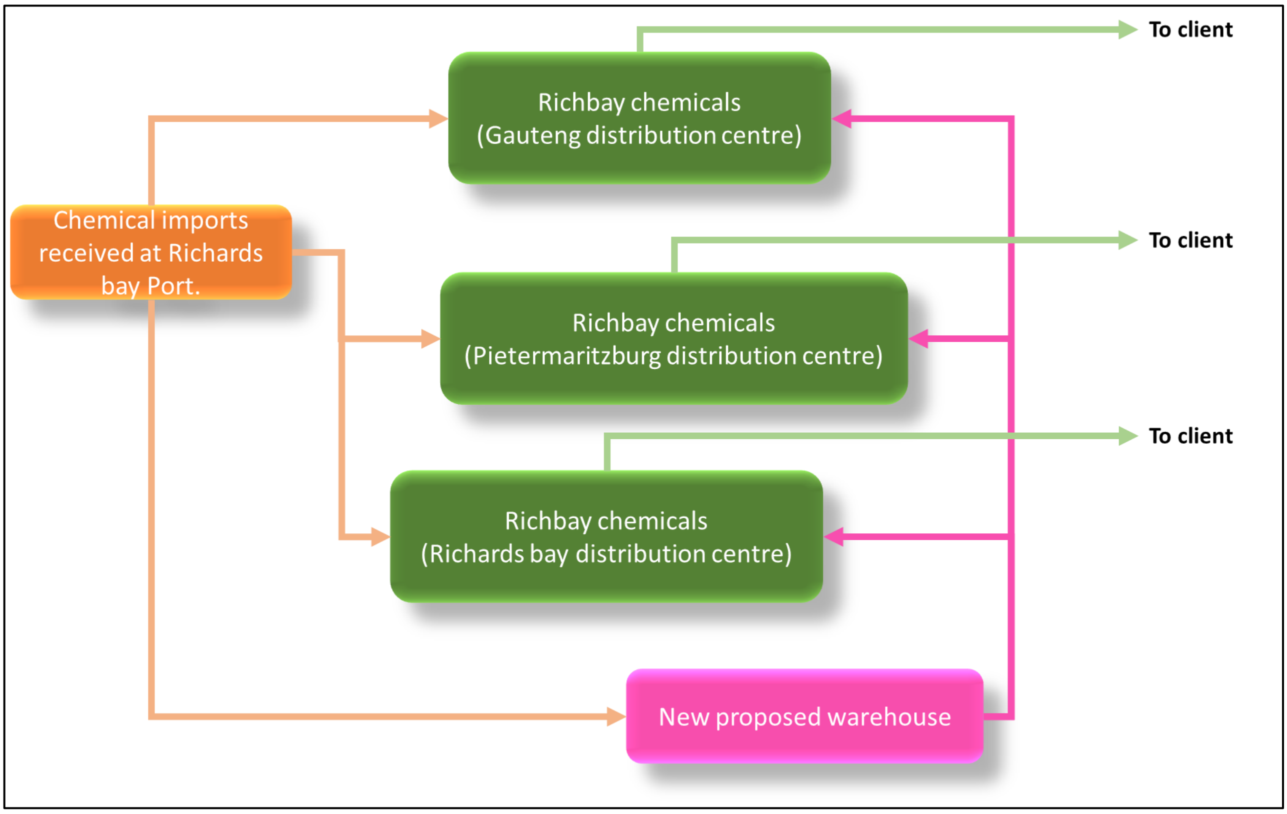
2.3 PLANT AND PROCESSES

2.3.1 ORIGIN, MANUFACTURE, INSTALLATION, ERECTION AND DATE

The proposed chemical warehouse falls under R- Bay properties which is part of Richbay Chemicals. Richbay chemicals has chemical distribution facilities in Richards Bay, Pietermaritzburg, and Gauteng.

2.3.2 PLANT AND PROCESS DESCRIPTION

The diagram below shows a basic overview of the proposed operations.



The new proposed warehousing will be used as an importation hub where the chemicals in drums and IBCs, will be offloaded from shipping containers, and stored, prior to dispatch to the Richbay Chemical Plants throughout Southern Africa. No decanting will take place in the warehouse.

The table below shows the chemicals that will be stored in the proposed warehouse.

2.3.3 STAFF AND SHIFT ARRANGEMENT

The admin office currently at the Richbay chemicals Pietermaritzburg will be moved to the new facility. The total number of employees to be determined at a later stage. There will only be day shift operations.

3. HAZARD IDENTIFICATION

3.1 MATERIAL HAZARDS

3.1.1 HAZARDOUS MATERIALS ON THE SITE

The materials on the site were categorised according to SANS 10228 classes of dangerous substances, as detailed below in Table 3.1. A determination was made whether these materials could constitute a MHI risk that needed to be quantified further, refer to following sections.

Table 3.1: Summary of hazardous material inventories

	CAS number	SANS10228 [Ref 2] Classification	Maximum Inventory (t)	Maximum Release Quantity (t)	Annual Through-put (t)	Potential MHI Material *(2001 regulations)*	New MHI Regs Named Substance ANNEX A Chapter 1	New MHI Regs Category of Substance ANNEX A Chapter 2	Potential MHI Material *(2022 regulations)*
33% Hydrochloric Acid	7647-01-0	8 Corrosive 2.3 Toxic gas	250L @4000units =1155t	250L drum	500t/mth@12mths/yr. =5000t/yr.	Likely may release toxic HCL fumes	No	No	No
98% Sulphuric Acid	7664-93-9	8 Corrosive	250L@ 200units =92t	250L drum	150t/month@12mths/yr. =1800t/yr.	Unlikely	No	No	No
Phosphoric Acid	7664-38-2	8 Corrosive	250L drums@ 80units =32t	250L drum	20t/month@12mths/yr. =240t/yr.	Unlikely	No	No	No
55-60% Nitric Acid	7697-37-2	8 Corrosive 2.3 Toxic gas	250L drums@ 100units =33t	250L drum	20t/month@12mths/yr. 240t/yr.	Likely, may release noxious fumes.	No	Acute Toxic Inhalation Cat 3 (H331) _ Oxidizing Liq Cat 3 H272	No if stored only in drums
70-99% Acetic Acid	64-19-7	3 Flammable liquid	250L drums@ 200units =218 t	250L drum	5t/month@12mths/yr. =60t/yr.	Likely	No	Flam Liq Cat 3	No Far below threshold of 1250 tonnes
45% Sodium Hydroxide solution	1310-73-2	8 Corrosive	250L drums@ 200units = 75t	250L drum	100t/month@12mths/yr. 1200t/yr.	No	No	No	No

	CAS number	SANS10228 [Ref 2] Classification	Maximum Inventory (t)	Maximum Release Quantity (t)	Annual Through-put (t)	Potential MHI Material *(2001 regulations)*	New MHI Regs Named Substance ANNEX A Chapter 1	New MHI Regs Category of Substance ANNEX A Chapter 2	Potential MHI Material *(2022 regulations)*
Sodium Hypochlorite	7681-52-9	8 Corrosive 2.3 Toxic gas	250L drums@ 200units =60t	250L drum	30t/month@12mths/yr. =360t/yr.	Likely	No	No	No
25-31% Sodium Chlorite	7758-19-2	8 Corrosive 2.3 Toxic gas	250L drums@ 40units = 12t	250L drum	15t/month@12mths/yr. =180t/yr.	Likely	No	Acute Tox Dermal Cat 3 (H311)	No Less than 15 tons and no IBCs
Formalin (37% formaldehyde)	50-00-0	8 Corrosive 2.3 Toxic gas	250L drums@ 20units =4 t	250L drum	3t/month@12mths/yr. =36t/yr.	Unlikely, low quantities	No	Flammable liq Cat 3 (H226) Acute Tox Inh Cat 2 (H301) Acute Tox Dermal Cat 3 (H311) STOT SE Cat 1	No Less than 15 tons No IBCs
25% Ammonium hydroxide solution	1336-21-6	8 Corrosive	250L drums@ 80units = 18t	250L drum	15t/month@12mths/yr. 180t/yr.	Likely	No	STOT SE Cat 3 (H335)	No
Sodium Metabisulphite (Solid)	7681-57-4	8 Corrosive 9 Miscellaneous	25kg bags @100units =2.5t	25kg bags	5t/month@12mths/yr. =60t/yr.	No	No	Acute tox oral Cat 4 (H302)	No
99% Caustic soda flakes	1310-73-2	8 Corrosive	25kg bags @8000units 200t	25kg bags	150t/month@12mths/yr. =1800t/yr.	No	No	No	No
Misc. cleaning solvents, lube oils etc.	Na					No catastrophic events expected	Small quantities	Small quantities	No

3.1.2 ENVIRONMENTAL HAZARDS

Assessment of environmental impacts is not included in this Major Hazard Installation risk assessment, as it should be addressed in an Environmental Impact Assessment for the site. Environmental hazards associated with the operations on this site should be addressed in an Environmental Management Programme.

3.1.3 HAZARDOUS MATERIAL INTERACTIONS

Some hazardous chemicals, when mixed, may result in flammable, explosive or toxic effects. Sodium hypochlorite when mixed with acids will form toxic chlorine gas.
R-Bay properties intends to have segregation of incompatible materials for any accidental mixes and a natural ventilation system in place.
There will be no decanting at the warehouse, and this reduces the chances of having incompatible materials mixing.

3.2 PAST ACCIDENTS AND INCIDENTS RELEVANT TO MAJOR HAZARDS

3.2.1 SITE

The site is still under design stage.

3.2.2 OTHER FACILITIES LOCAL AND INTERNATIONAL

Significant hazardous events have occurred at other similar or related installations around the world or with the MHI type materials that are used on site.

Refer to Appendix 3.2 for selected accidents and incidents.

4. HAZARD ANALYSIS

4.1. GENERAL SAFETY MEASURES

The following preventative and protective proposed features to be incorporated in the design and operation of the installation:

- Emergency response planning.
- Operator training

4.2. BOWTIE TABLE

A bow-tie type analysis was undertaken to identify the possible failure events, their causes, consequences, as well as the preventative and mitigative measures in the existing design of the installation and the details are shown in Table 4.2 below

Table 4.2 – Hazard Analysis

EQUIPMENT	CAUSES	PREVENTATIVE MEASURES IN PLACE	LOSS OF CONTAINMENT EVENT	CONSEQUENCES	MITIGATION MEASURES
Drums, IBCs	- Forklift accidentally drops pallet with HDPE drums - Forklift puncture - Drums fall off from rack	- Operating procedures, training, and awareness - Segregation of chemicals based on compatibility.	**Catastrophic rupture, Leaks**	- Spillages - Possible mixing of incomparable chemicals	- Bunding - Natural ventilation system if toxic chemicals are produced.

Refer to Appendix 4 for a summary of all the scenarios considered for modelling in this assessment, with associated key process data.

5. CONSEQUENCE ANALYSIS

Below are the consequence modelling results for the worst-case event for each material and selected additional events (*information on all incidents can be made available on request).*
Refer to the tables in the appendix 5 in order to interpret the impact (damage) from the contours below.

5.1 TOXIC EVENTS

5.1.1 HYDROCHLORIC ACID

Figure 5.1.1.1 Maximum concentration plot – catastrophic rupture of one pallet (4 drums) of 33% hydrochloric acid by forklift while offloading(S1).
Bold red circle shows the maximum extent of ERPG 3 = 150ppm in any wind direction and extends a 300m radius, the inner plume is the actual impact in the dominant south easterly wind.

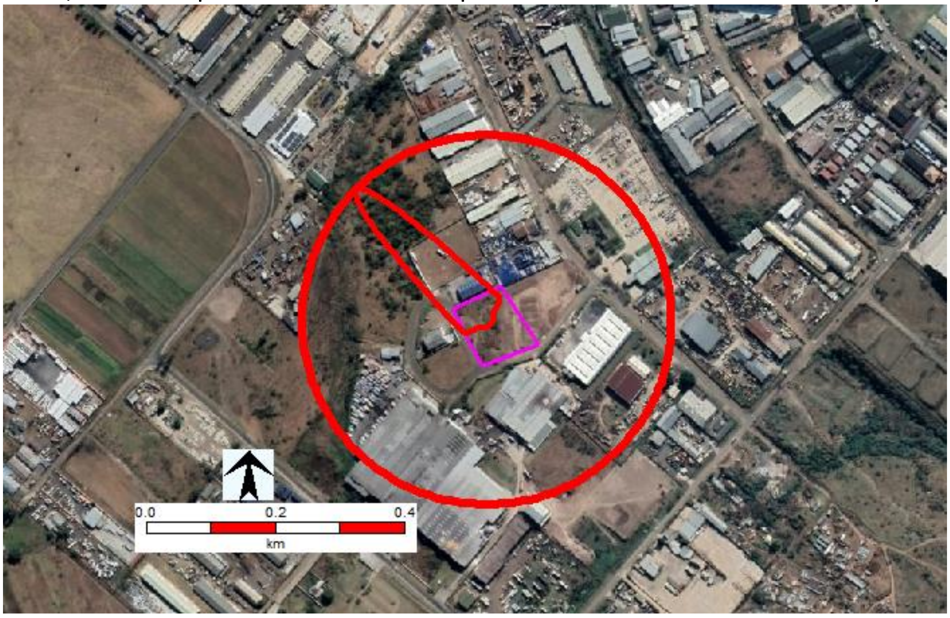


Figure 5.1.1.2 Lethality effect zone- catastrophic rupture of one pallet (4 drums) of 33% hydrochloric acid by forklift while offloading(S1).
Green = 1% Lethality effect zone (MHI threshold) –200m radius

Figure 5.1.1.2 Lethality effect zone- catastrophic rupture of one drum of 33% hydrochloric acid by forklift while offloading(S1).

Green = 1% Lethality effect zone (MHI threshold) –110m radius

5.1.2 NITRIC ACID

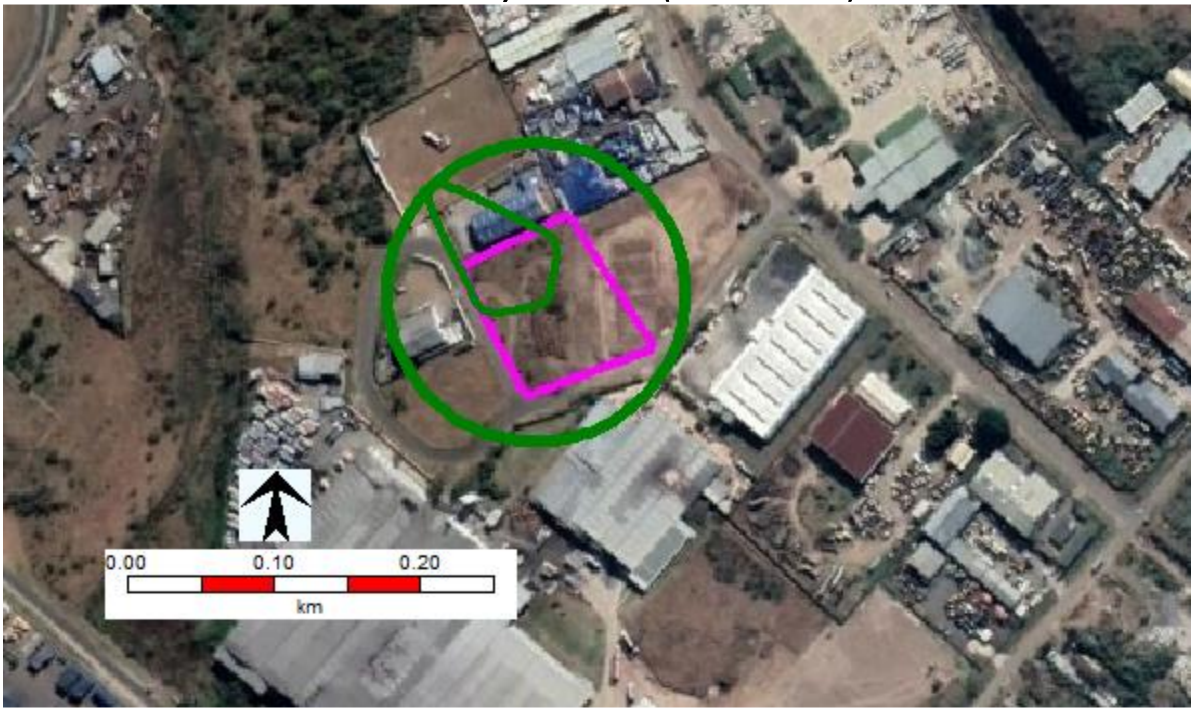
Figure 5.1.2.1 Lethality effect zone- catastrophic rupture of one pallet (4 drums) of nitric acid by forklift while offloading(S4).

Green = 1% Lethality effect zone (MHI threshold) –35m radius

5.1.3 AMMONIUM HYDROXIDE

Figure 5.1.3.1 Lethality effect zone- catastrophic rupture of one pallet (4 drums) of 25% ammonium hydroxide solution by forklift while offloading(S9).

Green = 1% Lethality effect zone (MHI threshold) –100m radius



5.2 FLAMMABLE EVENTS

5.2.1 ACETIC ACID

Figure 5.2.1.1 Radiation effects from a late pool fire resulting from the catastrophic rupture of one pallet with four drums of acetic acid

Green - 12.5 kW/m^2 - MHI threshold, 1% lethality, 30m radius

5.3 MHI CLASSIFICATION, NOTIFICATION AND REPORTING

5.3.1 CLASSIFICATION

The two criteria for a site to be classified as an MHI are:

1. Storage of a listed material as per GMR (See section 1)
2. Storage of a material which could cause a major incident that will affect the public

The table below summarises the classification findings for the R-Bay Properties Pietermaritzburg site according to these two criteria.

	2001 MHI REGS CRITERIA 1		2022 MHI REGS CRITERIA 1	2001 & 2022 MHI REGS CRITERIA 2		
MATERIAL	**STORAGE QUANTITY (Largest single vessel)**	**MHI ACCORDING TO GMR?**	**MHI ACCORDING TO ANNEXURE A**	**WORST-CASE INCIDENT***	**DISTANCE OF LETHAL (MHI) EFFECTS (m)**	**AFFECTING PUBLIC?**
33% Hydrochloric acid	250L drum	No	No	Catastrophic rupture – one pallet with four drums	200m	Only immediate industrial neighbours No Residential or vulnerable facilities
25% Ammonium hydroxide solution	250L drum	No	No	Catastrophic rupture – one pallet with four drums	100m	Only immediate industrial neighbours No Residential or vulnerable facilities
60% Nitric acid	250L drum	No	Only if >15 tons in IBC No if in drums	Catastrophic rupture – one pallet with four drums	35m	No
Acetic acid	250L drum	No	No	Catastrophic rupture – one pallet with four drums	30m	No

*Note that the events listed above are not the only events that could cause offsite effects and therefore the sole reason for MHI classification. The events listed are merely the events with the farthest offsite effects.

Under the MHI Regulations of 2022, the R-Bay warehouse would be a low level MHI ONLY if there were to be more than 15 tonnes of 55-60% nitric acid stored in IBCs. If nitric acid is stored in drums the facility will not be an MHI.
Given the above, ISHECON would suggest a precautionary approach with classification of the facility as a Low-Level Major Hazard Establishment. With this classification there is less likelihood of mistakenly exceeding thresholds on occasions and being in non-compliance. Note that should any other materials be

stored on site, or if the quantities exceed the above values, e.g. if there were more than 50 tonnes of nitric acid in IBCs, the facility may shift to a Medium Hazard Establishment.

5.3.2 NOTIFICATION OF MAJOR HAZARD INSTALLATION

If R-Bay wished to follow a precautionary approach as ISHECON suggests and this facility is to be considered a Major Hazard Installation, then notifications are required prior to commencing with construction.

Under the 2001 MHI Regulations the following were required:

- A letter and copy of this risk assessment should be submitted notifying the local government, the Department of Employment and Labour Chief Inspector and Provincial Director, of the Major Hazard Installation and that the risk assessment has been conducted.
- SDSs for the MHI materials materials indicated in the table above should be included in the notification.
- Public notifications should be done by placing an advertisement in a local paper, putting up public notices, and contacting adjacent neighbours to inform them of the site's classification.

The new 2022 MHI Regulations require in addition to the above:

- A newspaper adverts in a local language – IsiZulu, as well as in English.
- Completion of Form A in the Regulations. To complete this form there are various items that need to be addressed, e.g. on-site Emergency Response Plan signed off by the local authorities, proof of training in the ERP etc.

R-Bay is referred to the 2022 MHI regulations for details of the notification requirements.

The site should be reassessed again by 2028 (5 years), or earlier if major modifications are made, the installations are expanded, or a major incident occurs.

5.3.3 REPORTING OF EMERGENCY OCCURRENCES

Since the site is a Major Hazard Installation all incidents on the installations which require the emergency procedures to be activated should be reported to the local emergency services, as well as to the Provincial Director and National Chief Inspector. Such incidents should be recorded, and the register should be available for inspection. See MHI Regulation 7 (1).

5.4 EFFECT ON ADJACENT MAJOR HAZARD INSTALLATIONS

5.4.1 DOMINO EFFECTS WITHIN THE SITE

Fires on site from acetic acid could cause failure of adjacent drums with toxic chemicals, which could escalate the event. Toxic events alone do not normally lead to direct domino failures.

Figure 5.4.1 Potential domino effect zone - catastrophic rupture of acetic acid leading to a late pool fire, Red= 37.5 kW/m2 – Likely domino effects (20 m radius)

5.4.2 DOMINO EFFECTS ON ADJACENT MAJOR HAZARD INSTALLATIONS

There are no known MHIs near the R-Bay Properties, in Pietermaritzburg site, and the domino impact zone as shown in Figure 5.4.1 above is within the site boundary

6. FREQUENCY ANALYSIS

Generic failure data, as well as data available from the site or similar sites is used to determine the likelihood of hazardous events.

Standard failure data can be adjusted according to the assessor's evaluation of the 'systemic organizational factors' in operation on site is (i.e. the perceived level of maintenance and housekeeping, and how effective the actual implementation of any process safety management system etc.).

The R-Bay Properties Pietermaritzburg site was subjectively evaluated as a new installation and failure data was therefore only slightly negatively adjusted.

The most likely hazardous events on this site are:

1. Catastrophic rupture of drums with 33% hydrochloric acid

A table with the frequency of each event can be found in the process data table in Appendix 4.

7. RISK CALCULATION

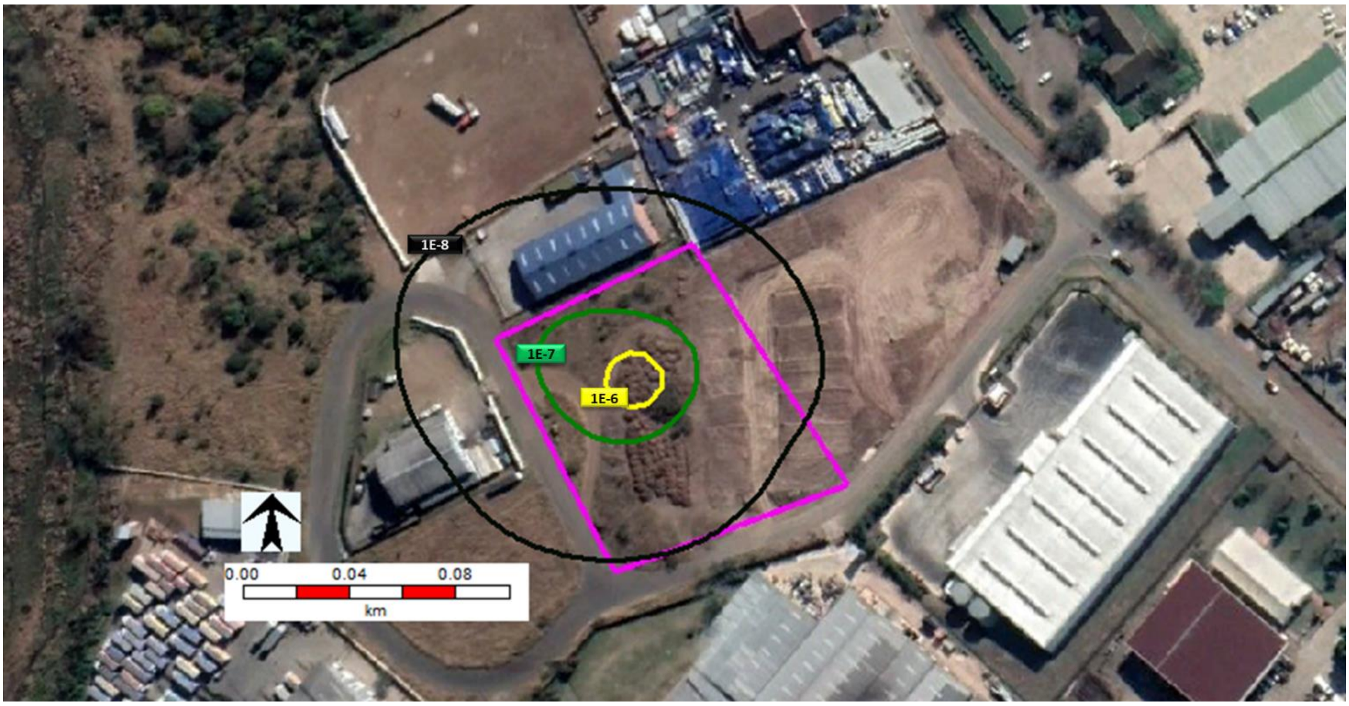
7.1 SAFETY RISK LEVELS

Two types of risk were evaluated in this risk assessment. They are outlined below and more details are presented in APPENDIX 7.

Individual risk: The chance that a particular individual at a particular location will be harmed. It is usually described in numerical terms such as "number of fatalities per person per year". The units are typically of one chance in a million of death per person per year and are shown as exponents i.e. $1 * 10^{-6}$ d/p/y.

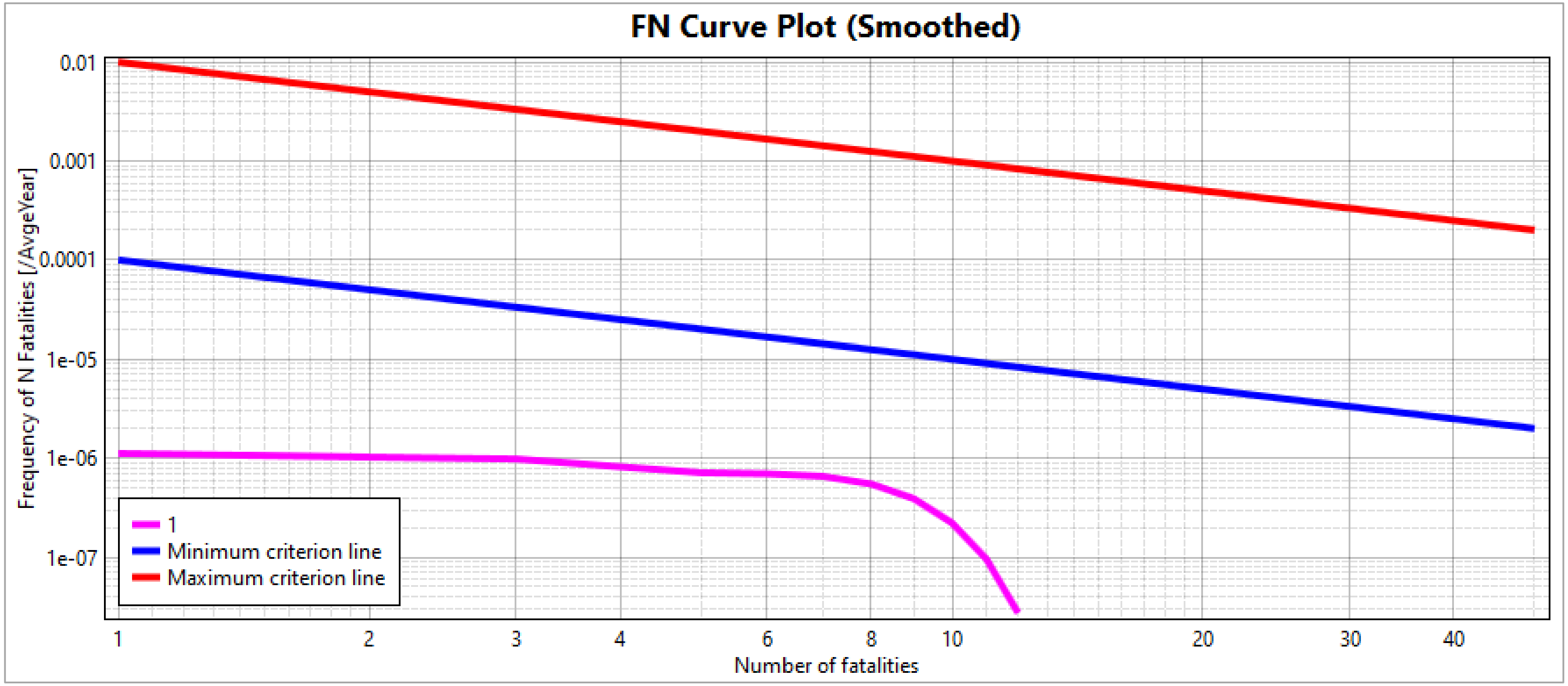
Societal risk: Societal risks do not focus on the risk to a single individual but consider the risk of numerous persons being killed for a given event. Societal risk considers each incident modelled and the corresponding numbers of persons affected, to provide an idea of the scale of an accident. Societal risks are considered to ensure that high likelihood events do not result in (relatively) large amounts of fatalities. Criteria for societal risk are described in Appendix 8.

Figure 7.1.1 – Individual Risk Isopleths for the R-Bay Properties Pietermaritzburg Installation
(Yellow=1E-6, Green=3E-7, Black = 1E-8)
Note: 1E-4 = $1 * 10^{-4}$ or 0.0001



No blue risk contours should be present within the site – as there are not, o**n-site risks are** Acceptably low.
The red lines **should not** extend beyond the site boundary – as they do not, **off-site risks are** Acceptably low.

Figure 7.1.2 – Societal Risk F-N Curve for the R-Bay Properties Pietermaritzburg Installation



The pink line for the installation risk **should not** be above the red risk criteria line and ideally below the blue line – societal risks are **Acceptably low.**

7.2 ENVIRONMENTAL RISKS

It should be noted that the assessment of environmental impacts in not within the remit of the MHI regulation nor the scope of an MHI Risk Assessment. Given the small size of individual packages, it is unlikely that spills would have major environmental impacts. As there are no flammables stored in the warehouse, a massive fire resulting in contaminated fire water run-off is also unlikely.

However, since this is a hazardous chemical warehouse, according the SANS 10263 & The National Building Regulations, some form of secondary, possibly even tertiary, containment will be required.

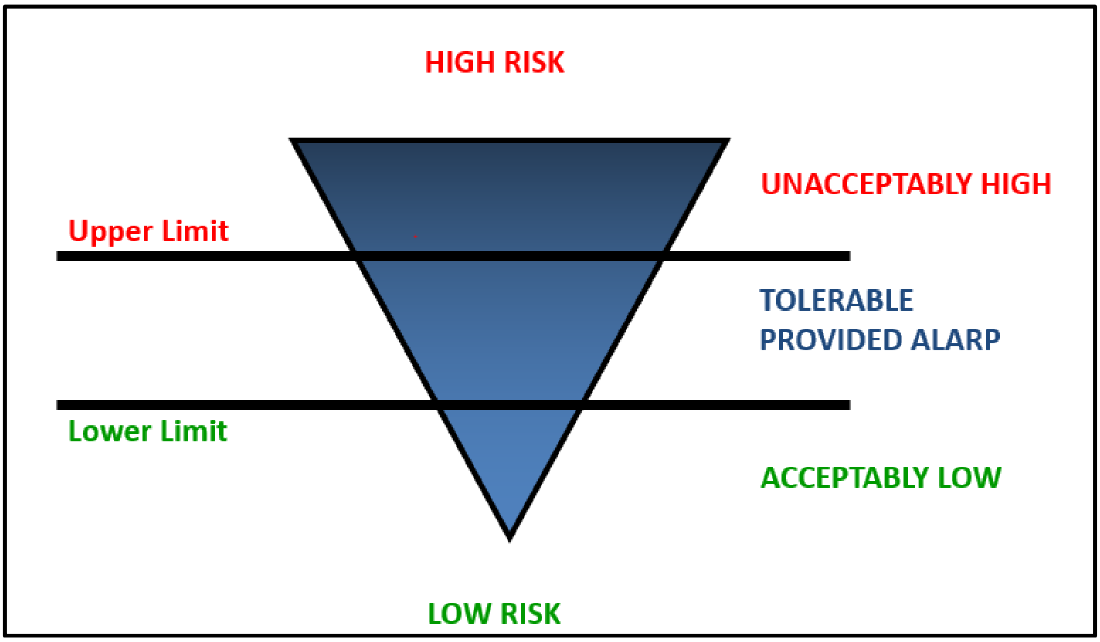
Note should be taken of the requirements of Section 30 of the National Environmental Management Act, as amended, (NEMA), which require various reports to be submitted in the event of any serious incidents on the installation. Safety, Health and Environmental management systems should be in place to facilitate the recording and reporting.

8. RISK JUDGEMENT

8.1 INDIVIDUAL RISK

Individual risk can fall into one of three broad categories:

- Unacceptably high
- Tolerable provided ALARP
- Acceptably low



With respect to acceptability of risk there are no agreed (or legislated) numerical criteria applicable in South Africa. The United Kingdom's Health and Safety Executive's criteria is widely used. These criteria are well developed, conservative and yet not stringent to the point of inhibiting industrial development. See APPENDIX 8.1 for a discussion on the acceptability of risk and the UK criteria.

Table 8.1.1 Summary of UK HSE individual risk criteria

RISK CLASSIFICATION	EMPLOYEES WITHIN SITE (chances in a million (cpm) of being fatally affected in any one year)	PUBLIC PERSONS (chances in a million (cpm) of being fatally affected in any one year)
Unacceptably High	More than 1000	More than 100
Tolerable Provided ALARP	Between 1000 and 10	Between 100 and 1
Acceptably Low	10 or less	1 or less

Risk levels vary as one moves away from or toward each hazardous installation. Cumulative risk levels for some significant locations are presented in the table below. For each area, the material/equipment contributing most to the risk in each location is listed in the last column.

Table 8.1.2 – Individual risk levels at various locations

LOCATION	INDIVIDUAL RISK LEVEL (per million)	ASSESSMENT PER UK HSE CRITERIA	AREAS CONTRIBUTING TO THE RESIDUAL RISK
RISK TO EMPLOYEES (ON-SITE LOCATIONS)			
Offloading area	2	Acceptably low	- 1. Hydrochloric acid 250L HDPE drum catastrophic rupture
Boundary with Neighbour (Buhle)	<1	Acceptably low	- 1. Hydrochloric acid 250L HDPE drum catastrophic rupture
RISK TO PUBLIC (OFF-SITE LOCATIONS)			
Ecosytle recycling	<1	Acceptably low	- 1. Hydrochloric acid 250L HDPE drum catastrophic rupture
Kingsley beverages	<1	Acceptably low	- 1. Hydrochloric acid 250L HDPE drum catastrophic rupture
Informal settlement	<0.1	Broadly acceptable	- NA

From the above table and the risk contours shown in Section 7.1, unmitigated location specific individual risk levels can be summarised as follows:

Onsite risk (employee risk
Acceptably low (i.e. Risk<$1*10^{-5}$ deaths/person/year). Risk to employees are highest at the offloading area

Offsite risk at the site boundary (risk to neighbours):
Acceptably low (i.e. Risk<$1*10^{-6}$ deaths/person/year). Risk to the public is highest at the site boundary with Buhle recycling.

Risk to the nearest residences/sensitive receptors:
Broadly acceptable (i.e. Risk<$1*10^{-6}$ deaths/person/year).

Risks are acceptably low beyond ±0m from the facility.

8.2 SOCIETAL RISK

Individual risk referred to above considers the risk to a typical individual but does not consider how many individuals could be affected. Communities have a strong aversion to large events, which lead to multiple fatalities. Therefore, the frequency of events that lead to multiple fatalities should be suitably low.

Societal risk includes the population in the vicinity and estimates the chances of numbers of people being harmed by an incident. The likelihood of the primary event (an accident at a major hazard plant) is still a factor, but the consequences are assessed in terms of level of harm and numbers affected, to provide an idea of the scale of an accident in terms of total numbers killed or harmed. Estimates of the societal risks incorporate the population distribution during day and night, as well as the location of people indoors or outdoors. (See the table in appendix 7 for the population data used).

The results are presented in the form of an F-N curve. This plots the number of persons potentially fatally affected by every one of the potential events on site, against the frequency with which these levels of fatalities can be expected to occur.

Figure 7.1.2 indicates that societal risks are acceptably low**.** The maximum number of fatalities for a worst-case scenario could be up to 12 persons. The likelihood of this is less than once in ten million years.

8.3 UNCERTAINTIES

The calculation of risk is affected both by the consequence modelling and the frequency estimates.

The consequence modelling is well known and international software was used. Consequence modelling therefore does not contribute greatly to the uncertainty and sensitivity of the risks results. However, the following should be noted:

- Bunding/ curbing was assumed in the modelling calculations.

Frequency estimates, on the other hand, do contribute especially with scenarios that are not readily available in international databases. When calculating these, this assessment has generally erred on the side of caution.

Overall, on-site risks may be an order of magnitude higher or lower than shown above. Either way this will not change the fundamental conclusions of this assessment that the site is an MHI and that the risks are mostly acceptable. Any facility should always strive to ensure they have done everything reasonably practicable to reduce the risks, i.e. ALARP.

9. RISK TREATMENT

Technical and organizational recommendations do not form part of the Approved Inspection Authority (AIA) certification extended by SANAS for MHI risk assessment AIAs. Therefore, o*pinions and interpretations expressed herein are outside the scope of SANAS accreditation.*

This MHI report may suggest that certain risk reduction measures be considered, however these will merely be **suggestions** that the client is responsible for investigating further. The client should undertake their own risk reduction study, and then implement those measures that are deemed reasonably practicable.

9.1 ORGANIZATIONAL MEASURES

MHI facilities should put organisational measures in place to <u>prevent</u> risk events that could result in a MHI incident. Such organisational measures are known as a ‘process safety management system’ (PSM system) and covers many elements for example:

- Management leadership
- Safety documentation
- Integrity assurance
- Instrumented protection functionality
- Permit to work
- Management of change
- Operator training and procedures
- Mechanical protective systems
- Electrical protective systems
- Process protective systems

The organizational measures in place on the site have been reviewed in using a checklist which covers many aspects of such a PSM system. R-Bay Properties could consider implementing the following measures:

Aspect	Review evaluation & Recommendation
Operator reliability - Major hazard awareness	– Ensure that operators are well informed of the impacts of toxic releases that have been included in this assessment. The training programmes should enable them to understand how to respond after an incident i.e. emergency planning and training – Forklift drivers must be licenced and well trained to minimise the likelihood of forklift accidents when carrying toxic chemicals.

9.2 TECHNICAL MEASURES

The following risk reduction suggestions can be considered:

Plant Area	Risk mitigated	Risk reduction suggestion
Offloading area.	Toxic release	Consider having curbing with drain to sump/ collection pit in the chemical offloading area to reduce the impact of toxic release from spills after a drum / pallet with drums has ruptured while offloading. A spill management schedule must be in place to prevent any incompatible chemicals ending up in the same pit.
Warehouse	Toxic release	Ensure product segregation as per SANS 10263. Ensure secondary containment as per SANS 10263 and the National Buildings Regulations. Ensure suitable ventilation through the warehouse.

9.3 DEMONSTRATING ALARP

Risks that are higher than “Broadly Acceptable”, but lower than “Intolerable”, fall into the “tolerable, provided ALARP” range. Risks in this range are considered “Tolerable,” **only** if further risk reduction is impractical or if its cost is grossly disproportionate to the improvement gained.

Proving ALARP is not considered part of the MHI risk assessment, moreover risks posed by this facility fall below the ALARP range so such a study should generally not be required.

10. LAND USE PLANNING

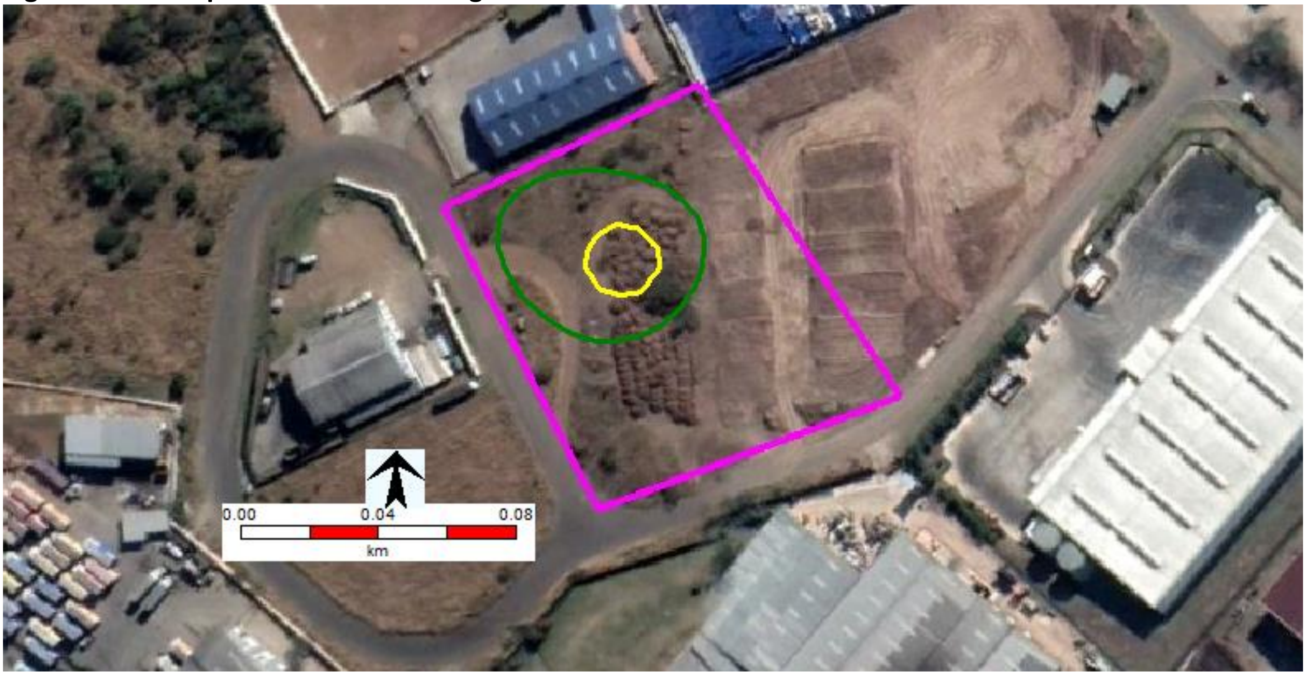
There is a twofold responsibility placed on the local authorities when dealing with an MHI (See MHI regulation 9).

- To should ensure that the existing MHI facility presents sufficiently low risks to existing neighbouring facilities and communities.
- To ensure that new developments within the area potentially affected by the MHI are suitable for the risk level in the area, e.g. no hospitals near very hazardous plants.

The site is situated on industrially zoned land, and is surrounded by other industries. Land-use planning restrictions are suggested as follows:

Development Type	Description	Suggested separation distance
Industrial use	Workplaces with buildings with <100 occupants and <3 storeys per building.	No land-use planning restrictions
	Workplaces containing buildings with >100 occupants and 3 or more storeys per building.	Not within the **orange** contours (0 m from site boundary)
Residential	Any housing developments, even those with less than 30 dwellings per hectare, except small infill projects of one or two units which could be allowed.	Not within the **orange** contours (0 m from site boundary)
	High density developments such as large blocks of flats, informal housing, etc.	Not within the **yellow** contour (0 m from site boundary)
Other	Hospitals, old-age homes, crèches, schools, large outdoor entertainment facilities (theme parks, sports stadia), etc.	Not within the **green** contour (0 m from site boundary)

Figure 10.1 – Map of Land Use Planning Zones.



ORANGE – within the orange contour is the Inner Zone (up to 0 m from site boundary)
YELLOW – between the yellow and the orange contour is the Middle Zone (up to 0 m from site boundary)
GREEN – between the green and the yellow contour is the Outer Zone (up to 0 m from site boundary)

Note that the above are merely suggestions and any decisions regarding land-use planning are entirely the responsibility of the local authorities.

11. EMERGENCY RESPONSE PLANNING

11.1 ON SITE EMERGENCIES

These can be emergencies that only have effects within the site boundary. There are Emergency Procedures for the R-Bay Properties Pietermaritzburg facility, and the procedure has been reviewed according to SANS 1514 and its requirements. Some ideas for improvement have been suggested below:

No.	Description of SANS 1514 Requirement	Not addressed	Partially addressed	Compliant	Suggested Action
1	Emergency Coordinating and Planning Committees - reciprocal representation			✓	
2	Documented ERP - document controlled			✓	
3	Owner/Operator/Occupier identified			✓	
4	Site location identified			✓	
5	EPR development process summary flow chart - interactions, inputs stated			✓	
6	Command structure - organogram, personnel appointments, roles, responsibilities, duties - transfer of command to emergency services		✓		Update for warehouse site
7	Emergency Controller and functional personnel authorizations		✓		Update for warehouse site
8	Contact details of functional personnel, emergency services and neighbours			✓	
9	Operations flow diagram/description	✓			Update for warehouse site
10	Hazardous substances inventory and location	✓			Update for warehouse site
11	Detailed site map	✓			Update for warehouse site
12	Table of contents	✓			Update for warehouse site
13	Aims and objectives			✓	
14	Hazard ID - MHI and other inputs used	✓			
15	Hazchem table - name, UN No, GHS class, quantity, location, safety critical equipment - isolation and containment	✓			
16	Emergencies defined			✓	
17	Levels and types emergency table			✓	
18	Key stakeholder analysis - roles, responsibilities, functions, needs		✓		Update for warehouse site
19	Physical method of identification of ER personnel			✓	

No.	Description of SANS 1514 Requirement	Not addressed	Partially addressed	Compliant	Suggested Action
20	Procedure: Raising the on-site alarm			✓	
21	Procedure: Receiving and responding to the alarm			✓	
22	Procedure: Activation of the on-site or off-site emergency plan			✓	
23	Procedure: Notifying the emergency services			✓	
24	Procedure: Safe evacuation and sheltering - accounting for all persons on site			✓	
25	Procedure: Control points for utilities listed with location or on map	✓			
26	Procedure: Decontamination following an incident			✓	
27	Procedure: Health and Safety functions - first aid, firefighting, roll call, search and rescue		✓		Update for warehouse site
28	Procedure: Termination of an emergency		✓		Update for warehouse site
29	ESD procedures			✓	
30	Emergency resource, equipment and maintenance plan	✓			To be updated once site starts operations
31	Supporting information package - SHE information, Location map, Site layout map, Emergency contact details, other relevant information	✓			To be updated once site starts operations
32	Documented evidence of drills/simulations	✓			To be updated once site starts operations
33	Documented evidence of ERP audits, reviews and updates	✓			To be updated once site starts operations
34	Training - employees	✓			To be updated once site starts operations
35	Awareness - neighbour	✓			To be updated once site starts operations
Description of OHS Act MHI Regulations Requirement					
36	Signed by CEO or 16.1/2				To be updated once site starts operations
37	Witnessed				To be updated once site starts operations
38	Reviewed at least every 3 years				To be updated once site starts operations
39	Other general issues				None

11.2 OFF SITE PUBLIC EMERGENCIES

R-Bay Properties Pietermaritzburg should communicate with the local emergency services to ensure that an off-site emergency plan is in place for the installation (see MHI Regulation 9). The off-site plan is the responsibility of the local authorities.

11.3 ANNUAL EMERGENCY DRILL

MHI Facilities are required to have an MHI type drill to test the emergency response plan at least once a year. This ideally needs the involvement of local emergency services (and preferably any other industries in the area that may be affected). R-Bay Properties Pietermaritzburg should ensure that they conduct such drills, even without the presence of the local emergency services, and keep record thereof.

12. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations for this MHI RA of the R-Bay Properties Pietermaritzburg facility:

12.1 CONCLUSIONS

Consequence Analysis and MHI Classification

- Due to the presence of certain hazardous materials, their associated offsite effects and the fact that some may be stored in IBCs (not drums) thereby exceeding the 2022 MHI Regulation Threshold, the R-Bay Properties Pietermaritzburg site should as a precaution be classified as a Low Level Major Hazard Establishment.

- The following materials within the R-Bay Properties Pietermaritzburg have the following impact distances:

Installation	Worst case incident	Distance to 1% lethality
33% Hydrochloric acid	Catastrophic rupture – one pallet with four drums	200m
25% Ammonium hydroxide solution	Catastrophic rupture – one pallet with four drums	100m
60% Nitric acid	Catastrophic rupture – one pallet with four drums	35m
Acetic acid	Catastrophic rupture – one pallet with four drums	30m

- There are no known other declared Major Hazard Installations in the vicinity. Domino effect range of worst-case events does not go offsite (35m), therefore offsite domino effects are not a possibility.

Risks

- Risk levels to individuals near the facility can be summarised as follows:

  Onsite risk (employee risk
  Acceptably low (i.e. Risk<$1*10^{-5}$ deaths/person/year). Risk to employees are highest at the offloading area
  Offsite risk at the site boundary (risk to neighbours):
  Acceptably low (i.e. Risk<$1*10^{-6}$ deaths/person/year). Risk to the public is highest at the site boundary with Buhle recycling.
  Risk to the nearest residences/sensitive receptors:
  Broadly acceptable (i.e. Risk<$1*10^{-6}$ deaths/person/year).

- Risks are acceptably low beyond ±0m from the site boundary.

- R-Bay Properties could consider implementing the following organisational measures:

Aspect	Review evaluation & Recommendation
Operator reliability - Major hazard awareness	– Ensure that operators are well informed of the impacts of toxic releases that have been included in this assessment. The training programmes should enable them to understand how to respond after an incident i.e. emergency planning and training – Forklift drivers must be licenced and well trained to minimise the likelihood of forklift accidents when carrying toxic chemicals.

- Risk reduction should always be explored. R-Bay Properties could consdier the following technical risk reduction suggestions have been made in section 9 of this report:

Plant Area	Risk mitigated	Risk reduction suggestion
Offloading area.	Toxic release	Consider having curbing with drain to sump/ collection pit in the chemical offloading area to reduce the impact of toxic release from spills after a drum / pallet with drums has ruptured while offloading. A spill management schedule must be in place to prevent any incompatible chemicals ending up in the same pit.
Warehouse	Toxic release	Ensure product segregation as per SANS 10263. Ensure secondary containment as per SANS 10263 and the National Buildings Regulations. Ensure suitable ventilation through the warehouse.

- Societal risks **are acceptably low.** The maximum number of fatalities for a worst-case scenario could be up to 12 persons. The likelihood of this is less than once in ten million years.

Emergency Plan

- There are Emergency Procedures for the R-Bay group and the procedure has been reviewed against the requirements of SANS 1514 and suggestions made in Appendix 11. The plan needs to be adjusted to suite the hazards assessed for the R- bay warehouse in Pietermaritzburg.

- In terms of the regulations, off-site emergency planning is the responsibility of the local authorities, with involvement from the operating personnel at the facility when developing the plan.

- Annual Emergency drills are required.

Land Use Planning

- Since there could be offsite effects Town Planning should be made aware of which areas could be affected, in order to manage the approval of new developments in the vicinity of this MHI.
- The following land use planning restrictions have been suggested in section 10 of this report:

Development Type	Description	Suggested separation distance
Industrial use	Workplaces with buildings with <100 occupants and <3 storeys per building.	No land-use planning restrictions
	Workplaces containing buildings with >100 occupants and 3 or more storeys per building.	Not within the **Inner Zone** (0 m from site boundary)
Residential	Any housing developments, even those with less than 30 dwellings per hectare, except small infill projects of one or two units which could be allowed.	Not within the **Inner Zone** (0 m from site boundary)
	High density developments such as large blocks of flats, informal housing, etc.	Not within the **Middle Zone** (0 m from site boundary)
Other	Hospitals, old-age homes, crèches, schools, large outdoor entertainment facilities (theme parks, sports stadia), etc.	Not within the **Outer Zone** (0 m from site boundary)

12.2 RECOMMENDATIONS

The following recommendations have been made:

1. Under both the MHI Regulations of 2001 and the MHI Regulations of 2022, the R- Bay warehouse site in Pietermaritzburg should as a precaution be classified as a Low-Level Major Hazard Establishment.

2. The MHI Regulations of 2002 (regulation 3) requires that a person be appointed as responsible for the MHI. In addition, there are various other administrative requirements such as training, neighbourhood communications, reporting of incidents etc. Refer to regulations 3, 5, 9, 16, 17 and 18 specifically. R-Bay should ensure compliance with these requirements. Note that regulations 11, 12 and 13 do not apply to this installation.

3. A copy of this risk assessment should be available on the site at all times for inspection by the authorities.

4. Prior to commencement of construction, the relevant authorities (i.e. local Fire and Emergency services, Provincial Department of Employment and Labour and National Department of Labour) should be notified as per the requirements of regulation 4 of the MHI Regulations of 2022. R-Bay Properties should retain proof of notifications. See section 5.3.2.

5. Prior to commencement of construction, public notifications should be undertaken as per the requirements of Regulation 4 of the MHI Regs of 2022. R-Bay Properties should retain proof of notifications. See section 5.3.2.

6. R-Bay Properties Pietermaritzburg should inform their Health and Safety Committee of the results of this risk assessment.

7. There are Emergency Response Procedures (ERP) for the R-Bay group, The procedure has been reviewed against the requirements of SANS 1514 and suggestions made in appendix 11. The plan needs to be adjusted to suite the hazards assessed for the R- bay warehouse in Pietermaritzburg. R-Bay need to ensure compliance with the requirements of regulation 15 of the 2022 MHI Regulations, e.g. the ERP plan needs to be signed off by the local authorities.

8. R-Bay Properties Pietermaritzburg should confirm that the local emergency services have an off-site emergency plan in place.

9. The proposed design presents **acceptably low** risk levels. Risk reduction measures should always be explored and implemented to ensure continuous improvement. Some possible improvements have been suggested in section 9.

10. The R-Bay Properties Pietermaritzburg facility is unlikely to affect land-use planning in the area. Land use planning restrictions need not apply outside the site boundary. See section 10.

11. This MHI facility should be reassessed 5-yearly, (i.e. due 2028), or earlier if major modifications are made, the installations are expanded, or a major incident occurs.

13 PROOF OF COMPETENCY

Refer to the certificates in Appendix 1.4.

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APPENDIX 1

APPENDIX 1.1 THE MAJOR HAZARD INSTALLATION REGULATIONS

During the 1970's and 80's there were many catastrophic events around the world related to the large scale production and storage of hazardous chemicals (e.g. Flixborough, Bhopal, Seveso, Mexico City to name a few). Many public persons outside the actual chemical sites were adversely affected by explosions, fires and the release of toxic gases. In many cases (e.g. Bhopal) this was compounded by the fact that the public as well as the emergency services had no idea of the types of chemicals on the sites and therefore no idea of how to respond when the events occurred. In some cases (Bhopal and Mexico City) the situations were compounded by the fact that residential developments (particularly low cost or informal settlements) had been allowed to develop right next door to these chemical factories.

In an attempt to prevent the reoccurrence of such disasters there was a trend in the 1980's and 90's around the world to implement legislation to control such situations. The so-called Seveso Directives in Europe and their implementation in the United Kingdom as the CIMAH and COMAH regulations are a good example of how these laws have been implemented.

When the first round of legislation was published in Europe the focus was on getting companies to notify (i.e. the government and interested and affected parties now knew where the installations were). The second round of legislation required companies to perform risk assessments of their operations and to submit these for scrutiny to the authorities. The most recent round of legislation is focussed on requiring companies to provide evidence that they are managing their risks adequately.

When the South African laws were compiled, the authors took cognisance of the regulations in other countries and any difficulties that had been experienced. The regulations tried to address these difficulties. For example, in Europe there was a tendency for some companies to keep just less than the threshold quantities to avoid having to comply. For this reason, the South African legislation does not set a lower limit on the quantities of substances that should be considered.

Ultimately the objective behind registering a site as a MHI is to ensure that the local authorities know what hazardous chemicals and hazards are out there, have emergency plans in place in case of an incident and have adequate information to control developments to suit (e.g. planning a suitable school, hospital or old age home near a hazardous chemical site). Companies are also better equipped to know what their risks are and can manage them accordingly.

The Major Hazard Installation Regulations falling under the Occupational Health and Safety Act of 1993 were promulgated on 16 January 1998. Although these regulations were revised in July 2001, the fundamental requirements remain in force [Ref. 1].

Part of these regulations require existing facilities and all new facilities, who have hazardous materials on their sites, to conduct a risk assessment to indicate their potential for causing major hazardous events (i.e. hazardous events of catastrophic proportions that can affect employees and the public outside the perimeter of the facility). This risk assessment should be reviewed every 5 years.

The risk assessment, which indicates why the installation is a major hazard installation, should then be presented to the National, Provincial and Local Authorities. The authorities have a responsibility to ensure suitable risk levels and separation distances between new installations, new residential developments, sensitive areas such as hospital etc. The public in the area of an MHI should be notified and for new installations persons have 60 days to make submissions to the relevant authorities.

The regulations are not prescriptive in terms of the classification of MHI's. Should anything occur which does indeed impact on the general public; the onus will lie with the management of the facility to prove why the installation is not classified as a major hazard and why the associated precautions / plans etc. were not implemented.

In South Africa there is other legislation (i.e. other regulations under the OHS Act) that govern assessment of hazards for employees. There is also legislation for environmental effects inside and outside a facility. Therefore, the focus of the MHI regulations is on the direct physical and chemical impacts of chemical installations on the public at large. An MHI assessment is therefore not a detailed audit of all the possible risks to plant equipment and operating personnel etc., but focuses rather on those hazardous events that could have a "significant" impact outside the installation boundary. Long terms environmental aspects (e.g. ground water contamination) and long-term health hazards (e.g. carcinogens) are therefore not within the scope of MHI considerations.

Terms frequently used in this report and the interpretation / meaning attached to each of these terms can be found in the Major Hazard Installation regulations.
Definitions of some other terms are listed below.

Hazard	A situation that has the potential to harm people, the environment or physical property, through a fire, explosion or toxic release (e.g. the use, storage or manufacture of a flammable or toxic material).
Hazardous Incident or Event	An occurrence due to use of plant or machinery or from activities in the workplace, that leads to an exposure of persons to hazards (e.g. the rupture of a vessel and loss of containment of flammable or toxic material –also referred to as a hazardous event).
Causative events	Occurrences that give rise to hazardous incidents (e.g. failure of a temperature indicator or pressure relief, etc.)
Consequences	The physical effects of hazardous incidents and the damage caused by these effects;
Severity	The seriousness of the consequences (e.g. death or injury or distress).
Risk	The overall probability of a particular type of consequence of a particular type of incident affecting a particular type of person.
Acceptability	The evaluation of the risk in comparison to certain known level of risk in other areas.

APPENDIX 1.2 CLASSIFICATION AS A MAJOR HAZARD INSTALLATION

An installation is classified as a major hazard installation if:

- More than the prescribed quantity (as per Schedule A in the General Machinery Regulations under the OHS Act [Ref. 1]) of any substance is kept on site in one fixed vessel.

- Where the form and quantity of any substance is such that it has the potential to cause a major incident (i.e. an incident of catastrophic proportions).

This classification therefore rests on defining what are considered to be 'catastrophic' consequences of major incidents. There is no clear definition and the interpretations can vary widely. ISHECON cc has adopted an interpretation that declares in this context that:

> *"A catastrophe constitutes any hazardous event which exposes members of the public to harmful effects of such a magnitude that a typical healthy adult would suffer some adverse health effects and a more vulnerable person could possibly be fatally injured."*

The above interpretation is converted into a consequence-based quantification criterion of 1% chance of fatalities from major hazardous events.

The focus of the legislation is on immediate acute effects due to hazardous chemicals. Therefore, only hazardous chemicals are considered and not the effect, for example, of hot high-pressure water or the potential energy in elevated water storage structures etc. If a material is not listed as hazardous in the South Africa Legislation (i.e. SANS 10228 [Ref. 2]) or in international databases such as materials safety datasheets, then it is not considered as contributing to a potential major hazard under this legislation. As there is other legislation (Environmental and Health legislation) governing chronic exposure to chemicals and long-term health effects (e.g. carcinogens) this is also not included in MHI classifications.

If there are potential incidents (e.g. gas releases, explosions or fires) that could generate effects at the site boundary but the magnitude of the effects are less than any of the levels of consequences listed below, then the installation is clearly NOT a Major Hazard Installation (i.e. fatalities are not expected). Although there would be effects, they are not considered significant enough to be catastrophic:

- Thermal radiation from fires: 4kW/m^2 for 1 minute [severe injuries, but no fatalities e.g. blistering of skin, second-degree burns] as per *API 521* [Ref 3] this is tolerable for a few minutes without protection. This is also a World Bank Standard [Ref 4] for what is considered potentially painful but not lethal.

- Blast overpressure from explosions: 7kPa [building damage, may be uninhabitable, injuries from glass etc but no direct fatalities] as per UK *HSE* consultation distances for developments [Ref 5].

- Toxic gas dose: ERPG 2 concentration for 1 hour (Emergency Planning Response Guidelines [acute health effects, but no fatalities] as per *America Industrial Hygiene Association 1990*.

If, however the effects exceed the following criteria the consequences are significant (1% or more chance of fatalities) and the installation is a major hazard installation.

- Thermal radiation from fires: 12.5kW/m^2 for 1 minute > 1 % fatalities [Ref 4], 5 seconds to pain, ignites normal clothing in 60 seconds [Ref 5].

- Blast overpressure from explosions: 14kPa, collapse of walls and structures [UK HSE required separation distance between developments].

- Toxic gas dose: Equivalent of ERPG 3 concentration for 1 hour and/or < 1% fatalities if using a probit equation for a typical healthy population.

In the range between the above insignificant and catastrophic levels, the MHI classification depends on the particular circumstances prevailing on the site and the characteristics of its surroundings population.

APPENDIX 1.4 RISK ASSESSMENT PROCESS AND AIA ACCREDITATION

I*SHE*CON is an Approved Inspection Authority by the Department of Labour for the risk assessment of flammable, explosive and toxic substances (Number MHI-001). This is dependent on I*SHE*CON's quality management system for an inspection body being accredited against ISO/IEC 17020 by SANAS (Number MHI-008). (See certificates below)

This study has been carried out in accordance with SANS 1461:2018 – Major hazard installations – Risk Assessments and ISHECON Work Procedures WP301 – MHI RA Assignment Administration and WP302 – MHI RA Methodology. This study has been carried out by an appointed risk assessor, in accordance with ISHECON Work Procedure 102- Training and appointment of personnel. The risk assessment has been approved by a signatory listed on the SANAS certificate.

I*SHE*CON uses a software package for quantitative risk assessment, SAFETI, under license from DNV in the UK (www.dnv.com). This study has been done on Version 8.7.

employment & labour

Department:
Employment and Labour
REPUBLIC OF SOUTH AFRICA

National Department of Employment and 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:

ISHECON CC

has been registered by the Department of Employment and 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: 13 June 2021
Expires: 12 June 2025
Certificate Number: CI MHI 0001

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:-

ISHECON CC
Co. Reg. No.: 1999/029022/23
MODDERFONTEIN

Accreditation Number: **MHI0008**

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 scope 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 and National Standards

ISO/IEC 17020:2012 AND SANS 1461:2018

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 M Phaloane
Acting Chief Executive Officer

Effective Date: 13 June 2021
Certificate Expires: 12 June 2025

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 Employment and Labour.

ANNEXURE A

SCOPE OF ACCREDITATION

Accreditation Number: MHI0008

TYPE A

Permanent Address: ISHECON CC H6 Pinelands Office Park Maxwell Drive Modderfontein Ekurhuleni Gauteng 1645 Tel: (011) 201-4783 Cell: 082 348 0070 Fax: 086 549-0878 E-mail: bothad@ishecon.co.za	**Postal Address:** P O Box 320 Modderfontein Ekurhuleni Gauteng 1645 Issue No.: 13 Date of Issue: 11 June 2021 Expiry Date: 12 June 2025

Nominated Representative:	**Quality Manager:**	**Technical Signatories:**
Mr CF Botha	Mr CF Botha **Technical Manager:** Mr DJE Rademeyer	Mr DJE Rademeyer Ms DC Mitchell Mr CF Botha

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. R692 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 SANS 1461:2018

Original Date of Accreditation: 13 June 2005 Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

APPENDIX 2

a. TOPOGRAPHY

The risk assessment software emission distribution package (SAFETI 8.7), does not take into account topography such as hills and valleys, nor local thermal conditions (upward currents due to heat generated by industries). However the surrounding land is classified according to its "surface roughness" which influences dispersion modelling.

The surface roughness parameter describes the roughness of the surface over which a vapour cloud is dispersing, and is a measure of the fluctuating velocity as a fraction of the mean velocity 10 m above ground.

Type of Surface	Roughness Length (m)
Open water, at least 5 km	0.0002
Mud flats, snow; no vegetation, no obstacles	0.005
Open flat terrain; grass, few isolated objects	0.03
Low crops; occasional large obstacles, x/h > 20	0.10
High crops; scattered large obstacles, 15 < x/h < 20	0.25
Parkland, bushes; numerous obstacles, x/h < 15	0.5
Regular large obstacle coverage (suburb, forest)	1
City centre with high- and low-rise buildings	3

MHI 0008

b. METEOROLOGY

WIND AND WEATHER INFORMATION

PIETERMARITZBURG WIND AND WEATHER DATA (2013) **-** Temperatures from Weather SA and wind from SA Weather Bureau

SUMMARY OF 2013 WIND AND WEATHER DATA FOR PIETERMARTIZBURG

		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Ambient Temp Deg C	Surface Temp Deg C	Humidity %
Day	**F1**	1.538608	1.805455	2.229022	2.440806	3.711507	4.770425	3.372653	2.229022	1.890168	1.805455	1.890168	1.890168	1.805455	1.254818	1.339531	1.424245	25	25	61
	B3	0.102187	0.510934	0.510934	0.306560	1.839362	3.883098	1.430615	0.306560	0.306560	0.408747	0.408747	0.102187	0.102187	0.102187	0.102187	0.408747	25	25	61
	D4.5	0.091968	0.102187	0.000000	0.000000	0.919681	1.001431	0.306560	0.000000	0.000000	0.102187	0.408747	0.204374	0.102187	0.000000	0.204374	0.204374	25	25	61
	D7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.102187	0.000000	0.000000	0.000000	0.020437	0.000000	25	25	61
	TOTAL	1.73	2.42	2.74	2.75	6.47	9.65	5.11	2.54	2.20	2.32	2.81	2.20	2.01	1.36	1.67	2.04			
Night	**F1**	2.17	2.55	3.15	3.45	5.24	6.74	4.76	3.15	2.67	2.55	2.67	2.67	2.55	1.77	1.89	2.01	12	25	84
	B3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	D4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	D7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	TOTAL	2.17	2.55	3.15	3.45	5.24	6.74	4.76	3.15	2.67	2.55	2.67	2.67	2.55	1.77	1.89	2.01			

There are three Pasquill stability conditions are normally applicable namely:

- Unstable: Sunny hot day (A, B, C).
- Neutral: Overcast day or night (D).
- Stable: Clear, cold night (E, F).

BASIS FOR WEATHER DATA

Wind rose allocations to Weather Categories

- all <2.5m/s to F and all F to night unless more than 50%
- all 2.5 - 3.5 to B3 m/s and all B3 to day
- all > 6m/s to D>6 and all D>6 to day unless total of B3 and D>6 more than 50%
- all that is left to D3 - 6 and split D3 - 6 over day and night to make up difference to 50% to each

Temp allocations based on SANS1461 MHI RA Std (Ave max and min)

Humidity average annual day and night values

APPENDIX 3

3.1 PROPERTIES OF HAZARDOUS MATERIALS

EXPLOSION, FLAMMABILITY AND REACTIVITY HAZARDS

Compound	BP at 1 atm (°C)	Density at 20 °C kg/m³	Vapour Press @ 20 °C (Pa)	Flash Point (°C)	Flammable (Y/N)	Flammable limits in air (vol %)	Auto-ignition Temperature (°C)	Reactivity (H/M/L)
Hydrochloric acid	83	1.198	3.13 kPa	-	N	-	-	stable under normal conditions of use
Acetic acid	118	1.05	-	40	Y	4-17	485	stable under normal conditions of use
Sodium hypochlorite	100	1.250	12 mmHg	-	N	-	-	stable under normal conditions of use
Nitric acid	86		9.4 hPa (20°C)	NA	N	NA	NA	discoloration during storage
Ammonia solution	36	0.6	0.8	NA	Y	16-25	651	Stable under normal conditions.
Sodium chlorite								

HEALTH HAZARDS ASSOCIATED WITH CHEMICALS

With respect to the detrimental health effects of chemicals on the public, it is really only the inhalation effects that are relevant. Skin contact and ingestion effects are only applicable to workers who are in immediate contact with the chemicals. This assumption has been confirmed for any of the sites, as there are no large storage vessels that could fail leading to either a spray or pool of immediately harmful liquid flowing off site.

Compound	Hazardous Breakdown / Combustion Products	Inhalation Acute	Inhalation Chronic	Ingestion Contact Acute	Ingestion Contact Chronic
Hydrochloric acid	Not combustible	The greatest impact is on the upper respiratory tract. May cause coughing, hoarseness, inflammation and ulceration of the respiratory tract, chest pain, and pulmonary oedema. Irritating and potentially corrosive to the respiratory tract and lungs. Exposure to	Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation that leads to frequent attacks of bronchial infection and	May cause severe burns of the mucous membranes, mouth, oesophagus, and stomach, with pain, nausea, vomiting, and diarrhoea reported in humans. May be fatal if swallowed. Causes irritation and burning, edema of the glottis, ulceration, or perforation of the oesophagus	May affect behaviour (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system oesophageal, gastric, pyloric).

Compound	Hazardous Breakdown / Combustion Products	Inhalation Acute	Inhalation Chronic	Ingestion Contact Acute	Ingestion Contact Chronic
		high concentrations can rapidly lead to swelling and spasm of the throat and suffocation.	may produce ulceration of the nose, mouth and gum	and digestive tract and resultant peritonitis, gastric haemorrhage and infection. Can also cause nausea, vomiting (with "coffee ground" emesis), diarrhoea, thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (	
Acetic acid	upon combustion: CO and CO2 are formed.	No sensitising effects known.	No sensitising effects known.	Swallowing will lead to a strong caustic effect on mouth and throat and to the danger of perforation of oesophagus and stomach.	Strong caustic effect on skin and mucous membranes
Sodium hypochlorite	Sodium hypochlorite solutions liberate the toxic gases chlorine or chloramine if mixed with acid or ammonia	Acute exposure to gases released from hypochlorite solutions can cause coughing and a burning sensation in the chest. Airway constriction and noncardiogenic pulmonary edema may also occur.		Ingestion of hypochlorite solutions may cause pain in the mouth or throat, dysphagia, stridor, drooling, odynophagia, and vomiting.	Hypochlorite irritates the skin and can cause burning pain, inflammation, and blisters
Nitric acid	Not combustible	coughing, dyspnoea.	Inhalation may lead to the formation of oedemas in the respiratory tract	tissue damage (mouth, oesophagus, gastrointestinal tract), severe pain (risk of perforation!), bloody vomiting, death	tissue damage (mouth, oesophagus, gastrointestinal tract), severe pain (risk of perforation!), bloody vomiting, death
Ammonia solution		Sneezing, coughing, burning sensation of throat with constricting sensation of the larynx and difficulty in breathing. Damage to lungs. Harmful if inhaled.		Corrosive. Causes burns. Symptoms may include: Redness. Pain. Serious skin burns. Blisters.	

TOXICITY INFORMATION

Compound	Odour Threshold (ppm)	Time Weighted Average OEL *** (ppm)	Short Term Exposure Level *** (ppm)	Immediately Dangerous to Life and Health **** (ppm))	LC 50 (30 mins)	ERPG 1 Value ***** (ppm)	ERPG 2 Value d (ppm)	ERPG 3 Value (ppm)	PROBIT k1 ~~	PROBIT k2	PROBIT n
Hydrochloric acid	Odourless				4701 ppm	3	20	150			
Acetic acid	Pungent	NDA	NDA	NDA	NDA	NA	NA	NA			
Sodium hypochlorite	0.3										
Nitric acid	Pungent					1	15	30			
Ammonia solution	5	25	35	1000		2	50	750			
Sodium chlorite											

** - TWA Threshold Limit Value – the time weighted average for a worker exposed 8 hours per day for a 40 hour week

*** - STEL short term exposure limit for a worker exposed to not more than the TWA but with a maximum of 4 excursions to this limit per day for a maximum duration of 15 minute each with at least 60 minutes between exposures

**** - IDLH (Immediately Dangerous to Life and Health) a value that is believed on the basis of research to be immediately harmful to human health, i.e. irrecoverable damage to health within 30 minutes exposure

***** - The ERPG (Emergency Response Planning Guidelines) values are established by the American Hygiene Association and are based on a 60 minute exposure.
The three categories have the following implications in terms of effects on people:
ERPG1 - below this concentration only minor irritation should be experienced by almost all persons
ERPG2 - below this value no permanent harm
ERPG3 - below this value permanent harm possible but fatalities are unlikely
ERPG values (and TEEL values) can be found through the AIHA website or the US Department of Energy website or the US EPA website.

d - where ERPG values or TEEL values are not available they have been derived using a DOW chemical guideline where ERPG2 = STEL or 3 * TWA, ERPG3 = LC50/30 or 5 * ERPG2, ERPG1 = Odour threshold or ERPG2/10, if there are different values the lower more conservative value has been used

~~ - Probit is an estimation of chance of death from exposure to a concentration of toxic material (c in ppm) for a period of time (t in mins)
PROBIT = k1 + k2 * ln ($c^n t$). Probit equation is based on actual or experimental data and can be found in literature references, e.g. the TNO Purple Book.

APPENDIX 3.2 ACCIDENT AND INCIDENT INFORMATION

The accident data below is extracted from Lees [Ref 8] and the IChemE Accident Database version 4 of 1999 [Ref 9] and Loss Prevention Bulletins. Only most recent incidents in the past 20 years 2000 upwards

DATE	COUNTRY	MATERIAL	EVENT DESCRIPTION	IMPACT **
Dec 2012		Nitric acid	Workers at the facility accidently poured Nitric Acid into a tank containing SH which caused a chemical reaction and released nitrous gasses.	250 factory workers and 1000 residents evacuated but explosion was averted
June 2009		Nitric acid	Five workers cleaning a heat exchanger unit with Nitric acid (70%) caused a reaction with a spandex manufacturing process component, releasing toxic fumes and causing chemical burns.	4 deaths 1 injury
Dec 2005		Nitric acid	A nitration process had 300 kg of Nitric acid added through pipes that contained a substance with which a reaction occurred, causing an explosion and leading to the release of toxic nitric fumes.	2 injuries
April 2001		Nitric acid	A nitric acid tank which was empty was to be repaired when a welder struck an arc on the inside surface of the tank leading to the liberation of nitrous fumes as a layer of acid had ingresses between layers of corrosion.	Na
Dec 2000		Nitric acid	An old tanker which was not inspected had contained corrosive chemicals until welded parts of the tanker failed and released these chemicals into a loading area	1 injury
Dec 2009		Acetic acid	Acetic Acid was hydrolysed by the water in the lines left after the tanks were cleaned and then causing the distortion and rupture and eventual ejection of content 9m into the air. Two further drums were observed to become distorted and were cooled by water spray and depressurised by the removal of the bungs.	No injuries occurred.
May 2002	Bahia Blanca, Argent	Ammonia solution	200 tons of aqueous ammonia was released from a fractured storage tank at a urea production line in a local plant. Air measurements taken after the release showed levels of 40–100 ppm of ammonia in the air (less than AEGL 2 for 60 min).	80 people hospitalized Many requiring oxygens supplement. Schools evacuated.
Jan 2007		Hydrochloric acid	A leak lead to three workers injured, due to hydrochloric fume inhalation when a leak on a pipe occurred during routine maintenance on a chemical plant	
June 2006		Hydrochloric acid	HCl spilt onto a highway; an IBC was found to be three times older than its design life	
December 2012		Hydrochloric acid	An explosion of a sight glass in an HCl gas delivery line occurred due to financial drive for production and consequently to excessive gas pressures in the production line.	There was no injuries.
		Hydrochloric acid		
April 1990		Formalin	Employees were preparing to off- load packages from a UPS trailer when they noticed that several packages were saturated with a liquid substance that had a toxic odour. The hazardous materials unit responded and identified the substance as formaldehyde. The employees were taken to the hospital, examined, and then released to go back to work. It was determined that approximately 1 1/2 gallons of the 37 percent formaldehyde liquid had leaked from around the filler cap of a 5 gallon container.	Na
AUGUST 1989	USA	Formalin	Employee was pulling a five-gallon container of formaldehyde and methanol solution from the second shelf of a pallet rack in the warehouse. The container fell on its side and the lid came off spilling the entire contents on employee from head to toe. He showered and flushed his eyes for 15 minutes prior to being taken to the hospital and treated for chemical burns.	NA

4.1 FULL LIST OF INCIDENTS CONSIDERED AND PROCESS DATA

SCENARIO NAME	MASS(kg)	TEMP (^oC)	PRESSURE (BARG)	FREQUENCY (FAILURES/YEAR)
1. Hydrochloric acid 250L HDPE drum catastrophic rupture	1155	23	Atm	1.49E-06
2. Sulphuric acid 250L HDPE drum catastrophic rupture	1830	23	Atm	2.83E-07
3. Phosphoric acid 250L HDPE drum catastrophic rupture	1600	23	Atm	4.32E-08
4. Nitric acid 250L HDPE drum catastrophic rupture	1336	23	Atm	5.17E-08
5. Acetic acid 250L HDPE drum catastrophic rupture	1090	23	Atm	3.96E-09
6. Sodium hypochlorite 250L HDPE drum catastrophic rupture	1200	23	Atm	8.63E-08
7. Sodium chlorite 250L HDPE drum catastrophic rupture	1210	23	Atm	4.28E-08
8. 37% Formaldehyde 250L HDPE drum catastrophic rupture	800	23	Atm	1.29E-08
9. 25% ammonium 250L HDPE drum catastrophic rupture	900	23	Atm	5.75E-08

There are other hazards that are typically considered during a design risk assessment of a new chemical installation, such as pollution, violent release of energy, noise, aesthetics etc. For the purposes of the assessment of major hazards, the focus of the legislation is on the instantaneous detrimental effects. The hazards of noise (low level, not explosions) are not immediate and therefore do not form part of the MHI hazards (note these are addressed in other assessments).

In a similar vein, chronic exposure to chemicals is a long-term hazard. It is not a Major Hazard Installation issue, and is rather covered under the Hazardous Substances Regulations and occupational health risk assessments. The hazards associated with the violent release of energy (kinetic or potential) were also not considered (e.g. overpressure burst of air receiver or collapse of structures etc). Pollution should be considered under the Environmental Management Plan for the installation.

4.2. TYPICAL CAUSES OF EVENTS

Primary cause events

Most hazards are due to loss of containment events and possible causes are the following:

Failure of equipment:

- Deterioration of the equipment integrity (physical impact damage, material of construction failure e.g. stress corrosion cracking) followed by thorough inspections throughout the life of the equipment.
- Deterioration of the plant integrity (material of construction failure) causing a rupture of equipment and piping. This may be as a result of a crack developed in the piping or equipment material due to fatigue from vibration, stress corrosion cracking or an inherent fabrication defect not detected during X-ray inspection. Such a rupture could then be initiated by, e.g., a pressure surge, or external damage from actions of people. Failure is normally in the form of small cracks. The best assurance against failure is correct design, specification, fabrication and construction procedure followed by thorough inspection, but this is no guarantee against the possibility for material of construction to fail.
- Uncontrolled pressure rise: in the pipes and vessels due to liquid blocked-in between two isolation valves, or liquid exposed to fire, or compressor discharge pressure being higher than expected, due to surging, etc. Lines can be protected by bursting discs. Alternatively run away reactions or the mixing of incompatible chemicals can also lead to reactions inside vessels/containers leading to over pressurization or the release of toxic gases
- Failures of the preventative equipment e.g. computer controls, control instruments and hardware trips.
- Failure of the protective / mitigative hardware barrier equipment e.g. deluge water,

Failure of systems:

- Failure of the preventative systems through human or management system errors (e.g. inadequate instruments).
- Failure of the protective / mitigative systems through human and procedural errors. E.g. creation of an open end through incorrect venting or opening of drain valves.

Secondary cause events

Possible causes for ignition (fire & explosions) of flammable or combustible materials are:

- Hot work
- Static spark discharges and lightning
- Electrical faults
- Smoking
- Failure of nitrogen blanketing systems.
- Ingress of foreign oxidising materials (e.g. air or strong acids) into the system containing flammable materials and then some form of ignition of the mixture. This is generally caused by inadequate purging during shut down and start-up operations. The source of ignition is often hot work tools during maintenance, warming up procedures, static or high process temperatures.

Possible causes for toxic exposure or gassing of people from released materials are:

- Not wearing personal protective equipment
- Lack of awareness
- Failure to evacuate

- Inadequate provision of gas escape facilities on site (only for toxic gases).

Minor and rare causes

Since the assessment mainly deals with the major hazards of explosion, fire and toxic releases, the following causes were excluded:

- Small general leaks, which may include valve spindle seal leaks, leaks due to normal wear, or improper maintenance.
- Natural events (earthquakes, storms, floods, etc.)
- External or internal sabotage as a result of personnel grievances.
- Aeroplane crashes into facility.

APPENDIX 5

5.1. CONSEQUENCE ANALYSIS

MAGNITUDE OF SOURCE TERM

In terms of the rate of release the following are generally applicable:

For vessels including road tankers or drums, the following scenarios are usually considered;

- complete rupture,
- a large hole the size of the largest appurtenance (typically 25 - 52 mm),
- a small hole the size of a typical flange leak or valve stem leak (typically 1 - 10 mm).

For pipes:

- complete severance (full bore),
- a small leak (the size of a typical flange leak, 10 mm).

These scenarios were used to evaluate the consequences using a modelling package called PHAST RISK (version 6.7). This package has built in fluid dynamics simulations and prior to simulating the consequences, accurately calculates the flows due to ruptures, leaks etc. based on pressures, temperatures, pipe diameters and material properties.

In terms of the duration of incidents where specific information is not available or calculable, the duration was estimated using the British Health and Safety Executive (HSE) standards [Ref. 5]:

5 seconds	for normal lifting and re-seating of relief valve
1 minute	for automatic detection and isolation e.g. in the event of a pipe rupture and rapid de-pressurisation leading to a plant trip
5 minutes	for remotely operable isolation e.g. operator responds to panel alarm and can isolate either on the panel or at strategically located external isolation valves.
20 minutes	operator is required to isolate manually directly at or very close to the source of the release e.g. required to don a BA set and move through vapour cloud to close a valve.

DISPERSION

Dispersion of gas clouds is governed by the prevalent weather conditions including:

- Wind speed and direction (essentially horizontal mixing)
- Stability of the atmosphere (essentially vertical mixing)

The latter is essentially the extent to which wind turbulence, which is responsible for the dispersion, is suppressed or assisted. On cold windless nights, cold air is trapped close to the surface of the earth and any gas release will not be easily dispersed. On the contrary, on a hot summer's day there is generally a lot of turbulence in the air due to heating of the earth's surface and the air in contact with it. This aids dispersion of gases. These conditions had been labelled with the letters A to F.

The principal results from dispersion calculations are the concentrations at ground level at various distances downwind from the release source. In addition concentration isopleths in the vertical and horizontal planes can also be obtained. There are many dispersion combinations, due to the different probabilities of weather stability's and wind speeds. The wind direction was considered only for the eight major wind directions and the percentage of time that the wind is blowing in a particular direction was used to determine the final risk levels.

Following dispersion of the vapour the flammable or toxic concentrations can be determined at certain key distances from the installation. The effects will also be determined at these key distances.

<u>FLAMMABLE EFFECTS</u>

The following overpressures are usually considered in a risk assessment, and a pressure of 14 kPa is taken as the MHI fatality threshold for explosions.

TABLE 5.1 – Levels of Damage at Key Explosion Overpressures

Over-pressure (kPa)	Injuries / Fatalities	Structural Damage	Other
100	100 %	Typical blast wall design limit	
70	> 90 %	Almost complete demolition of plant 100% damage	
35	Eardrum Rupture	80 % damage	
14	**< 1%**	**40% damage**	**HSE development separation distance**
7	Injuries, no fatalities	5 % damage	
4		Minor structural damage	HSE safe housing consultation distance
0.7			Maximum missile distance
0.3	Loud noise	Large glass windows break	

An explosion generally produces missiles as well as over-pressure wave. With respect to missiles it is unlikely that they will travel kilometres to affect the public directly, and moreover the large area of possible strikes means that the probability of a public fatality is so low that it is generally not worth considering as a major hazard.

The consequences of fires are damage to equipment and radiation burns to people. In terms of burns there are two aspects that are important, namely the intensity of the radiation and the duration of exposure. In quantifying the magnitude of a fire, the information is presented in the form of radiation intensities for simplified specific exposure times. It is assumed that 1 minute is insufficient time to escape from the source of the threat. In this regard the following radiation guidelines have been used.

TABLE 5.2 – Levels of Damage at Key Fire Radiation Levels

Radiation Intensity kW / m2	Exposure Limit (time)	Consequence
75	5 secs	100% lethal
37.5	1 min	100 % lethal, will damage process equipment and structures
15	1 min	50 % lethal, permissible structure exposure level
12.5	**1 min**	**< 1 % lethal**
4	1 min	No fatalities expected
1.6		Pain Threshold, typical flare design limit
1.2	Unlimited	Equivalent to midday sun

This means that any person in the 37.5 kW/m^2 radiation circle for a minute is likely to be fatally burned, while there is a 50% chance of those persons between the 12.5 and 37.5 kW/m^2 radiation circles being fatally burned within a minute. Outside of the 12.5 kW/m^2 radiation level there are less than 1% fatalities. A level of 4 kW/m^2 is taken as the MHI fatality threshold for huge fires close to open public areas where shelter or escape is unlikely and a level of 12.5 kW/m^2 is taken as the threshold for small fires or where there are buildings and structures that provide some shielding between the public and the source of the fire.
EVENTS INVOLVING FLAMMABLE MATERIALS

The release of a flammable material can result in many different effects depending on the particular circumstances of the release. A pressurized release (e.g. pipe leak) that is ignited immediately and close to the source will result in a jet (liquid) or torch (vapour) fire. If the liquid is not ignited or it is not pressurized at the point of release it will from a pool on the ground. Vapours will evaporate off the pool. Multiple factors may catalyse the speed at which vapours are released; such as the volatility of the material, increased surface temperature, increased wind strength and/or spill surface area. In the case of release of vapour or liquefied gases a cloud of vapour or vapour with entrained liquid droplets (mist) will be formed directly.

This cloud of flammable vapour (either from the pool or directly from the vapour release) can drift with the wind and disperse. If the cloud disperses to below its lower flammable limit then it cannot be ignited. However, while it is dispersing the area of the cloud where the vapour is below the upper flammable limit and above the lower flammable limit can be ignited. If the cloud is in an open uncongested, unconfined area a vapour cloud fire or so called “flash” fire will result. The fire will “flash” back from the point of ignition to the point of release. At the point of release there will now be either a jet fire or pool fire or both.

However, if the cloud of flammable gases has drifted into areas where it is confined within pipe work, plant structures, buildings, vessels, forests etc. the ignition may lead to a vapour cloud explosion. The strength of the explosion will depend on the properties of the material involved. However, another critical factor is the particular layout of the congested / confined areas in which the gas is located. Within one release event there may be areas where the gas is extremely confined and other areas where the gas is out in the open. Each of the pockets of ignited gas may have different effects: some may explode while others are essential flash fires. The direction in which the gas burns through the areas (i.e. the manner in which the flame front is broken up by obstacles) may also result in different flash fire zones or explosions with strength effects.

The consequences of each of the flammable hazardous events are radiation burns, blast and shock wave damage and possible damage due to missiles. In general, every flammable release will have radiation and explosive effects. However, depending on the type of release either the radiation or the over-pressure (explosion) effects will dominate the severity of the consequences. For example the explosive effects of a jet fire are negligible in comparison with the radiation effects and vice versa for a confined vapour cloud explosion. With condensed phase explosions (e.g. explosives or certain organic peroxides – NOTE, not present on this site) it is the over-pressure element as well as ground vibration that can have significant effects.

The major consequence of an explosion is the shock wave effect. The shockwave shatters glass, damages equipment and can cause fatalities; either directly through rupture of bodily organs, or indirectly through structures collapsing onto people. The consequences of fires are damage to equipment and radiation burns to people. In terms of burns there are two aspects that are important, namely the intensity of the radiation and the duration of exposure. Details of the overpressures and radiation levels that lead to specified degrees of harm are present in APPENDIX 5.5.

TOXIC EFFECTS

In addition to Probit equations, it is often useful to have a single number or single concentration of toxic vapours that can be used as a first approximation to the extent of dangerous exposure. For example there is the concentration which is deemed to be Immediately Dangerous to Life and Health (IDLH) and it is the concentration that can cause significant harm to almost all persons within 30 minutes of exposure.

Another single number that is often used is the Emergency Response Planning Guidelines that were developed by a consortium of chemical companies under the auspices of the American Industrial Hygiene Association. These guidelines indicate the maximum exposure concentrations that can be endured for 60 mins (i.e. a reasonable evacuation period) with certain levels of effects.

ERPG 1 - only mild irritation will result
ERPG 2 - no permanent damage
ERPG 3 - no life-threatening health effects (Possible permanent damage)

Often the ERPG3 and IDLH concentrations are often similar. Generally emergency services would consider evacuation of persons who could be exposed to ERPG 2, ERPG 3 or IDLH concentrations depending on their resources. Therefore, the local emergency services need to know the distance at which the gas concentration would drop below this concentration under both probable and well as worst-case release scenarios.

APPENDIX 6

LIKELIHOOD ANALYSIS

6.1. OPERATOR AND EQUIPMENT FAILURE DATA

1. Equipment Failure

Most of the failures leading to potential major hazards are associated with loss of containment as a result of vessel or pipe rupture, or due to leaks. For the purpose of this assessment ruptured vessels and pipes tank were considered as representing the worst-cases. Failure data was taken from the manual published by the Dutch Government Committee for the Prevention of Disasters viz. "Guidelines for Quantitative Risk Assessment" CPR 18E (1999) [Ref 22], known in the industry as the Purple Book. Examples of the frequency data used are presented below.
Note: 1E-8 = 1 * 10^{-8} or 0.00000001

EQUIPMENT	FAILURE	FREQUENCY Failures/year
Full containment atmospheric tank (i.e. semi-explosion and missile penetration proof double containment tank)	instantaneous release	1 E-8
Atmospheric tank with protective outer shell	- instantaneous release - small release to secondary container	5 E-7 1 E-4
Single walled atmospheric containment tank	- instantaneous rupture - 10-minute release of entire inventory - 10 mm hole	5 E-6 5 E-6 1 E-4
Pressure vessel	- instantaneous rupture - 10-minute release of entire inventory - 10 mm hole	5 E-7 5 E-7 1 E-5
Process vessels and reactors	- instantaneous rupture - 10-minute release of entire inventory - 10 mm hole	5 E-7 5 E-7 1 E-5
Pipes Ø < 75 mm	- Rupture - leak	1 E-6 /metre 5 E-6 /metre
Pipes 75 mm <Ø < 150 mm	- rupture - leak	3 E-7 /metre 2 E-6 /metre
Pipes Ø > 150 mm	- rupture - leak	1 E-7 /metre 5 E-7 /metre
Pumps (canned)	- catastrophic failure - leak	1 E-5 5 E-5
Pressure relief valve fails open		2 E-5
Storage of explosives	Mass detonation	1 E-5
Road tanker (atm)	- instantaneous rupture - large leak - hose rupture	1 E-5 5 E-7 4 E-6 /hour

EQUIPMENT	FAILURE	FREQUENCY Failures/year
	- hose leak - arm rupture - arm leak	4 E-5 /hour 3 E-8 /hour 3 E-7 /hour
Road tanker (pressure)	- instantaneous rupture - large leak - hose rupture - hose leak - arm rupture - arm leak	5 E-7 5 E-7 4 E-6 /hour 4 E-5 /hour 3 E-8 /hour 3 E-7 /hour

2. Human Failure

Source	Person	Task Level	Failure Rate Prob of Error
ICI	Operator	Simplest	$1*10^{-4}$
		Routine	$1*10^{-3}$
		Should take care, e.g. a checklist is needed	$1*10^{-2}$
		Non routine	$1*10^{-1}$
		Checking another operator	$1*10^{-1}$
	Supervisor	Checking an operator	$1*10^{-2}$
Du Pont	Operator	Simple	$1*10^{-3}$
		Checking another operator or shift change-over	$1*10^{-1}$

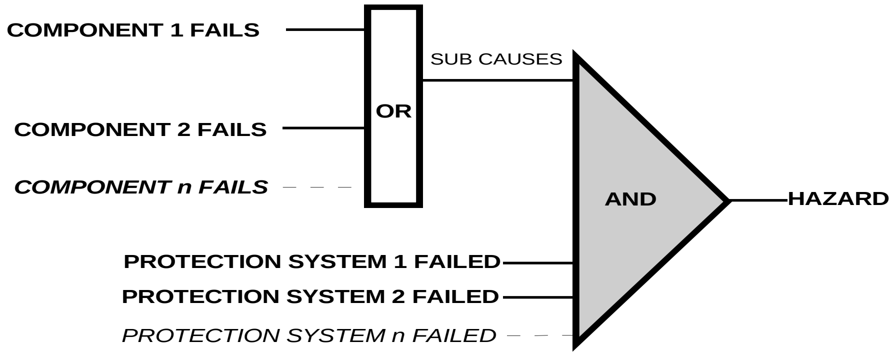
3. Organizational Measures and System Failures

The standard of maintenance, the implementation of operating and emergency procedures and the general safety management systems in place on site can have a significant effect on the failure rates used. Pitblado (Ref. 19 pg. 115) states that one can adjust generic data based on an assessment of the particular plant effectiveness at maintenance, safety systems etc. The basic standard of safety should be 1, i.e. neutral if good maintenance, operating and emergency procedures in place. Many plants fall below this standard; hence failure data should actually be increased up to a maximum of one order of magnitude. For those that are of world class standard and have much more that the basic safety systems in place the failure data can be reduced by up to one half an order of magnitude.

Measures in the organisation to reduce the major risks and suggestion have been made in the body of the report for improvement to the management systems on site.

4. Simple Fault Trees

For most events in this study the simple failure rates above were not sufficient to estimate the final likelihood of a hazardous event. This is due to the layers of protection provided on the plant. Simple fault trees were compiled for most events. A fault tree is essentially a logic diagram, which represents the development of events from the root causes with failure data in terms of their frequency or probability of occurrence to the final 'top' event or hazard as illustrated below.



For these risk assessment very simple fault trees were compiled. For example the following were included:

- the generic equipment failure data (as listed above)
- the number of drums, tankers, lengths of pipeline etc,
- the amount of time that the equipment is On-site and in use (e.g. for road tankers)
- the ability of operator to respond or not or to cause failures (e.g. for stopping transfer if alarms provide warning),
- the likelihood of failure of any automated shut off valves, excess flow valves, ventilation, scrubbers or any ESD's etc the general perceived level of Safety Management on site (see systems failure above).

APPENDIX 7

7.1. RISK ESTIMATION

Individual risk

Individual risk: The chance that a particular individual at a particular location will be harmed. It is usually described in numerical terms such as “number of fatalities per person per year” or “one fatality per person per, e.g. 1000, 10 000, 100 000, $10^{6,}$ etc. years”. The units are typically of one chance in a million of death per person per year, and are shown as exponents i.e. 1 * 10^{-6} d/p/y.

Assessment of individual risk does not take into account the total number of people at risk from a particular event, or the possibility that people may take action to escape the effects of a toxic gas or fire etc. The individual risks were determined based on the combination of frequency or likelihood of events and their severity, taking into account ignition probabilities and the distribution of the weather conditions in terms of stability, wind speed and direction.

The individual risks can be plotted on a map of the site. This has been done and is shown on **Figure 7.1.1** for the all the activities on the installation. On the map all the areas where risks are lower than 1 * 10^{-7} d/p/y lie outside the 1 * 10^{-7} d/p/y risk contour (i.e. the green line), and the same for the other higher risk contours. The map easily allows one to see where certain risk levels e.g. 1 * 10^{-6} extend beyond the site boundary.

Societal risk

Individual risk referred to above considers the risk to a typical individual but does not consider how many individuals could be affected. Communities have a strong aversion to large events, which lead to multiple fatalities. Therefore, the frequency of events that lead to multiple fatalities should be suitably low. The F-N curve attempts to represent this concept graphically and to set some standards. The graph shows the frequency of accidents on the ‘y-axis’, and the maximum number of fatalities that could result from this accident on the ‘x-axis’
Societal risk includes the population in the vicinity, and estimates the chances of numbers of people being harmed by an incident. The likelihood of the primary event (an accident at a major hazard plant) is still a factor, but the consequences are assessed in terms of level of harm and numbers affected, to provide an idea of the scale of an accident in terms of total numbers killed or harmed. Estimates of the societal risks incorporate the population distribution during day and night, as well as the location of people indoors or outdoors. (See the table below for the population data used). The results are presented in the form of an F-N curve. This plots the number of persons potentially fatally affected by every one of the potential events on site, against the frequency with which these levels of fatalities can be expected to occur

Population estimations

The area around the site was split into zones such as each of the neighbours, or the general surrounding industrial area, residential areas, open spaces etc. The population in each area was either estimated from a count of houses or based on known information such as employee records or the typical population density was used for that type of area, e.g. typical industrial areas have a density of between 40 -100 persons per hectare depending on the type of activity. For this information the guidelines in the Green Book 1992 [Ref 23] were used. The Green book also suggests guides on day versus night time occupation of certain areas, e.g. 100 % of a population would be in a residential area at night but during the day 70% leave to go to work. A probability that people would be indoors was assigned to each population area, based on the guidelines Green Book 1992. See Table 5.10.1 below.

Night / Day	Area	Population	Fraction indoors	Density (persons / m2)
Day population	R- bay site	103.6	0.99	103.6
	Neighbouring industry	2808	0.99	2808
	Open area	50	0.99	50
Night population				
	R- bay site	3	0.9	0.0002896
	Neighbouring industry	200	0.9	0.0007124
	Open area	2	0.99	1.956E-5

Being indoors gives protection that is affected by the air exchange rate in building and the time it takes to clear a room of gas after an event. For normal buildings this study used an air exchange rate of 4 ACH (Air Changes per Hour) and a tail time of 1800 sec.

APPENDIX 8

8.1. RISK ASSESSMENT CRITERIA

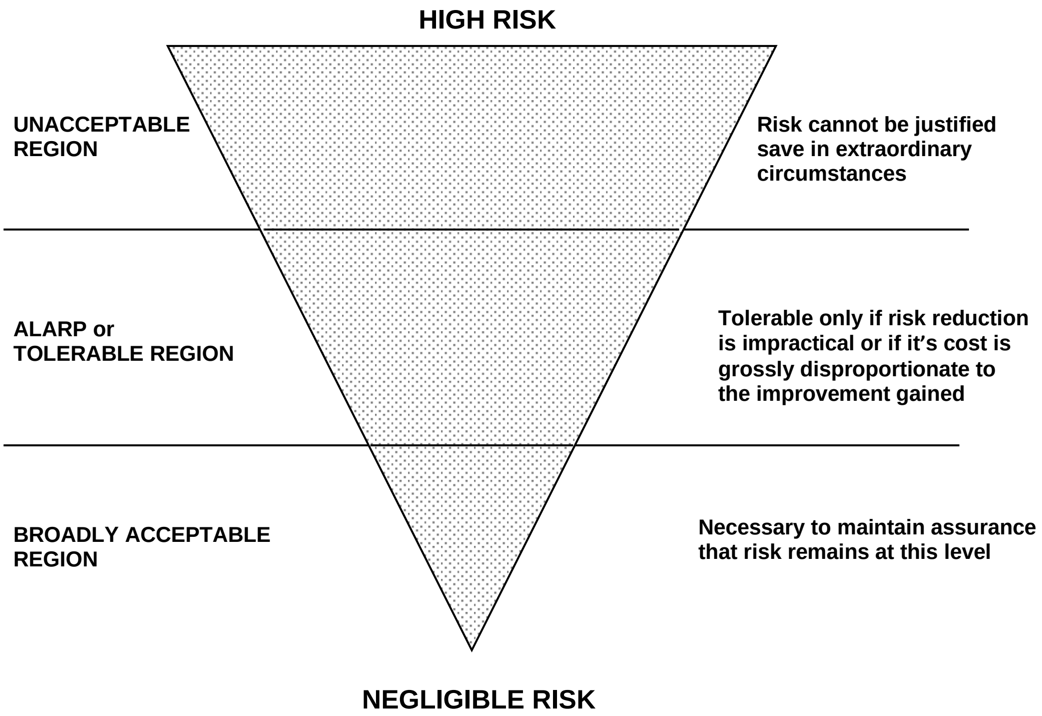
INDIVIDUAL RISK

Risks that major hazard installations pose to persons are usually represented quantitatively as the chance in any one year of a typical person being fatally affected by an accident on the site. The acceptability of chemical risks is related to the other risks to which persons in society are exposed. Risks that are accepted voluntarily by persons are often quite high while risks that are not voluntarily accepted, e.g. the risk of so called acts of God, are quite low. The table below shows some risks that individuals tolerate.

ACTIVITY / HAZARD	RISK *
Becoming a homicide victim (RSA)	410 chances in a million
Becoming a traffic fatality (RSA)	220 in a million
Becoming a traffic fatality (UK)	6 in a million
Becoming a victim of some other accident (e.g. drowning, electrocution UK)	2.5 in a million
Being struck by lightning (RSA)	1.5 in a million
Being struck by lightning (UK)	0.05 in a million
Being struck by a falling aircraft (world-wide)	0.01 in a million

- - approximate risk rounded-off data UK from “Reducing Risks, Protecting People” , Traffic RSA AA 1997, Crime CIAC SAPS 2004/5

Once an approximation of the risk has been made it is possible to judge that risk according to agreed criteria and establish if it is acceptable or unacceptable to persons who may be affected. In many cases there is no clear and easy distinction between what is acceptable and unacceptable. There is a zone between these two extremes where risks could be tolerated provided, they are as low as reasonably practicable (ALARP). The installation whose risks fall into this category, need to prove that they have done everything reasonably practicable to reduce risk. The ALARP principle in illustrated below:



The dividing lines between the zones, e.g. unacceptable and tolerable, can be set at different levels depending on the situation e.g. who is affected, whether they also receive benefits in addition to the risks etc.

In residential areas, a public risk level of 10^{-6} chances of death per person per year (i.e. 10^{-6} d/p/y = one in a million chances of death in one year) is accepted in the United Kingdom as being a broadly acceptably risk to which people could be exposed [Ref. 8]. This risk is more than 10 times higher than the risk of being struck by lightning in the UK and is therefore considered virtually negligible. In the UK, public risk levels in excess of 10^{-4} d/p/y are considered to be unacceptable, and immediate attention should be given to reducing the risk. In the area between 10^{-4} and 10^{-6} risks are tolerable but not negligible and therefore some form of risk management program should be instituted with the aim of reducing risks within the constraints of what is practicable and reasonable. This range is referred to as the ALARP range, i.e. risks should be as low as reasonably practicable

In industrial areas the risk levels should be similarly low. However, it is possible that slightly higher risks could be tolerated than in residential areas provided everything reasonably practicable has been done to reduce the risks. This assumes that employees at neighbouring industrial sites are generally fit, healthy, able to be trained in emergency procedures etc. Within the broader manufacturing industry in the UK, the average employee serious injury rate is $2.3 * 10^{-5}$ d/p/y. The risks that a new installation poses to employees of adjacent industrial installations should not exceed the risk to which they would normally be exposed at work. The individual risk to employees of neighbouring installations should therefore be below $1*10^{-5}$ d/p/y. (Note ideally it should be below the $1*10^{-6}$ d/p/y as these persons are also members of the public).

SOCIETAL RISK

In the case of major hazard installations, the more persons that are potentially exposed to the effects of accidents the greater will be the absolute number of persons that could be affected by any one event. In terms of fatalities there is no distinction between employees and the public, i.e. 100 deaths is serious whether it is employees or public persons. Major hazard installations that are located in remote uninhabited areas will pose lower societal risks that the same industries located near residential areas, despite the fact that both industries could pose identical individual risks.

In all communities there is an aversion to large accidents that affect many people at once. For example, in South Africa we appear to ‘tolerate’ a road accident fatality rate of about 30 persons per day. It is only the very large accidents where typically 10 or more persons are affected that may jog our awareness and make us consider that the road traffic accident situation is ‘intolerable’. The same would apply to major hazard installations. Therefore, in addition to considering the risks to a typical individual near an installation, it is important to consider the possible impact on the absolute numbers of persons potentially exposed. This gives an indication of how many persons could possibly be affected in any one accident.

There has been a debate internationally about whether employees should also be included as part of the population. The Health and Safety Executive in the United Kingdom has adopted the principle that workers located on a major hazard installation subjected to Occupied Building Controls will be excluded from societal risk assessments. As there are no binding Occupied Building Regulation in RSA, employees on the site were included in the societal risk evaluation.

The UK HSE’s have recommended societal risk guidelines [Ref 15]. The criteria are that there should be no chance that more than 50 persons could be fatally affected by accidents on the site more often than once in 5000 years. The criteria are presented in the form of an F-N curve. This shows the number of persons potentially fatally affected by each and every one of the potential events on site and the frequency with which these levels of fatalities can be expected to occur.

APPENDIX 9

SITE EMERGENCY PLAN